# GEOCHEMISTRY, MICROSTRUCTURE AND GROWTH BANDING IN *Stylaster campylecus parageus* AND *Primnoa pacifica*- IMPLICATIONS FOR COMMONLY OBSERVED DEEP SEA CORALS AS PALEOCEANOGRAPHIC ARCHIVES

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**Geochemistry, microstructure and growth banding in *Stylaster campylecus parageus* and *Primnoa pacifica*– Implications for commonly observed deep sea corals as paleoceanographic archives.**

By

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science

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## Abstract

A sclerochronological study of two common cold-water corals from the Northeast Pacific, *Stylaster campylecus parageus* and *Primnoa pacifica*, was performed on specimens collected in 2008 from Dixon Entrance, BC, and the Olympic Coast National Marine Sanctuary, Washington State. SEM imaging of *S. campylecus* revealed the presence of growth banding and extensive skeletal remineralization. Profiles of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca could, however, be obtained with Secondary Ion Mass Spectrometry. Sr/Ca values were observed to display two maxima over distances covering approximately 12 growth bands, with corresponding minima in Mg/Ca and Na/Ca. These cyclical co-variations were interpreted to be primarily influenced by surface water productivity. This cyclicity in the trace element profiles, in the context of a documented biannual increase in productivity, suggested that the growth bands are monthly.

The average radial growth rate of *S. campylecus* was $1.4 \pm 0.1$ mm.yr$^{-1}$, and the average axial growth rate was $17.3 \pm 1.1$ mm.yr$^{-1}$. Temperature changes cannot account for the variation in Mg/Ca and Sr/Ca in either *S. campylecus* or *P. pacifica.* These variations appear instead to be modulated by surface water productivity. The annual radial growth rate of *P. pacifica* varied between 0.23 and 0.58 mm.yr$^{-1}$ in the samples studied - considerably higher than growth rates of a similar species in the North Atlantic. Geographic variation in growth rates is likely influenced by primary productivity.

*Dedicated to my parents*

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# CHAPTER 1: INTRODUCTION

Zooxanthellate corals have been used in paleoceanographic reconstructions for decades. However, since they mostly occur between 30ºN and 30ºS latitude in relatively warmer waters (Hughes et al, 2003), the climate records preserved by them have reduced significance for non-equatorial processes (Smith et al, 2000). Azooxanthellate cold water corals on the other hand have several unique traits that make them potentially useful for a range of paleoceanographic applications especially in higher latitude regions where sources of paleoceanographic data are sparser (Lazier et al, 1999; Smith et al, 2000).

## 1.1 Distribution and habitat of cold water corals:

Azooxanthellate cold water corals mainly comprise a variety of cnidarians, including Scleractinians (the stony corals, including solitary and colonial species), Octocorals (true soft corals) including Alcyonaceans (soft corals, usually without stiffened branches), Gorgonians (fan corals, usually with stiffened branches), and Pennatulaceans (sea pens), Antipatharians (black corals), Stylasterids (members of the Hydrozoa, the lace corals), some Zoanthids and Hydractiniids (Freiwald et al, 2004; Cairns, 2007). They are generally found to inhabit areas where the ocean water temperature is between 4º C and 12ºC (Roberts et al, 2006) and can be found at depths of up to 6200m (Cairns, 2007; Stanley and Cairns, 1988). The highest density of cold water corals is presently documented in the Northeast Atlantic Ocean. However, this is probably due to the higher intensity of related research in this region to date. They could potentially be found in considerable numbers in all oceans and can be expected at greater water depths in relatively warmer regions (Freiwald et al, 2004).

Cold water corals generally grow on hard substrates, in areas where strong bottom currents control the sedimentation and food supply (Freiwald et al, 2004). They probably mainly derive nutrition from detrital particulate organic matter (POM) and zooplankton (Sherwood & Risk, 2007). Some hypotheses suggest that the distribution of cold water scleractinian corals is dependent on the depth of the Aragonite Saturation Horizon (ASH). The ASH in the Northeast Atlantic Ocean is more than 2000m deep and this is proposed as the reason why a larger number of cold water corals are found in the North Atlantic as compared to the North Pacific Ocean- where the ASH is less than 600m deep in places (Guinotte et al, 2006). A recognized centre for scleractinian species diversity in azooxanthellate corals occurs in the waters surrounding the Philippines, where 160 species of azooxanthellate scleractinian corals have been identified (Roberts et al, 2006).

**1.2: Lifespans, growth rates and fragility of deep sea coral ecosystems:**

Zoanthids, Antipatharians and Gorgonians have some of the longest lifespans of any corals (Sherwood & Risk, 2007). Some deep sea Gorgonians and Antipatharians are known to live for hundreds of years (Williams et al, 2005; Sherwood et al, 2006). The growth rates of most deep sea corals are several times lower than tropical corals (Druffel et al, 1995; Sherwood& Risk, 2007; Sherwood & Edinger, 2009).

Due to their slow growth rates and long lifespans, these corals are extremely susceptible to damage from deep-sea trawling (Krieger, 2000; Hall-Spencer et al.2002). Since many deep sea corals form nursery habitats for commercially important fish

(Freiwald et al, 2004), accurately determining the growth rate of deep sea corals is very important in order to assess the recovery time of coral habitats from possible damage due to deep sea trawling and similar anthropogenic disturbances.

Even though the growth rates of most deep sea corals are lower than tropical corals, there can be a large variation in the comparative growth rate of different species of cold water corals (Andrews et al, 2002; Gass & Roberts, 2006; Sherwood & Edinger, 2009). Growth rates of deep sea corals could be controlled in part by tidal currents (Sherwood & Edinger, 2009), POM flux (Roark et al, 2005) and other, undetermined factors.

One of the aims of this thesis is to determine primary factors controlling growth rates in two species of these corals from the same region.

### 1.3 Cold water corals as paleoclimate proxies:

Their long lifespan, in addition to their wide global distribution, give cold water corals the potential to record paleoclimate data at all latitudes and to provide useful clues to the changes that occurred in deep and intermediate water masses in the past. Consequently cold water corals are of particular value in places where other paleoclimate proxies are scarce.

Stable isotope determinations in certain deep sea corals have been used to successfully interpret paleotemperatures (Smith et al, 2000) and ocean circulation changes (Smith et al, 1997). Trace elements profiles from some octocorals have also been used to interpret paleotemperatures (Thresher et al, 2004; Sherwood et al, 2005a).

The main objective of this study is to assess the growth rates and potential paleoceanographic significance of two commonly observed cold water coral species in the Northeast Pacific Ocean through growth band imaging and analysis of the trace element geochemistry of their skeletons.

## 1.4 Stylasterid corals:

### *1.4.1 Classification and biogeography of Stylasterids:*

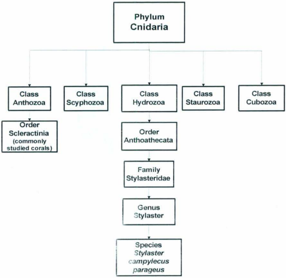
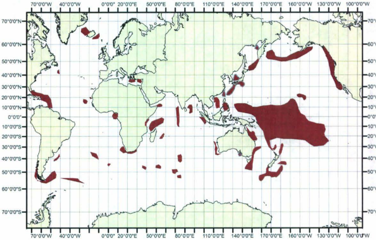



**Figure 1.1: The biological classification of Stylasterids. *Stylaster campylecus parageus* (Fisher, 1938) is the Stylasterid species studied herein**

Most commonly studied calcified cnidarians belong to the Order Anthozoa. Stylasterids (Family: Stylasteridae) belong instead to the Class Hydrozoa. All Stylasterids are azooxanthelate (Cairns, 1992b). Stylasterids have an extensive global distribution (Figure 1. 3). They are most commonly found off small 'low' islands, atolls, archipelagos, seamounts, offshore reefs and submarine ridges.

They seem rare proximal to continental land masses or 'high' continental islands. Their distribution is reported to follow plate boundaries and is empirically associated with geothermal hot spots beneath the oceanic crust. The highest Stylasterid species diversity is reported along the Norfolk, Kermadec, and Macquarie Ridges as well as around New Zealand (Cairns, 1992b). They have been reported at latitudes as high as 58°17'N in the North Pacific and 68°30'N in the North Atlantic. Stylasterids have been found in water temperatures varying from -1.5°C to 30° C and at depths varying from 0m to 2103m (Cairns & Macintyre, 1992a).

**Figure 1.2: An image of *Stylaster campylecus parageus* obtained by *ROPOS* in July 2008 (Dixon Entrance, Northeast Pacific)**




**Figurel. 3: Global distribution map of Stylasterids (modified from Cairns, 1992b).**

### *1.4.2 Growth banding and geochemistry:*

Most species of Stylasterids have aragonitic skeletons. Seven species are known to have calcitic skeletons. A few species are also known to have variable percentages of both calcite and aragonite in their skeletal framework. The calcitic species are generally found in areas where the water temperature is lower than 13°C (Cairns & Macintyre, 1992a).

Growth banding has been documented in some Stylasterids. *Errina dabneyi* was noted to have faint growth bands (Wisshak et al, 2009). *Stylaster erubescens* is reported to show growth increments as well (Andurs et al, 2007). The temporal significance of these growth bands is unknown, and none of the previously observed growth bands in Stylasterids have been explicitly verified as annual or otherwise.

A recent study on the biomineralization of *Errina dabneyi* (a deep sea Stylasterid) revealed that, during the organism's growth, a steady dissolution and reprecipitation of skeletal material occurs in the central canals of the skeleton (Wisshak et al, 2009). This reprecipitation would appear to severely complicate the use of radiocarbon or $^{210}$Pb dating to estimate the age and growth rate of these corals. The associated skeletal modification also likely alters the stable isotope and/or trace element profiles of these corals, making them potentially less reliable as geochemical archives, depending on the scale of sampling (Wisshak et al, 2009).

Studies by Weber & Woodhead (1972) indicated that tropical hydrocorals precipitate their skeleton close to equilibrium with sea water. Further, preliminary studies on the stable isotope geochemistry of *Stylaster erubescens* (Andurs et al, 2007) and

*Stylaster sp* (Mienis, 2008) have indicated that these organisms show cyclic variability in their $\delta^{18}O$ and $\delta^{13}C$ profiles, and it has been proposed that this cyclicity might be annual.

Their broad geographic distribution and depth distribution, abundance and large temperature tolerance makes Stylasterids potentially useful as monitors of oceanographic change. A study of their growth rates, longevity, skeletogenesis and geochemistry should therefore, provide useful insights into this potential.

## 1.5 Primnoid corals

### *1.5.1 Classification and biogeography of Primnoids:*

Primnoids are gorgonian octocorals. They are so called because they have an arborescent skeleton partially comprised of a horny proteinaceous material called gorgonin. They have polyps with eight hollow, marginal and usually pinnate tentacles. Their sclerites are calcareous (Brusca & Brusca, 1990).

A total of 233 valid species belong to Family Primnoidae. These corals usually form large colonies. For example the genus *Primnoa* forms colonies up to 2m high and 7m wide (Cairns & Bayer, 2009).

The living colonies are usually brightly coloured (Figure 1.5). Primnoids occur worldwide at depths of 8m to 5850 m, with very rare occurrences in shallow water (i.e < 8m), although they are a dominantly deep sea family (Cairns & Bayer, 2009). Genus *Primnoa* occurs extensively in the northern boreal Pacific and Atlantic, sub-Antarctic, South Pacific and is very common in waters surrounding the Aleutian islands (Cairns & Bayer, 2005).

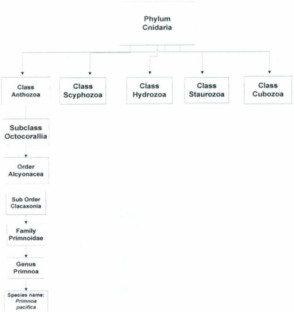



**Figure 1.4: The biological classification of Primnoids. *Primnoa pacifica* is the Primnoid studied herein**

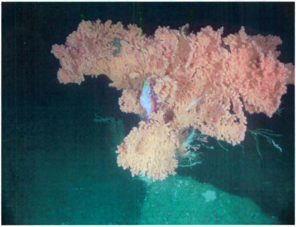


**Figure 1.5: An image of *Primnoa pacifica* obtained by the *ROPOS* during the 2008 cruise in the Dixon Entrance, Northeast Pacific (Depth: 245m)**

### *1.5.2 Growth banding and geochemistry of Primnoids:*

Primnoids are known to have a long lifespan (up to 700 years; (Sherwood et al, 2006)). The skeletal structure of most Primnoids includes calcareous segments usually composed of calcite, which alternate with thin horny intercalary plates (Brusca & Brusca, 1990). These alternations manifest as growth bands in cross sections of the skeleton (Figure 1.6). These growth bands are known to be annual in at least two species: *Primnoa resedaeformis* and *Primnoa pacifica* (Andrews et al, 2002; Sherwood et al, 2005b).

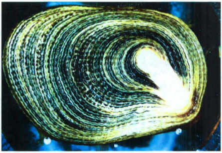


**Figure 1.6: Basal cross-section of *Primnoa pacifica* showing growth banding. The darker growth bands are composed of gorgonin (horny protein). The alternating light segments are calcite.**

An analysis of the $\delta^{18}O$ and Sr/Ca in the skeletal calcite of *Primnoa resedaeformis* has indicated that growth related kinetic effects may have a major impact on these variables (Heikoop et al, 2002). Preliminary studies on *Primnoa resedaeformis,* indicate that skeletal variation in Mg/Ca may be controlled by seawater temperature (Sherwood et al, 2005a).

Their longevity, annual skeletal banding and wide geographic distribution make Primnoids of interest from the standpoint of paleoceanography. Trace element studies of their calcitic skeletons provides a useful initial step in exploring the potential of Primnoid species as paleoceanographic monitors.

### 1.6 Aims and Objectives:

The general aim of this study is to assess the utility of two commonly observed cold water corals in the Northeast Pacific ocean as paleoceanographic archives.

The detailed aims are as follows:

1. To study the skeletal microstructure, growth rate and longevity of *Stylaster campylecus parageus* in order to determine its suitability for paleoclimate reconstructions.
2. To determine an appropriate technique to obtain meaningful geochemical profiles from *Stylaster campylecus parageus* in spite of skeletal remineralization/reorganization observed during its growth.
3. To determine the periodicity of growth banding in the skeleton of *Stylaster campylecus parageus.*
4. To assess the potential paleoceanographic record in *Stylaster campylecus parageus* and *Primnoa pacifica,* available through microanalytical determinations of Sr/Ca, Mg/Ca, Na/Ca and Ba/Ca profiles across the basal cross-sections of these corals and to interpret the effects of physical or biological variables on these trace element profiles. (The physical variables mainly include temperature, salinity and POM flux. The biological variables mainly include the growth rate of the coral.)
5. To compare the growth rate of *Primnoa pacifica* collected from different sites in the Pacific Ocean, and to the documented growth rate of *Primnoa resedaeformis* from the Northwest Atlantic Ocean.

### 1.7: References:

Andrews, A.H., Cordes, E., Heifetz, J., Cailliet, G.M., Coale, K.H., Somerton, D., Munk, K. and Mahoney, M. (2002) Age and growth of a deep sea, habitat-forming octocorallian (*Primnoa* sp.) from the Gulf of Alaska, with radiometric age validation. *Hydrobiologia* **471**: 101-111

Andrus, C.F.T., Romanek, C.S., Sedberry, G.R. (2007) Incremental growth in a deep-sea hydrocoral. *1st Int Sclerochronology Conf*, St. Petersburg, FL, 17–21 July 2007, p 3

Brusca, R.C. & Brusca, G.J. (1990) *Invertebrates*. Sinauer Associates, Sunderland

Cairns, S.D., Macintyre I.G. (1992a) Phylogenetic implications of calcium carbonate mineralogy in the Stylasteridae (Cnidaria:Hydrozoa). *Palaios* **7**: 96–107.

Cairns, S.D. (1992b) Worldwide distribution of the Stylasteridae (Cnidaria: Hydrozoa), *Sci Mar* **56**: 125–130.

Cairns, S.D., Bayer, F.M. (2005) A review of the genus *Primnoa* (Octocorallia: Gorgonacea: Primnoidae), with the description of two new species. *Bull. Mar. Sci.* 77, 225–256.

Cairns, S.D. (2007) Deep-water corals: an overview with special reference to diversity and distribution of deep-water scleractinian corals. *Bull Mar Sci* **81**: 311–322.

Cairns, S.D., Bayer, F.M. (2009). A generic revision and phylogenetic analysis of the Primnoidae (Cnidaria: Octocorallia). *Smithson Contrib Zool* **629**:1–79.

Druffel, E. R. M., Griffin, S., Witter, A., Nelson, E., Southon, J., Kashgarian, M., &Vogel., J.(1995) Gerardia :Bristlecone pine of the deep-sea? *Geochim. Cosmochim. Acta* **59**:5031-5036.

Fisher, W.K. (1938). Hydrocorals of the North Pacific Ocean. *Proceedings of the United States National Museum*, **84** (3024):493-554.

Freiwald, A. , Fosså, J. H. , Grehan, A. , Koslow, T. , Roberts, J. M.( 2004) Cold-Water Coral Reefs Out of sight – no longer out of mind. United Nations Environment Programme–World Conservation Monitoring Centre, Biodiversity series no 22

Gass, S.E., Roberts, J.M. (2006) The occurrence of the cold water coral *Lophelia pertusa* (Scleractinia) on oil and gas platforms in the North sea: colony growth, recruitment and environmental controls on distribution. *Mar Pollut Bull* **52**: 549–559

Guinotte, J.M., Orr, J., Cairns, S., Freiwald, A., Morgan ,L., and George, R. (2006) .Will human induced changes in seawater chemistry alter the distribution of deep-sea scleractinian corals? *Front Ecol Environ*; **4**(3): 141–146

Hall-Spencer, J., Allain, V., J. H. Fossa (2002), Trawling damage to Northeast Atlantic ancient coral reefs, Proc. R. Soc. Lond., Ser. B: *Biol. Sci.*, **269**, 507– 511

Heikoop, J.M., Hickmott, D.D., Risk, M.J., Shearer, C.K., Atudorei, V. (2002) Potential climate signals from the deep-sea gorgonian coral *Primnoa resedaeformis*. *Hydrobiologia* **471**:117-124

Hughes, T. P., Baird, A. H., Bellwood, D. R., Card, M., Connolly, S. R., Folke, C., Grosberg, R., Hoegh-Guldberg, O., Jackson, J. B. C., Kleypas, J., Lough J. M.,, Marshall, P., Nyström, M., Palumbi, S. R., Pandolfi, J. M., Rosen, B., and Roughgarden, J. (2003) Climate change, human impacts, and the resilience of coral reefs. *Science* **301**:929-933

Krieger, K.L., Wing, B.L., (2002) Megafauna associations with deepwater corals (Primnoa spp.) in the Gulf of Alaska. *Hydrobiologia* **471**, 83–90.

Lazier, A.V., Smith, J.E., Risk, M.J., Schwarcz, H.P. (1999) The skeletal structure of *Desmophyllum cristigalli* - the use of deep-water corals in sclerochronology. *Lethaia* **32**: 119-130

Mienis, F. (2008) Environmental constraints on cold-water coral growth and carbonate mound formation. PhD thesis, Vrije Universiteit Den Burg, Amsterdam

Roark, E.B., Guilderson, T.P., Flood-Page, S.R., Dunbar, R.B., Ingram, B.L., Fallon, S.J. and McCulloch, M.T. (2005) Radiocarbon-based ages and growth rates for bamboo corals from the Gulf of Alaska. *Geophys Res Lett* **32**:L04606

Roberts, J.M., Wheeler, A.J. and Freiwald, A. (2006) Reefs of the deep: the biology and geology of cold-water coral ecosystems. *Science* **312**:543–47

Sherwood, O.A., Heikoop, J.M., Sinclair, D.J., Scott, D.B., Risk, M.J., Shearer, C. and Azetsu-Scott, K. (2005a) Skeletal Mg/Ca in *Primnoa resedaeformis*: relationship to temperature. In: Freiwald A, Murray JM (eds) *Cold-water corals and ecosystems.* Springer, Berlin, p 1061–1079

Sherwood, O. A., Scott D. B., Risk, M. J., and Guilderson, T. P. (2005b). Radiocarbon evidence for annual growth rings in the deep-sea octocoral *Primnoa resedaeformis*. *Mar. Ecol. Prog. Ser.* **301**: 120–134.

Sherwood, O.A., Scott, D.B. and Risk M.J. (2006) Late Holocene radiocarbon and aspartic acid racemization dating of deep-sea octocorals. *Geochim Cosmochim Acta* **70**:2806–2814

Sherwood, O.A. and Risk, M.J. (2007) Deep sea corals: New insights into paleoceanography, In: Hillaire Marcel, C, , de Vernal A (eds) *Proxies in Late Cenozoic Paleoceanography*. Amsterdam; London: Elsevier, c.pp 491-522

Sherwood, O.A. and Edinger, E. (2009) Ages and growth rates of some deep-sea gorgonian and anthipatharian corals of Newfoundland and Labrador. *Can J Fish Aquat Sci* **66**: 142–152

Smith, J.E., Risk, M.J., Schwarcz, H.P. and McConnaughey, T.A. (1997) Rapid climate change in the North Atlantic during the Younger Dryas recorded by deep-sea corals. *Nature* **386**, 818 – 820

Smith, J.E, Risk, M.J., Schwarcz, H.P., McConnaughey, T.A. and Keller, N. (2000), Paleotemperatures From Deep-Sea Corals: Overcoming'Vital Effects' *Palaios*, **15**, 25–32

Stanley, G.D., Jr. and Cairns, S.D. (1988) Constructional azooxanthellate coral communities: an overview with implications for the fossil record *Palaios* **3**,233-242.

Thresher, R., Rintoul, S.R., Koslow, J.A., Weidman, C., Adkins, J.F. and Proctor C. (2004) Oceanic evidence of climate change in southern Australia over the last three centuries. *Geophys Res Lett* 31:L07212

Weber, J. N. and Woodhead, P. M. J. (1972) Stable isotope ratio variations in nonscleractinian coelenterate carbonates as a function of temperature. *Mar. Biol.*, **15**, 293-297

Wisshak, M., López Correa, M., Zibrowius, H., Jakobsen, J., and Freiwald, A. (2009): Skeletal reorganisation affects geochemical signals, exemplified in the stylasterid hydrocoral *Errina dabneyi* (Azores Archipelago), *Mar. Ecol.-Prog. Ser.*, **397**, 197–208

Williams, B., Risk M.J., Sulak, K., Ross, S., & Stone, R. (2005) Deep water Antipatharians and Gorgonians: Proxies for biogeochemical processes. *Proceedings of the 3rd International Symposium on Deep- sea corals* (p.70) Miami, USA

**CHAPTER 2: Microanalytical evidence for monthly growth banding and an intact record of sea surface productivity in *Stylaster campylecus parageus.***

**Chapter Status:** For submission to Geochimica et Cosmochimica Acta

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## 2.1 Abstract:

*Stylaster campylecus parageus,* a deep sea Stylasterid, is widely distributed in the Northeast Pacific Ocean (Fisher, 1938; Cairns, 1992a). Live colonies of *Stylaster campylecus parageus* were collected between depths of 250 and 350m, offshore from NW British Columbia, Canada and NW Washington State, USA. SEM imaging on etched basal cross sections revealed that the skeletal material was extensively overprinted with secondary aragonite, particularly nearing the center of the coral. In spite of this observed overprinting, it was possible to obtain profiles of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca from skeletal cross sections of *Stylaster campylecus parageus* using SIMS (Secondary Ion Mass Spectrometry). Detailed SEM images helped recognize individual SIMS spot analyses that contained secondary aragonite. Broader scale SEM imaging revealed the presence of growth bands otherwise not visible in transmitted or reflected light.

Sr/Ca values were observed to display two maxima over distances covering approximately 12 growth bands, with corresponding minima in Mg/Ca and Na/Ca. These cyclical co-variations were interpreted to be primarily influenced by surface water productivity. Based on the cyclicity noted in the Na/Ca, Mg/Ca and Sr/Ca profiles, and the biannual increase in productivity documented in the area of collection (Landry et al, 1989), it was determined that the growth bands are monthly.

An average radial growth rate of $1.4 \pm 0.1$ mm $yr^{-1}$ ($1\sigma$) was obtained based on counting growth bands in the skeletal cross-sections. The axial growth rate calculated was $17.3 \pm 1.1$ mm $yr^{-1}$ ($1\sigma$). The age of the corals, based on the growth banding, varied from 3 to 6 years.

**2.2 Introduction:**

Scleractinian corals, both zooxanthellate and azooxanthellate, have been studied extensively for paleoclimate and paleoceanographic records (Gagan et al, 2000; Sherwood & Risk, 2007; Smith et al, 2000; Dunbar et al, 1994 ). By contrast, Stylasterids (lace corals), have received little attention for their potential as paleoclimate recorders. Stylasterids have an extensive global distribution. They are most commonly found off small 'low' islands, atolls, archipelagos, seamounts, offshore reefs and submarine ridges. They seem rare proximal to continental land masses or 'high' continental islands. Their distribution is reported to follow plate boundaries and is empirically associated with geothermal hot spots beneath the oceanic crust (Cairns, 1992b). They have been reported at latitudes as high as 58°17'N in the North Pacific and 68°30'N in the North Atlantic. Stylasterids have been found in water temperatures varying from -1.5°C to 30° C and at depths varying from 0m to 2103m (Cairns, 1992a).

Most species of Stylasterids have aragonitic skeletons. Only seven species are known to have calcitic skeletons. A few species are also known to have variable percentages of both calcite and aragonite in their skeletal framework. The calcitic species are generally found in areas where the water temperature is below 13°C (Cairns, 1992a).

Growth banding has been documented in some Stylasterids. *Errina dabneyi* was noted to have faint growth increments (Wisshak et al, 2009). *Stylaster erubescens* is reported to show growth increments as well (Andurs et al, 2007). None of these growth bands have been explicitly verified as annual or otherwise.

Their broad geographic and depth distributions, abundance, and wide temperature tolerance makes Stylasterids potentially useful as monitors of oceanographic change. Studies by Weber & Woodhead (1972) indicated that tropical hydrocorals precipitate their skeleton close to equilibrium with sea water. Further, preliminary studies on the stable isotope geochemistry of *Stylaster erubescens* (Andurs et al, 2007) and *Stylaster sp* (Meines et al, 2008) have indicated that these organisms show cyclic variability in their $\delta^{18}O$ and $\delta^{13}C$ profiles, and it has been proposed that this cyclicity might be annual.

The recent study by Wisshak et al, (2009) on examples of the cold water Stylasterid *Errina dabneyi* from the NE Atlantic showed that during the organism's growth, a steady dissolution and reprecipitation of skeletal material occurs in the coral skeleton. This reprecipitation would appear to severely complicate the use of radiocarbon or $^{210}Pb$ dating to estimate the age and growth rate of these corals. The associated skeletal modification also likely alters the stable isotope and/or trace element profiles of these corals, making them potentially less reliable as geochemical archives, depending on the scale of sampling (Wisshak et al, 2009).

In this paper, we study the trace element geochemistry, skeletal organization pattern and growth banding in *Stylaster campylecus parageus* in order to better understand the mechanism of skeletal growth in this coral and to further our understanding of the use of these corals as paleoceanographic archives. The skeletal structure of *Stylaster campylecus parageus* was characterized through SEM imaging of appropriately etched basal cross sections. Detailed geochemical profiles of these same sections were then obtained using SIMS.

## 2.3 Material and Methods:

### *2.3.1 Field collection of specimens:*

Live specimens of *Stylaster campylecus parageus* were collected in July 2008 using the Remotely Operated Vehicle (ROV) *ROPOS* deployed by Canadian Coast Guard Ship *John P. Tully* (Figure 2.1, Table 2.1). These corals were collected as a part of the CHONE (Canadian Healthy Oceans Network) Pacific Coral and Sponge Project. Most of the specimens were collected from Learmonth Bank, Dixon Entrance and from the Olympic Coast National Marine Sanctuary (OCNMS) in the Northeast Pacific Ocean (Figure 2.2). All specimens were collected between depths of 250 and 350m. Only the specimens collected from the OCNMS were used in this study.

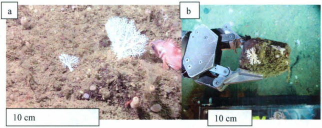



**Fig 2.1: (a) Two live colonies of *Stylaster campylecus parageus* in the Dixon Entrance. (b) A specimen of *Stylaster sp* being collected by the ROPOS in July 2008 from the Dixon Entrance.**

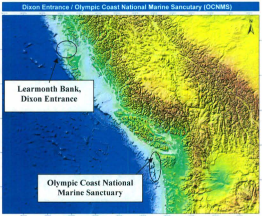



**Fig 2.2: Location of the coral collection sites in the Northeast Pacific.**

| Sample number | Latitude (N) | Longitude (W) | Depth (m) | Date of collection (dd/mm/yyyy) | Distance Offshore (km) |
|---|---|---|---|---|---|
| 232 | 48° 8' 34.8" | -125° 11' 6" | >310 | 13/07/2008 | ~35 |
| 235 | 48° 8' 39.6" | -125° 11' 0.6" | 304 | 13/07/2008 | ~35 |
| 237 | 48 °8' 6" | -125° 11' 1" | 294 | 13/07/2008 | ~35 |
| 238 | 48° 8' 37.4" | -125° 11' 3.7" | 292 | 13/07/2008 | ~35 |
| 241 | 48° 8' 37.2" | -125° 11' 3.6" | 291 | 13/07/2008 | ~35 |

**Table 2.1: Sample locations for *S. campylecus.***

### *2.3.2 X-ray diffraction*:

X-ray diffraction (XRD) was used to ascertain the bulk mineralogy of the skeleton of *Stylaster campylecus parageus*. Three 1 g samples of whole skeleton (from samples 232, 235 and 241) were crushed into a fine powder using a ceramic mortar and pestle. An aliquot of powder from each sample was placed into separate pack mount sample holders for analysis using a Rigaku Ultima 1V XRD instrument. The software JADE with an International Center for Diffraction Data (ICDD) database was used to match the resultant diffraction pattern.

### *2.3.3 Growth band imaging, counting and microstructure analysis:*

In order to assess the presence of growth bands in samples of *Stylaster campylecus parageus,* 2.5-3mm thick radial sections were cut from unbranched regions along the base of the skeleton (Figure 2.3) using a water lubricated thin kerf diamond blade, mounted on a Buehler Isomet low speed saw. These sections were then individually embedded in Buehler Epothin, a two-component epoxide (Resin:Hardener = 10:3.9 by weight). The casts were ground using Buehler CarbiMet2 120-600 grit SiC wet/dry papers and then polished on a Struers TegraPol 31 lapping wheel using Struers 6μm diamond suspension. Following this they were manually polished using 0.5 μm and 0.03 μm Buehler Alpha Micropolish II deagglomerated alumina on Buehler ChemoMet cloth. After polishing, the sections were digitally photographed in transmitted light under a Zeiss Stemi 2000-C stereoscopic microscope (Figure 2.4). The same polished sections were also later used for SIMS analyses.

**Figure 2.3: Sample 235 of *Stylaster campylecus parageus*. The green line indicates the location of an individual basal cross-section.**

In order to reveal the growth bands clearly and to assess the microstructure of the skeleton of *S. campylecus,* the surface of the polished sections embedded in epoxy were etched with 0.1N HCl for 70 minutes. These sections were then carbon coated and imaged using the secondary electron mode of a Quanta 400 Environmental Scanning Electron Microscope equipped with mineral liberation analysis (MLA) software. Several high resolution SEM images of each basal section were collected and detailed composite images were assembled using a function in the MLA software package (Figure 2.5a, 2.6, Appendix B, D). The brightness and contrast of each composite image was then adjusted using Adobe Photoshop CS3 in order to maximize the clarity of the growth bands.

The coral sections were later etched with 0.1N HCl for a longer period of time (>70 minutes), as well as stronger HCl (>0.1N) and similarly imaged with a SEM in order to reveal the presence of more growth features (Figure 2.5b).

The growth bands (as seen on the composite SEM images), were counted by three amateur ring counters. Growth bands were counted along the entire radial axis of each sample, including bands evident in the remineralized center.

### *2.3.4 Trace element analysis:*

Mg/Ca and Sr/Ca in coral skeletons are very commonly used as proxies for sea surface temperatures in reef-forming tropical corals (e.g., Cohen et al, 2006; Mitsuguchi et al, 1996). Although their behaviour during skeletal growth, and their utility as proxies for seawater temperature or chemical variations, has been examined in far less detail in the available literature, Na/Ca and Ba/Ca also vary systematically in many types of marine biomineralization (Boyle 1981; Lea et al, 1989; Lea & Boyle, 1990; Amiel et al, 1973). A Cameca IMS 4f Secondary Ion Mass Spectrometer (SIMS) was used to perform high spatial resolution spot analyses of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca in detailed traverses across the polished basal cross-sections from three specimens of *S. campylecus*.

SIMS transects began at the outermost edge of each basal cross section and ended at its center. The traverses were between 3mm and 13mm long and centers of individual SIMS spots were spaced 25μm apart. The longest transect had 459 SIMS analyses spots while the shortest one had 121 analyses spots. Two parallel sets of SIMS analyses were performed on sample 232.

SIMS analyses utilized bombardment of the samples with primary $^{16}O^-$ ions accelerated through a nominal potential of 10 kV. A primary ion current of 3.0-6.0 nA was critically focused on the sample over a spot diameter of 10-20 μm.

Sputtered secondary ions were accelerated into the mass spectrometer through a nominal potential of 4500 V. Secondary ions were energy filtered using a sample offset voltage of -80 V and an energy window of 60eV to suppress isobaric interferences. Prior to each analysis, the spot was pre-sputtered for 120 s. This was designed to eliminate contamination from the 500Å gold coat and also to penetrate the damaged and homogenized surface layer of the mechanically polished sample. Analytical craters were thus typically < 20μm diameter and <2 μm deep at the completion of each analysis.

Each analysis involved repeated cycles of peak counting on $^{23}Na^+$ (2s), $^{24}Mg^+$ (6 s), $^{42}Ca^+$ (2 s), $^{88}Sr^+$ (4 s), $^{138}Ba^+$ (10 s), as well as counting on a background position (22.67 Da; 1s) to monitor detection noise. A small wait time (0.2 – 0.5 s) was added between each peak switch for magnet settling. For this study, 15 cycles of data were collected over 546 s, for total analysis times of <10 minutes per spot, including pre-sputtering. Typical signal on the $^{42}Ca^{+}$ reference peak was 10,000-25,000 cps.

The Memorial IMS 4f is equipped with a High Speed Counting System (Pulse Count Technology Inc.) that produces dark noise background of less than 0.03 cps (2 counts per minute) when used with an ETP133H discrete dynode electron multiplier. Overall system dead time in pulse-counting mode is 14 ns. This system also produces very low detection limits for the elements studied. The elemental detection limits based only on the uncertainty in correcting for detector dark noise (0.03 cps) are typically 1 $ng.g^{-1}$, 2 $ng.g^{-1}$ for Mg, 2 $ng.g^{-1}$ for Sr and 2 $ng.g^{-1}$ for Ba. The error of individual spot analyses was estimated using the standard error of the mean of n cyclical measurements of each ratio during an analysis (internal precision).

## 2.4 Results:

### *2.4.1 X-ray diffraction*:

The XRD patterns (Appendix A) indicated that the skeleton of *S. campylecus* is composed wholly of aragonite.

### *2.4.2 Microstructure imaging and analysis:*

Initial observation of the polished basal cross-sections with low magnification reflected light microscopy showed only faint growth bands (Fig. 2.4). These growth bands appeared very diffuse and were apparent to different degrees in the specimens pictured in Figure 2.4. Samples 241 and 232 showed more distinct growth bands than the others. However, the composite SEM images obtained on acid etched (0.1N HCl, 70 minutes) samples showed sharp, distinct growth bands (Fig. 2.5a, Fig. 2.6). It was noted that etching the cross-sections in stronger acid (>0.1N HCl), or etching for a longer period of time (>70 min) in 0.1N HCl, made the growth bands less evident in the SEM images; however this process made an anastomosing pattern of growth canals more evident (Fig 2.5b).

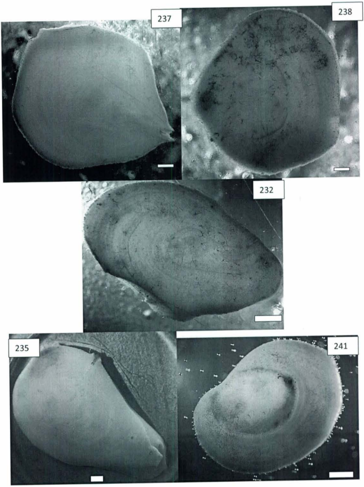



**Figure 2.4: Basal cross sections of *Stylaster campylecus parageus* viewed under reflected light showing faint growth bands. All white scale bars are 1mm long.**

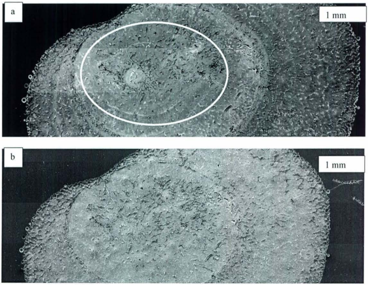
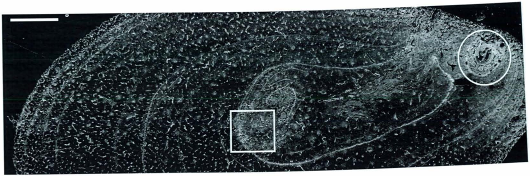



**Figure 2.5 (a) Composite SEM image of the radial cross-section of Coral 241 (etched for 70 minutes in 0.1 N HCl) showing distinct growth banding. Growth banding is visible even in the central region of the cross-section where a dense overprinting of primary growth with secondary aragonite aggregates occurs (circled in white). (b) Composite SEM image of Coral 241 (etched for over 70 minutes). Growth banding is more obscure but the anastomosing pattern of growth canals is more distinct.**

Figure 2.6 : A composite SEM image of the radial cross-seection of specimen 232 of *Stylaster campylecus parageus* showing growth banding in the coral skeleton. This image is a composite of 52 individual high resolution images compiled with MLA software. The white scale bar is 1mm long. The white circle indicates the region where a new branch growth was initiated. It has been noted that this latter region, like the central region of the basal cross-section, is densely overprinted with secondary aragonite aggregates. The white square indicates an area where several growth bands overlap.



Three notable textures were observed with SEM (Fig. 2.7):

(1) Fan shaped arrangements of aragonite needles reflecting primary growth (Fig.2.7a). Growth bands occur where adjacent bundles of fan shaped needles terminate. The growth bands appear to become narrower towards the center of the coral.

(2) Circular and semi-circular aggregates of aragonite that overprint the primary growth (Figs. 2.7 b, c). This texture is pronounced in the central region of the basal section of the coral (Fig.2.5 Fig.2.6), and also observed in regions that surround the initiation of new branch growth (Fig 2.6).

(3) Growth canals that appear as a dense anastomosing network throughout the coral skeleton (Figs. 2.5b, 2.6, 2.7d). These growth canals are wholly or partially in-filled with secondary aragonite.

No textures were revealed, even at this degree of magnification which appear to correspond to centers of calcification for the primary growth of aragonite.

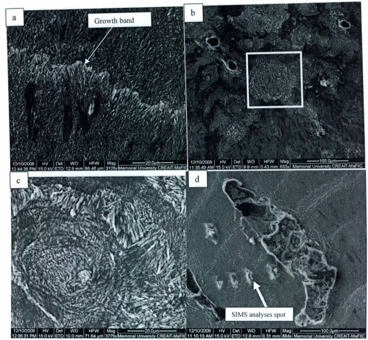



**Figure 2.7: (a) Primary growth. Fan shaped arrangements of aragonite needles, defining individual growth bands. (b) Semi circular aggregates of aragonite that overprint the primary growth, (found mainly towards the center of the skeletal cross-section and in regions of branch initiation). (c) Magnified image of the area indicated by the white square in Figure 5b showing the aggregates of aragonite that overprint the primary growth in the coral skeleton. (d) Partially filled growth canals on the surface of the basal cross section. SIMS analyses spots visible in figure have been modified by subsequent sample etching.**

### *2.4.3 Trace element microanalysis*:

#### *2.4.3.1 Range of trace element values*:

The initial SIMS transects were designed to avoid the obvious infilled growth canals emerging on the surface of each cross section. Nonetheless, in SEM images taken after the SIMS analysis and subsequent etching it was apparent that some SIMS analyses spots were wholly or partially within the texturally distinct overprinted material (Fig. 2.8). These analyses were eliminated from the dataset for primary growth skeleton based on the fact that they were within the secondary aragonite aggregates or the infilled growth canals (Fig. 2.8). In the three specimens analyzed in detail, the Sr/Ca ratios varied between 7.25 and 9.26 $mmol.mol^{-1}$. Mg/Ca ratios between 1.74 and 3.93 $mmol.mol^{-1}$, Ba/Ca ratios between 0.006 and 0.023 $mmol.mol^{-1}$, and Na/Ca ratios between 27.2 and 48.7 $mmol.mol^{-1}$ (Table 2.2). The trace element values of the SIMS analyses corresponding to the secondary aragonite were also well within the range of the trace element values observed in the primary growth.

| Sample number | Sr/Ca ($mmol.mol^{-1}$) | Avg Sr/Ca | Mg/Ca ( $mmol.mol^{-1}$) | Avg Mg/Ca | Ba/Ca ( $mmol.mol^{-1}$) | Avg Ba/Ca | Na/Ca ( $mmol.mol^{-1}$) | Avg Na/Ca |
|---|---|---|---|---|---|---|---|---|
| 232-transect 1 | 7.25-9.00 | 8.40 | 1.74-3.64 | 2.99 | 0.0065-0.0149 | 0.0087 | 33.2-43.6 | 40.5 |
| 232-transect 2 | 7.52-8.73 | 8.32 | 1.89-3.29 | 2.52 | 0.0096-0.0151 | 0.0121 | 27.2-43.3 | 38.0 |
| 235 | 7.80-9.26 | 8.61 | 1.81-3.15 | 2.54 | 0.0082-0.0125 | 0.0101 | 37.5-48.7 | 44.8 |
| 241 | 7.62-8.84 | 8.40 | 2.68-3.93 | 3.35 | 0.0115-0.0230 | 0.0134 | 32.7-46.0 | 44.8 |

**Table 2.2: Summary of maximum ranges in trace element analysis results (Samples 232, 235 & 241).**

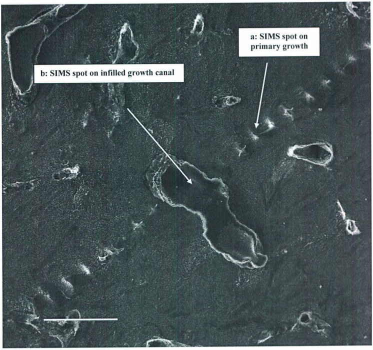



Figure 2.8 a: SIMS spot within primary growth (included in analysis). b: SIMS spot within growth canal (excluded from analysis). The sample was etched after SIMS analysis. The white scale bar is 100μm long.

*2.4.3.2 Relationship between Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca:*

A significant inverse correlation between Mg/Ca and Sr/Ca was noted in all three specimens analyzed. A significant positive correlation was also noted between the Na/Ca and Mg/Ca ratios (Table 2.3). The correlation coefficient (r) in these cases does not yield a perfect 0.99 value, nor is one necessarily expected, due to the large sample size (therefore large degree of freedom, {degree of freedom = sample size-2}). The p values in all samples is below 0.05; which indicates that the 'r' value is statistically significant at the at the 5% level.

| Sample number | R value (Mg/Ca vs Sr/Ca) | R value (Mg/Ca vs Na/Ca) | Degrees of freedom (sample size-2) | P value (Mg/Ca vs Sr/Ca) | P value (Mg/Ca vs Na/Ca) |
|---|---|---|---|---|---|
| 232 transect 1 | -0.28 | 0.61 | 76 | 0.0144 | <0.0001 |
| 232 transect 2 | -0.40 | 0.27 | 136 | <0.0001 | 0.0017 |
| 235 | -0.57 | 0.74 | 126 | <0.0001 | <0.0001 |
| 241 | -0.33 | 0.33 | 39 | 0.0351 | 0.0351 |

**Table 2.3: Correlation coefficients between various elemental ratios.**

When the raw SIMS data are plotted against corresponding growth bands, cyclicity in the trace element profiles is apparent over many intervals. In Figure 2.9, broad cyclicity is apparent from anti-correlation of Mg/Ca and Sr/Ca profiles for growth bands 16 to 24.

Similar broad cyclicity is apparent in Figure 2.10 for growth bands 1 to 14 and 21 to 34. In Figure 2.11 such cyclicity is apparent for bands 41-50.

Thus, in portions of transects where a sufficient density of SIMS spots were available in primary growth skeleton, average (W) values of all spot analyses collected within a given band were obtained. The W values for each ratio were then plotted against corresponding growth bands (Figure 2.13a-d), revealing a much more obvious cyclical inverse correlation between Mg/Ca and Sr/Ca. The grand mean (X) of all analyses in each traverse are also shown as horizontal dotted lines in Figures 13 a-d. Further, graphs of the minima and maxima for Mg/Ca, Sr/Ca and Na/Ca for each band (with respect to the pertinent grand mean) were plotted against the number of growth bands (Figs. 2.14 – 2.16). The anti-correlation between Mg/Ca and Sr/Ca is more apparent in Figs 2.13-2.15 where data has been reduced to a mean trace element value for each band and compared to the sample mean for each trace element value.

In Figure 2.14 and Figure 2.15 it seems that the Na/Ca, Mg/Ca and Sr/Ca display two apparent cycles within a span of approximately 12 bands.

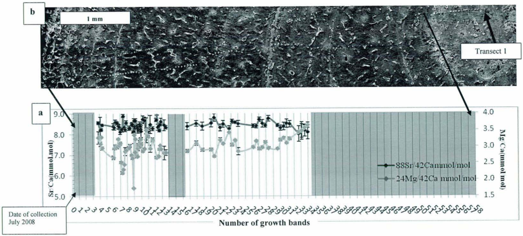



Figure2.9: Sample 232 (Transect 1). a: Sr/Ca (left axis) and Mg/Ca (right axis) *vs.* Number of growth bands for Sample 232 (Transect 1). The x-axis starts at the outermost edge of the coral i.e., the time of collection July -2008.The vertical lines in the graph are representative of the edges of growth bands. The error bars are 1σ.The profile is incomplete because the SIMS spots corresponding to certain growth bands were on remineralized material and were thus eliminated while constructing this profile. The SIMS data is unsmoothed. The grey areas are areas of extensive remineralization. b: A composite SEM image of sample 232 representing the area where the SIMS transect is located.

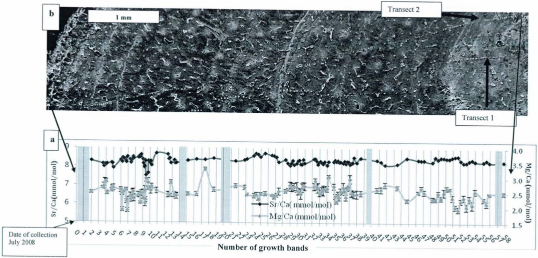



Figure 2.10: Sample 232 (Transect 2) a: Sr/Ca mmol.mol$^{-1}$ (left axis) and Mg/Ca mmol.mol$^{-1}$ (right axis) *vs.* Number of growth bands for Sample 232 Transect 2. The x-axis starts at the outermost edge of the coral i.e the time of collection July -2008. The vertical lines in the graph are representative of the sharp edges of growth bands The error bars are 1σ.The profile is incomplete because the SIMS spots corresponding to certain growth bands were on remineralized material and were thus eliminated while constructing this profile. The SIMS data is unsmoothed. The grey areas are areas of extensive remineralization. b: A composite SEM image of sample 232 representing the area where the SIMS transect is located.

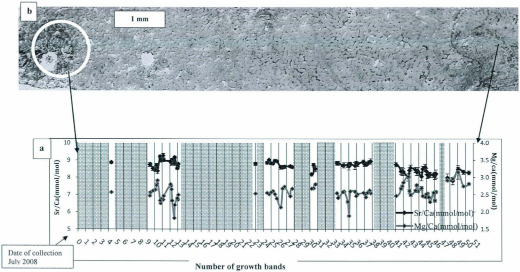



**Figure 2.11: Sample 235: a Sr/Ca mmol.mol$^{-1}$ (left axis) and Mg/Ca mmol.mol$^{-1}$ (right axis) *vs.* number of bands for Sample 235. The x-axis starts at the outermost edge of the coral i.e the time of collection July -2008. The vertical lines in the graph are representative of the sharp edges of growth bands. The error bars are 1σ.The profile is incomplete because the SIMS spots corresponding to certain growth bands were on remineralized material and were thus eliminated while constructing this profile. The SIMS data is unsmoothed. The grey areas are areas of extensive remineralization. b: A composite SEM image of sample 235 representing the area where the SIMS transect is located. The white circle in the figure is an area of extensive remineralization where new branch growth is initiated.**

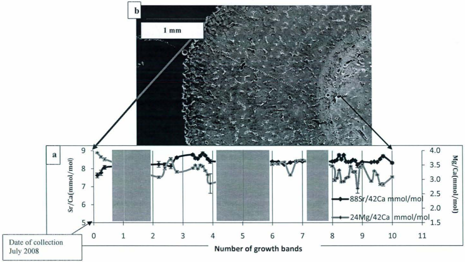



**Figure 2.12: Sample 241. a: Sr/Ca mmol.mol$^{-1}$ (left axis) and Mg/Ca mmol.mol$^{-1}$ (right axis) *vs.* time (months) for Sample 241. The x-axis starts at the outermost edge of the coral i.e the time of collection July -2008. The vertical lines in the graph are representative of the sharp edges of growth bands. The error bars are 1σ.The profile is incomplete because the SIMS spots corresponding to certain months were on remineralized material and were thus eliminated while constructing this profile. The SIMS data is unsmoothed. The grey areas are areas of extensive remineralization. b: A composite SEM image of sample 241 representing the area where the SIMS transect is located.**

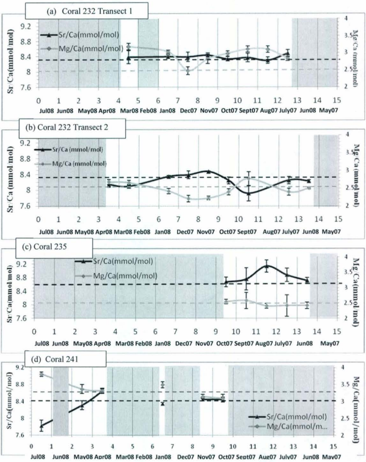



**Figure 2.13: The variation in average Mg/Ca mmol.mol$^{-1}$ (grey-right axis) and average Sr/Ca mmol.mol$^{-1}$ (black-left axis) per band in (a) sample 232 transect 2 (b) sample 232 transect 1 (c)sample 235 (d) sample 241. All the trace element ratios are plotted against growth bands as well as the interpreted time in months starting from July 08 to May 07. Data does not exist for the grey areas due to remineralization. The dotted black lines across the graph are bulk Sr/Ca values for each coral and the dotted grey lines are bulk Mg/Ca values for each coral. All error bars are 1σ.**

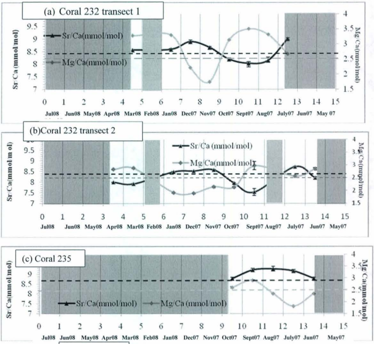



**Figure 2.14: The variation in Mg/Ca mmol.mol$^{-1}$ (grey-right axis) and Sr/Ca mmol.mol$^{-1}$ (black-left axis) ratios in (a) sample 232 transect 2 (b) sample 232 transect 1 (c) sample 241. All the trace element ratios are plotted against number of growth bands as well as the interpreted time in months starting from July 08 to May 07. Data does not exist for the grey areas due to remineralization. The dotted black lines across the graph are bulk Sr/Ca values for each coral and the dotted grey lines are bulk Mg/Ca values for each coral. The error bars are 1 σ.**

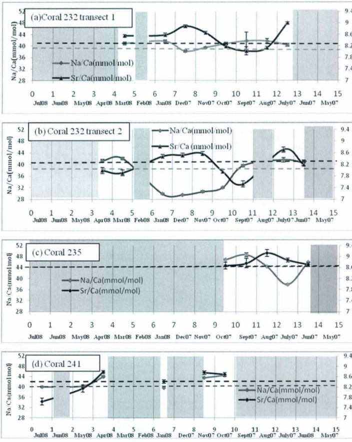



**Figure 2.15: The variation in Na/Ca mmol.mol$^{-1}$ (grey-left axis) and Sr/Ca mmol.mol$^{-1}$ (black-right axis) ratios in (a) sample 232 transect 2 (b) sample 232 transect 1 (c) sample 235, (d) sample 241. All the trace element ratios are plotted against number of growth bands and interpreted time in months starting from July 08 to May 07. Data does not exist for the grey areas due to remineralization. The dotted black lines across the graph are bulk Sr/Ca values for each coral and the dotted grey lines are bulk Na/Ca values for each coral. The error bars are 1 σ.**

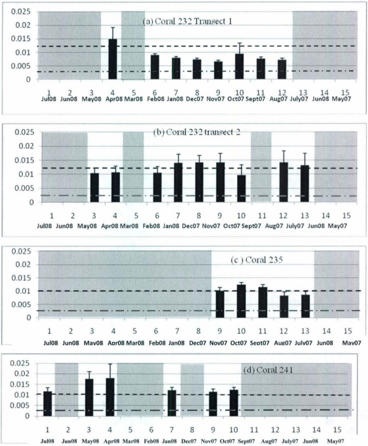



**Figure 2.16: Bar graphs for Ba/Ca ($mmol.mol^{-1}$) vs number of growth bands and interpreted time in months for (a) sample 232 transect 1 (b) sample 232 transect 2 (c) sample 235 (d) sample 241. All the trace element ratios are plotted against time in months starting from July 08 to May 07.Data does not exist for certain months due to remineralization. The dotted black are bulk Ba/Ca values for each transect. The dotted grey lines are Ba/Ca detection limits for the SIMS. The error bars are 1σ**

### *2.4.4 Growth rate analysis (Band counting) and comparative growth rate study:*

It was noted during SEM imaging that growth bands were discernible even in the highly remineralized centers of the cross sections (Figs. 2.5a, 2.6). These are likely remnant aragonite structures that are visible in spite of the extensive overprinting with secondary aragonite. The growth bands observed towards the center of the coral were generally narrower in width than the growth bands observed towards the outer edges (Fig 2.5a, Fig 2.6, Appendix B). Further, the distance between any two growth bands can vary widely depending on radial direction. As in the example in Figure 2.6, two or more growth bands can virtually overlap at certain areas in the cross-section. Sample 235 had the most number of bands (53±15), sample 241 had the least number of bands (35±1) (Table 2.4). The typical counting error was ± 6 rings (1 $\sigma$) on an average of 45 total rings.

Based on monthly growth banding the average age of the samples of *S. campylecus* is 45 months, or approximately 4 years. The lifespan of the oldest sample (235) was 53±9 months (~ 4-5 years). The axial and radial growth rates calculated for all five samples studied are summarized in Figure 2.17, and overlap within the range of error. The average radial growth rate obtained was 1.4 ± 0.1 $mm.yr^{-1}$. The average axial growth rate (i.e., vertical extension) was calculated as 17.3 ±1.1 $mmyr^{-1}$ (Table 2.4).

The observed axial growth rate of *S.campylecus* is comparable to in situ observations of axial growth rates in the deep sea scleractinian corals *Lophelia pertusa* and *Madrepora oculata* (Gass & Roberts, 2006; Orejas et al, 2007). Though the axial growth rate of *S.campylecus* appears to be generally higher than the reported growth rates for other Stylasterids like *Errina Dabneyi* and *Errina novaezelandiae (Chong & Stratford, 2002;*

*Miller et al, 2004; Wisshak et al, 2009)*; it is not the highest reported axial growth rate among Stylasterid corals - a single colony of *Errina novaezelandiae* was reported to have an axial growth rate of 680 $mm.yr^{-1}$ (Miller et al, 2004).

Although no other published data exist for radial growth rates in Stylasterid corals, the radial growth rate of *S. campylecus* appears appreciably higher than published data for other types of deep sea corals (Table 2.5).

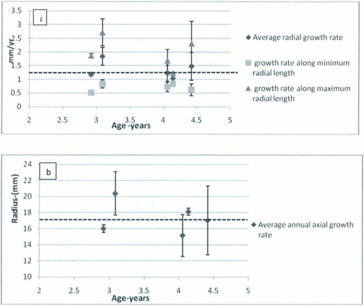



**Figure 2.17 (a) Radial growth rate (mm.yr$^{-1}$) for *S. campylecus* vs. Sample age (in years) (b) Axial growth rate (mm.yr$^{-1}$) *vs.* Sample age (in years) for *S. campylecus*.**

| Sample number | Basal radius (mm) maximum | Basal radius (mm) minimum | Colony height (mm) | No. of bands ($\pm 1\sigma$) | Mean band width (mm) max radius | Mean band width (mm) min radius | Max Band width (mm) | Min Band width (mm) | Age (months) | Radial growth rate ($mm.yr^{-1}$) | Axial growth rate ($mm.yr^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 232 | 6.92 | 2.95 | 60.1 | 49±9 | 0.142 | 0.059 | 0.42 | 0 | 49±9 | 1.2±0.3 | 14.8±1.5 |
| 235 | 10.31 | 2.77 | 71.4 | 53±15 | 0.195 | 0.052 | 0.27 | 0 | 53±15 | 1.5±0.5 | 16.2±2.8 |
| 237 | 8.68 | 2.67 | 66.1 | 37±5 | 0.235 | 0.072 | 0.27 | 0 | 37±5 | 1.8±0.3 | 21.4±1.7 |
| 238 | 5.10 | 3.47 | 74.9 | 50±1 | 0.103 | 0.069 | 0.32 | 0 | 50±1 | 1.04±0.03 | 18.1±0.4 |
| 241 | 5.44 | 1.50 | 46.6 | 35±1 | 0.154 | 0.043 | 0.65 | 0 | 35±1 | 1.2±0.3 | 15.9 ±0.5 |

**Table 2.4: Growth characteristics of *Stylaster campylecus parageus*. All errors are ±1σ.**

| Species name | Radial growth rate ($mm.yr^{-1}$) | Axial growth rate ($mm.yr^{-1}$) |
|---|---|---|
| *S. campylecus* (this study) | 1.4 ± 0.1 | 17.3 ± 1.1 |
| *Errina Dabneyi (Wisshak et al , 2009)* | ----- | 4 - 6 |
| *Errina novaezelandiae (Chong & Stratford, 2002)* | ----- | 3.1±0.6 (calcein tagging method)<br><br>8.0±0.9 (stereo photography method)<br><br>2.7±1.1 (net growth rate) |
| *Errina novaezelandiae (Miller et al, 2004)* | ------ | 7 (net growth rate)<br><br>680 (max growth rate recorded in one colony ) |
| *Lophelia Pertusa (Orejas et al, 2008)* | ----- | 15 - 17 |
| *Madrepora oclulata (Orejas et al, 2008)* | ----- | 3 -18 |
| *Lophelia pertusa (Gass and Roberts, 2006)* | ----- | 26± 5 |
| *Lophelia pertusa (Brooke &Young, 2009)* | --------- | 2.44-3.77 |
| *Primnoa resedaeformis* (Sherwood & Edinger, 2009) | 0.083±0.006 | 26.1±4.5 |
| *Stauropathes arctica* (Sherwood & Edinger, 2009) | 0.075±0.110 | 12.7±3.3 |
| *Keratoisis ornata* (Sherwood & Edinger, 2009) | 0.033±0.011 | 9.3±0.8 |
| *Paramurecia spp* (Sherwood & Edinger, 2009) | 0.215±0.037 | 5.6±0.5 |

**Table 2.5: Summary of published growth rates for modern deep sea corals.**

## 2.5: Discussion:

### *2.5.1 Trace elements:*

#### *2.5.1.1 Primary control on trace element variation in S. campylecus:*

Mg/Ca and Sr/Ca ratios from tropical corals have increasingly been used as proxies for sea surface temperatures (SSTs) (Smith et al., 1979; Mitsuguchi et al, 1996). Preliminary studies on *Primnoa resedaeformis*, a deep sea octocoral, indicate that Mg/Ca variations in the calcite cortex region of this coral are likely controlled by temperature (Sherwood et al, 2005a). Sr/Ca variations in *Lophelia pertusa,* (a shallow dwelling cold water scleractinian) may also be controlled in part by temperature (Cohen et al, 2006). The temperature dependence of Sr/Ca in most reef-forming tropical corals is between -0.08 and -0.10 $mmol.mol^{-1}.^{o}C^{-1}$ (de Villiers et al, 1994; Gaetani & Cohen, 2006). Cold water scleractinian corals like *Lophelia pertusa* have a more extreme Sr/Ca sensitivity: approximately -0.18$mmol.mol^{-1}$ (Cohen et al, 2006). The temperature dependence of Sr/Ca in abiogenic aragonite, however, is only -0.039 $mmol.mol^{-1}.^{o}C^{-1}$ (Cohen et al, 2006).

In contrast to shallow tropical ocean waters, the average annual temperature variation is less than ±1 °C in the ocean floor locations where our samples of *S. campylecus* were collected (Boyer et al, 2009). Although, there are no continuous temperature profiles available of the area of collection at a depth of 300m, the highest temperature recorded through CTD casts, during the last 70 years is 6.9 °C and the lowest is 5.4 °C (Boyer et al, 2009). If the variations of Sr/Ca reported in Table 2.2 were attributed solely to this maximum observed temperature range of 1.5 °C, it would imply a temperature dependence of approximately -2.8 $mmol.mol^{-1}.^{\circ}C^{-1}$, almost thirty times more sensitive than observed in any tropical coral, and fifteen times more than that for the cold water scleractinian *L. pertusa*. It is implicit, therefore, that factors other than temperature likely exert a major control on the variation in Sr/Ca ratios observed in *S. campylecus*.

A significant inverse correlation between Mg/Ca and Sr/Ca was noted in all three specimens of *S. campylecus*. Precipitation experiments carried out to investigate the partitioning of alkaline earth elements ($Mg^{2+}$, $Ca^{2+}$, $Sr^{2+}$ and $Ba^{2+}$) between abiogenic aragonite and sea water (as a function of temperature) indicate that Mg/Ca and Sr/Ca both decrease with increasing temperature and are thus expected to be positively correlated in abiogenic processes (Gaetani & Cohen, 2006).

A twelve month record of Mg/Ca, Sr/Ca and Ba/Ca from the skeleton of *Diploria labyrinthiformis* (a scleractinian zooxanthellate coral collected from Bermuda) showed that Mg/Ca and Sr/Ca ratios were inversely correlated to each other and Mg/Ca was positively correlated to SSTs recorded in the region (Gaetani &Cohen, 2006). In another study, on the cold water coral *Lophelia pertusa,* a similar inverse correlation between Mg/Ca and Sr/Ca was noted (Cohen, 2006). The magnitude of oscillations in both Mg/Ca and Sr/Ca ratios in *D. labyrinthiformis* and *L. pertusa* cannot be explained by the behaviour of abiogenic aragonite in the precipitation experiments described above (Gaetani & Cohen, 2006; Cohen et al, 2006). Calculations performed in the 2006 study by Gaetani and Cohen indicate that, at a constant temperature, when 'precipitation efficiency' increases (i.e. increase in the mass fraction of aragonite precipitated from the calcifying fluid) the Mg/Ca values increase and the Sr/Ca and Ba/Ca values simultaneously decrease. In *L. pertusa* the oscillations in the Sr/Ca ratios could be reproduced by doubling the assumed precipitation efficiency, coupled with the observed temperature dependence of the partition coefficients determined from the abiogenic aragonite (Cohen at al, 2006).

Since a extremely small degree of the variation observed in the Sr/Ca ratios in the *S. campylecus* can be realistically attributed to temperature, the observed changes in Sr/Ca and Mg/Ca (Table 2.2) ratios and their inverse correlation would call for substantial variations in skeletal 'precipitation efficiency' during the growth of the coral.

In biogenic aragonite growth, a change in precipitation efficiency (i.e., mass of aragonite precipitated/growth rate of biogenic aragonite) occurs due to changes in the saturation state of the calcifying fluids. In tropical corals this change in saturation state is linked to zooxanthellate photosynthesis which is, in turn, linked to changes in temperature and sunlight (Cohen & McConnaughey, 2003; Cohen et al, 2006). Since any change in precipitation efficiency would be primarily reflected as a change in the observed growth rate of the coral, factors controlling growth rate are indirectly coupled to the trace element changes observed in *S. campylecus* and similar deep sea corals. Observations of Sr/Ca ratios in *Corallium rubrum* (deep sea coral) indicate that Sr/Ca ratios vary with skeletal density viz. indirectly coupled to growth rate (Weinbauer et al., 2000). It has also been suggested that the cyclicity in Sr/Ca in deep sea bamboo corals can be used as an indicator of growth rate, rather than temperature (Roark et al, 2005).

While no changes in light occur at a depth of ~ 300m (from where *S. campylecus* was collected), and the change in temperature in the area of collection is negligible; the primary factor driving changes in the growth rate would likely be changes in food availability (Miller, 1995; Ferrier-Pages et al, 2003; Houlbreque et al, 2003; Houlbreque et al, 2004; Roark et al, 2005; Weinbauer et al., 2000). We therefore suggest that the changes in Sr/Ca and Mg/Ca in the skeleton of *S.campylecus* are reflective of surface ocean productivity changes.

Even though little is known about the feeding habits of most deep sea corals, it is well established that several corals, including zooxanthellate species, can meet part of their energy requirements by preying on zooplankton, phytoplankton, pico-nanoplankton, dissolved organic matter and particulate organic matter (Tsounis et al, 2010; Ribes et al, 2003; Miller, 1995; Ferrier-Pages, 2003; Houlbrèque et al, 2003; Houlbrèque et al, 2004). Stable isotope analysis of two commonly occurring cold water corals, *Lophelia pertusa* and *Madrepora oculata*, indicated that they might be omnivores and may primarily feed on mesozooplankton (Duineveld et al., 2004; Kiriakoulakis et al, 2005). Stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analysis indicated that *P. resedaeformis* likely feeds on phytodetritus supplemented by mesozooplankton (Sherwood et al, 2008). A previous study on *P. pacifica* suggested that it likely feeds on the same trophic level as *P. resedaeformis* (Sherwood, 2005c). Since cold water corals cannot depend on any symbiotic algae for energy, they likely derive almost all of their nutrition from one or more of the other sources mentioned above.

In controlled laboratory experiments on *Stylophora pistillata* (a zooxanthellate scleractinian coral) it was noted that that an increase in plankton feeding under constant water temperature increased the rate of both skeletal and tissue growth of the coral. This occurred under both light and dark conditions, indicating that feeding has a direct effect on the mass fraction of skeletal material precipitated in the absence of light or temperature changes. (Miller, 1995; Ferrier-Pagès, 2003; Houlbrèque et al, 2003; Houlbrèque et al, 2005). It was also noted that in *Stylophora pistillata* the amount of food ingested was proportional to food density and that the coral never reached a saturation of feeding capacity in the experiments (Ferrier-Pagès, 2003). Growth rates almost equivalent to tropical corals were noted in *Lophelia pertusa* and *Madrepora Oculata* specimens stored in dark conditions in aquaria and fed exclusively with zooplankton - with temperature variation during the experiments controlled to ~±0.5°C (Orejas et al, 2008). Thus, in the absence of light, zooxanthellae, or substantial temperature variations, a change in the feeding of the coral should be the major factor modulating the skeletal precipitation efficiency and, consequently, the trace element values. If the mass fraction of aragonite precipitated increases at a fixed temperature then we would expect to observe a decrease in the Sr/Ca ratios and an increase in the Mg/Ca ratios of the aragonite (Gaetani & Cohen, 2006).

#### *2.5.1.2 Oceanography of the Olympic Coast National Marine Sanctuary*:

The waters of OCNMS, are subject to changes in physical, chemical and biological properties due to the California Current system (CCS) (Hickey et al, 2006). The CCS mainly includes the southward California Current, the wintertime northward Davidson Current, and the northward California Undercurrent (Hickey & Banas, 2003). The California Undercurrent (CUC) is of special interest with respect to our samples because it is very active in the area of collection. It is continuous at depths of about 100-400 m and likely carries larval fish, invertebrates and even phytoplankton seed stock

(Hickey & Banas, 2003). The intensity of the CUC is known to attain its maximum values in late spring and early autumn (Collins et al, 2003), and is the source of much of the nutrient-rich water supplied to the shelf during coastal upwelling (Hickey & Banas, 2003).

The seasonal upwelling (Huyer, 1983) in this area favours a large spring plankton bloom, followed by a smaller autumn plankton pulse (Anderson, 1964; Landry et al, 1989; Thomas & Strub, 2001). Landry et al (1989) have reported an increased concentration in chlorophyll twice a year offshore of Washington State (between 50 to 90 km); one of these episodes occurs between February and April and the other in October. Thomas & Strub (2001) observed that, in the Pacific Northwest, chlorophyll concentrations greater than 2.0 $mg.m^{-3}$ extend further offshore in late spring-summer (May- June) and that a second offshore extension occurs in late summer (September).

#### *2.5.1.3 Expected and observed Trace element variations in S. campylecus based on the oceanography of the region:*

Given that *S. campylecus* likely feeds on the downward flux of particulate organic matter, plankton and similar sources, measured Sr/Ca and Mg/Ca ratios should respond to changes in the skeletal growth brought about by changes in food availability. Studies of the primary production, new production and vertical flux of organic carbon in the eastern Pacific have indicated that production and vertical flux are directly related (Pace et al. 1987; Loubere & Fariduddin, 1999).

The biannual increase in food flux (due to the two plankton blooms noted in the area) is hypothesized to provoke an increase in the growth rate of *S. campylecus* – coupled with a concomitant increase in the precipitation efficiency of the calcifying fluid in the skeleton of *S. campylecus*. This increase in precipitation efficiency should then be reflected as a decrease in Sr/Ca ratios accompanied by an increase in Mg/Ca ratios in the skeleton. The biannual increase in food availability (due to the two plankton blooms per year) should thus theoretically be observed as two complementary cycles per year in detailed Mg/Ca and Sr/Ca profiles – one in late spring-summer (March-June) and another in Sept-Oct each year.

In the trace element profiles in the skeleton (figure 2.15-2.17) it was noted that minima in Sr/Ca occur twice in a distance covering approximately 12 growth bands, with Mg/Ca and Na/Ca showing a complementary behaviour. If the growth bands are interpreted as monthly in creating the time axis for trace element profiles - it becomes evident that in the spring and early fall months (around May and September-October) the trace element profiles show a drop in Sr/Ca with a simultaneous increase in Mg/Ca (Figure 2.14). Na/Ca behaves similarly to Mg/Ca in all samples except coral 241– which has the smallest windows of unremineralized skeleton of the three samples.

Taking into consideration the monthly time axis in Figure 2.14, it is quite apparent that there is a peak in the Mg/Ca ratios accompanied by a dip in the Sr/Ca in Sept 07 in Coral 232 (transect 1 and transect 2). A peak in Mg/Ca is also noted in Sept 07 for Sample 235, however, a simultaneous dip in Sr/Ca is not noted. Data for Sept 07 is missing in sample 241, however the lowest Mg/Ca value is recorded in Nov 07. Thus, it is noted that in the spring and early fall months (~April-May and ~September-October) the trace element profiles show a drop in Sr/Ca values with a simultaneous increase in Mg/Ca. Conversely Mg/Ca values decrease and Sr/Ca values increase in the winter months.

Na/Ca closely tracks the behaviour of Mg/Ca in all samples except coral 241 – which has the smallest windows of unremineralized skeleton of the three samples (Figure 2.15).

Ba/Ca (Figure 2.16a) shows elevated values in April 08 and October 07 in Coral 232 transect 1. It also shows elevated values in coral 235 (Fig. 2.16c) during September and October 07. Such an elevated value in Ba/Ca is also noted in May 08 and April 08 in coral 241 (Figure 2.16 d). Thus, Ba/Ca is elevated in spring and early fall months. This seasonal trend in Ba/Ca, however, is not clearly apparent in Coral 232 transect 2.

Detailed profiles of contemporaneously harvested samples may not match, due to small differences in conditions, growth rates and the difficulty of enumerating every band with perfect accuracy. In future, multi-sample studies of individual colonies or near neighbours might assist in verifying such correlations.

An increase in Ba/Ca is a strong indicator of cold upwelling waters (Lea et al, 1989). The seasonal upwelling in this area that favours the plankton blooms (Landry, 1989) likely causes the elevated values in Ba/Ca observed in *S. campylecus*. All the above factors strongly suggest that the growth banding is likely monthly.

These observations also suggest that the Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca ratios are responding primarily to changes in food availability. The assumption that the growth banding in *S. campylecus* is monthly appears valid based on the fact that the expected changes in Sr/Ca and Mg/Ca due to changes in food availability closely match the observed changes in Sr/Ca and Mg/Ca. However, the current dataset does suffer incompleteness due to remineralization. If the growth bands are assumed instead to be annual then the cyclical patterns in the trace element profiles call for cyclicity in food availability or primary production that must occur twice in approximately 12 years. An inter-annual variation in food flux or primary productivity of this periodicity is not documented in the available literature. If bands are instead some other sub-annual frequency, then there is no logical explanation for this frequency apparent in current literature. Further, it seems unlikely that banding is wholly random, and not driven by some cyclical external force.

In order to further validate this apparent monthly banding, it would be useful to perform similar geochemical analyses on a specimen of Stylaster from an area with a different surface productivity and/ or temperature regime. It would also be useful to perform detailed multi-specimen radial sampling of individual *S.campylecus* colonies from a single location in order to search for matching patterns in growth banding and/or trace element profiles. Timed harvesting experiments, designed in order to determine the exact radial growth rate of the coral, followed by detailed radial sampling and microanalysis could confirm the exact periodicity of the growth bands.

### *2.5.2 Possible mechanism for monthly growth banding in S. campylecus:*

It was noted in a study by Hernandez-Leon et al. (2002) that zooplankton biomass north of the Canary Islands was greatly influenced by lunar illumination.

Zooplankton biomass was noted to be significantly greater during the second quarter of the moon's cycle, and decreased dramatically immediately after the full moon. This implied link between the synodic lunar month (29.53 days) and cyclicity in zooplankton biomass was cited as an explanation for the approximate 30 day periodicity noted in gravitational fluxes in waters south of the Canary Islands (Khirpounoff et al., 1998). Due to the dependence of deep sea coral growth on Particulate Organic Carbon (POC) flux, it is likely that the influence of the synodic lunar month on zooplankton biomass could induce the observed monthly banding in deep sea corals like *S. campylecus*. The dramatic decrease in zooplankton that follows the full moon could provoke sharp banding observed in the SEM images of the corals. Roark et al., 2005 also observed apparent lunar growth banding, in deep sea bamboo corals form the Gulf of Alaska, and invoked the above explanation as well.

***2.5.3 Growth rate:***

Based on the conclusion that the growth bands are monthly, the average axial growth rate for *S. campylecus* is $17.3 \pm 1.1$ mm.yr$^{-1}$. The average radial growth rate obtained was $1.4 \pm 0.1$ mm.yr$^{-1}$.

The axial growth rate of *S.campylecus* reported here is generally higher than the linear growth rates reported for the two species of Stylasterids previously documented (Table 2.5). Further, there is no evidence that *S. campylecus* has an unusually fast growing juvenile stage. As described above, initial growth banding (nearing the center of the skeletal cross-section) is, in fact, generally narrower than subsequent banding in the samples studied.

The highest reported growth rate for a Stylasterid is reported by Miller et al, 2004. They reported an annual axial growth rate of 680 mm for one of the specimens of *Errina novaezelandiae* studied However, they reported a net growth rate of 7 $mm.yr^{-1}$ for this species in general.

*S.camplylecus* specimens used in this study are from the Olympic Coast National Marine sanctuary, which lies in the California Current System. The California current system is one of the most productive ecosystems in the world (Carr, 2002). Since the growth of most deep sea corals is dependent on POM flux, it is likely that the relative higher productivity in the NE Pacific is likely the dominant cause of the higher growth rates observed in *S.campylecus*. The observed faster growth rate is also consistent with the common observation that Stylasterids are one of the first species observed (in ROV videos) to recolonize an area after bottom trawling activities have ceased (Althaus et al, 2009; Williams et al, 2010). If banding were annual, the implied axial growth rate would be only 1.4 $mm.yr^{-1}$, which would make it extremely difficult to notice a Stylasterid only a few years by remote sensing.

### *2.5.4 Implications of observed SEM textures*:

The overprinting of primary growth with circular and semi-circular aggregates of secondary aragonite, combined with the infilling of the network of growth canals with secondary aragonite, militates against using traditional radiometric dating methods on *S. campylecus*. The nature of remineralization in *S.campylecus* is also distinct in some ways from that observed in *Errina Dabneyi*. In *Errina Dabneyi* the central core was not densely overprinted with secondary aggregates of aragonite (Wisshak et al, 2009) - unlike *S.campylecus*. Due to this dense overprinting with secondary aragonite at the center of the *S.campylecus* skeleton, it would appear impossible to obtain even a minimum age of the coral by radiometric dating of the skeletal core.

The widespread presence of reprecipitated material also severely complicates the use of traditional mechanical microdrilling methods in studying the geochemistry of this coral. In order for the geochemical data from *S. campylecus* to be potentially useful for paleoceanographic purposes one is compelled to use microanalytical techniques that allow targeted analysis of primary skeletal growth.

Since reprecipitated carbonate is also biologically mediated by the organism, the trace element values of this non-primary material did not show a distinct signature (i.e., depletion or enrichment beyond the normal range of primary skeleton) and only textural criteria, as observed in the SEM images, could be used to distinguish between primary and secondary growth.

### *2.5.5 Implications of Stylaster mineralization for choice of analysis methods:*

The unusual biomineralization pattern of Stylaster, in which the skeleton is reprecipitated as secondary aragonite aggregates, clustered most commonly at the centre of the coral skeleton, makes it more difficult to obtain paleoceanographic records. Our approach, of combined SEM imaging and SIMS microanalysis, was able to provide useful geochemical data from the skeleton along a growth transect where more traditional sampling methods would have had insufficient spatial resolution. For this reason, microdrilling or LA-ICP-MS would be expected to yield geochemical results of equivocal paleoceanographic significance in *Stylaster campylecus parageus*. The average volume consumed by microdrilling is anywhere from 50 μg to 6 mg, and the diameter of the drilled hole will be at least 0.2mm. Thus, the probability of including the secondary reprecipitated material is extremely high. Even with LA-ICP-MS the analyses spot would typically be at least 50 μm in diameter and would use 1μg of material, based on a crater depth of 5 μm (e.g., Fallon et al, 1999). However, SIMS is capable of producing an analysis spot that is just 10 μm in diameter and 5μm deep, requiring less than 10 ng of material for the analyses (Layne & Cohen, 2002). The high spatial resolution of the SIMS is thus effective in obtaining meaningful geochemical profiles from *S. campylecus*.

### 2.6 Conclusions:

Since *Stylaster campylecus parageus* appears to remineralize its skeleton as it grows, it creates unique challenges in obtaining meaningful geochemical data. In particular, the remineralization precludes validating the age or growth rate of the coral through traditional radiometric methods. However, using SEM and SIMS it is possible to obtain useful trace element profiles from these corals. The Na/Ca Mg/Ca, Sr/Ca and Ba/Ca profiles of modern *S. campylecus* appear to be strongly controlled by surface water productivity – reflecting twice annual planktonic blooms in overlying surface waters This study indicates that growth bands in *Stylaster campylecus parageus* are monthly, based on this seasonal cyclicity in the Sr/Ca and Mg/Ca profiles - with obvious implications for the interpretation of growth rates.

Stylaster specimens up to 10 cm high had apparent ages of 5 years or less. The average axial growth rates of the samples studied was $17.3 \pm 1.1$ mm.yr$^{-1}$ and the average radial growth rate was $1.4 \pm 0.1$ mm.yr$^{-1}$. The radial growth rate of *S. campylecus* is much higher than those published for other deep sea corals. However, this higher growth rate is empirically validated by the fact that Stylasterids are one of the earliest recolonizing species observed after an area has been bottom trawled. The identification of monthly periodicity in the growth banding of *S. campylecus* is especially valuable because it provides a means to establish age and longevity for a species which cannot be dated through traditional radiometric methods.

In order to confirm the monthly periodicity of the growth bands it would be useful to perform similar geochemical analyses on specimens of Stylaster from an area with a different surface productivity and/ or temperature regime. It would also be useful to perform more detailed radial sampling of individual *S.campylecus* colonies from a single location in order to search for matching patterns in growth banding and/or trace element profiles. Timed harvesting experiments designed to determine the exact radial growth rate of the coral, followed by detailed radial sampling and microanalysis would help confirm the periodicity of the growth bands.

**2.7 References:**

Althaus, F., Williams, A., Schlacher, T.A., Kloser R.J., Green, M.A., Barker, B.A., Bax, N.J., Brodie P., and Schlacher-Hoenlinger, M.A. (2009) Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. *Mar. Ecol. Prog. Ser*, **397**, ,279–294.

Amiel, A. J., Friedman G. M., and Miller, D. S. (1973) "Distribution and nature of incorporation of trace elements in modern aragonitic corals*," *Sedimentology* **20**, no. 1: 47-64.

Anderson, G. C. (1964) The seasonal and geographic distribution of primary productivity off the Washington and Oregon coasts. *Limnol Oceanogr*, **9**, 284-302.

Andrus, C.F.T., Romanek, C.S. and Sedberry, G.R. (2007) Incremental growth in a deep-sea hydrocoral. *1st Int Sclerochronology Conf, St. Petersburg*, FL, 17–21 July 2007, p 3 (Abstract)

Boyer, T.P., Antonov , J. I. Baranova, O. K., Garcia, H. E., Johnson, D. R., Locarnini, R. A., Mishonov, A. V., Seidov, D., Smolyar, I. V., and Zweng, M. M. (2009): World Ocean Database 2009, Chapter 1: Introduction, *NOAA Atlas NESDIS 66*, Ed. S. Levitus, U.S. Gov. Printing Office, Wash., D.C. , 216 pp., DVD

Boyle, E. A., (1981) "Cadmium, zinc, copper, and barium in foraminifera tests," *Earth. Planet. Sci. Lett.* **53**, no. 1: 11-35.

Brooke, S. and Young, C.M. (2009) *In situ* measurement of survival and growth of *Lophelia pertusa* in the northern Gulf of Mexico. *Mar. Ecol. Prog. Ser.* **397**:153-161

Bograd, S. J., and Lynn, R. J. (2003). Anomalous Subarctic influence in the southern California Current during 2002. *Geophys. Res. Lett.* **30** (15):8020.

Cairns, S.D., Macintyre, I.G. (1992a). Phylogenetic implications of calcium carbonate mineralogy in the Stylasteridae (Cnidaria:Hydrozoa). *Palaios* **7:** 96–107.

Cairns, S.D., (1992b). Worldwide distribution of the Stylasteridae (Cnidaria: Hydrozoa), *Scientia Marina* **56**: 125–130.

Cairns, S.D. and Bayer F.M. (2009). A generic revision and phylogenetic analysis of the Primnoidae (Cnidaria: Octocorallia). *Smithson Contrib Zool* **629**:1–79.

Carr, M.-E. (2002). Estimation of potential productivity in Eastern Boundary Currents using remote sensing, *Deep Sea Res.*, Part II, **49**, 59– 80.

Chong, A.K., Stratford, P. (2002) Underwater digital stereoobservations technique for red hydrocoral study. *Photogramm Eng Remote Sens* **68**:745–751

Cohen.A., McConnaughey, T. (2003) Geochemical perspectives on coral mineralization. *Rev Mineral Geochem* **54**:151-187

Cohen, A.L., Gaetani, G.A., Lundalv, T., Corliss, B.H., George, R.Y. (2006). Compositional variability in a cold-water scleractinian, *Lophelia pertusa*: new insights into "vital effects". *Geochem. Geophys. Geosyst. 7*, Q12004

Collins, C. A., L. M. Ivanov, and O. V. Melnichenko (2003), Seasonal Variability of the California Undercurrent: Statistical Analysis based on the Trajectories of Floats with Neutral Buoyancy, *Phys. Oceanogr.*, **13**(3), 135–147.

de Villiers, S., Shen, G.T., Nelson, B.K., (1994). The Sr/Ca-temperature relationship in coralline aragonite: influence of variability in (Sr/ Ca)seawater and skeletal growth parameters. *Geochim. Cosmochim. Acta* **58** (1), 197–208.

Duineveld, G.C.A., Lavaleye, M.S.S., Berghuis E.M. (2004) Particle flux and food supply to a seamount cold-water coral community (Galicia Bank, NW Spain). *Mar Ecol Prog Ser* **277**:13–23

Dunbar, R. B., Wellington, G. M., Colgan, M. W. and Glynn P. W.(1994), Eastern Pacific sea surface temperature since 1600 A.D.: The $\delta^{18}$ O record of climate variability in Galapagos corals, *Paleoceanography*, **9**, 291–315

Fallon, S. J., McCulloch, M. T., van Woesik, R., and Sinclair, D. J. (1999) Corals at their latitudinal limits: laser ablation trace element systematic in *Porites* from Shirigai Bay, Japan. *Earth Planet. Sci. Lett.* **172**, 221–238.

Ferrier-Pagès, C., Witting, J., Tambutté, E., Sebens, K.P. (2003) Effects of natural zooplankton feeding on the tissue and skeletal growth of the scleractinian coral *Stylophora pistillata*. *Coral Reefs* **22**:229–240

Fisher, W.K. (1938). Hydrocorals of the North Pacific Ocean. *Proceedings of the United States National Museum*, **84** (3024):493-554.

Gaetani, G. A., and A. L. Cohen (2006), Element partitioning during precipitation of aragonite from seawater: A framework for understanding paleoproxies, *Geochim. Cosmochim. Acta,* **70**, 4617–463

Gagan, M.K., Ayliffe, L.K., Beck, J.W., Cole, J.E., Druffel, E.R.M., Dunbar, R.B., Schrag, D.P. (2000) New views of tropical paleoclimates from corals. *Quat Sci Rev* 19:45–64

Gass, S.E., Roberts, J.M. (2006) The occurrence of the cold water coral *Lophelia pertusa* (Scleractinia) on oil and gas platforms in the North sea: colony growth, recruitment and environmental controls on distribution. *Mar Pollut Bull* **52**: 549–559

Hernandez-Leon, S., Almeida, C., Yebra, L., Aristegui, J. (2002), Lunar cycle of zooplankton biomass in subtropical water: Biogeochemical implications, *J. Plankton Res.*, **24,** 935– 939.

Hickey, B.M., Banas, N.S., (2003). Oceanography of the Pacific Northwest coastal ocean and estuaries with application to coastal ecosystems. *Estuaries* **26** (48), 1010–1031.

Hickey, B., MacFadyen, A., Cochlan, W., Kudela, R., Bruland, K. and Trick, C. (2006), Evolution of chemical, biological, and physical water properties in the northern California Current in 2005: Remote or local wind forcing?, *Geophys. Res. Lett.*, **33,** L22S02, doi:10.1029/2006GL026782.

Houlbrèque, F., Tambutté, E. and Ferrier-Pagès, C. (2003). Effect of zooplankton availability on the rates of photosynthesis, tissue and skeletal growth of the scleractinian coral *Stylophora pistillata J. Exp. Mar. Biol. Ecol.* **296**, 145-166.

Houlbrèque, F., Tambutté, E., Allemand, D., Ferrier-Pagès, C. (2005) Interactions between zooplankton feeding, photosynthesis and skeletal growth in the scleractinian coral *Stylophora pistillata*. *J Exp Biol* **207**:1461–146

Huyer, A. (1983) Coastal Upwelling in the California Current System. *Prog. Oceanogr.* **12**:3 259-284

Khripounoff, A., Vangriesheim, A. and Crassous, P. (1998) Vertical and temporal variations of particle fluxes in the deep tropical Atlantic. *Deep-Sea Res*. I, **45**, 193–216.

Kiriakoulakis, K., Fisher, E., WolV, G.A., Freiwald, A., Grehan, A. and Roberts JM (2005) Lipids and nitrogen isotopes of two deep-water corals from the North-East Atlantic: initial results and implications for their nutrition. In: Freiwald A, Roberts JM (eds) *Cold-water corals and ecosystems*. Springer, Berlin, pp 715–729

Landry, M.R., Postel, J.R., Peterson, W.K., Newman, J., (1989). Broad-scale distribution patterns of hydrographic variables on the Washington Oregon shelf. In: Landry, M.R., Hickey, B.M. (Eds.), *Coastal Oceanography of Washington and Oregon*. Elsevier, Amsterdam (Chapter 1).

Layne, G.D. and Cohen, A.L.( 2002) Advantages of Secondary Ion Mass Spectrometry for trace element studies of marine biomineralization, *Geochim. Cosmochim. Acta*, **66**, A436 (abstr.)

Lea, D.W., Shen G.T., Boyle E.A., (1989) "Coralline barium records temporal variability in equatorial Pacific upwelling," *Nature* **340**, no. 6232 : 373-376.

Lea, D.W., and Boyle,E.A. (1990) Foraminiferal reconstruction of barium distributions in water masses of the glacial oceans, *Paleoceanography* **5** : 719–742.

Loubere, P., Fariduddin, M., (1999) Quantitative estimation of global patterns of surface ocean biological productivity and its seasonal variation on timescales from centuries to millennia. *Global Biogeochem. Cycles* **13**,115^133.

Mienis, F. (2008) Environmental constraints on cold-water coral growth and carbonate mound formation. PhD thesis, Vrije Universiteit Den Burg, Amsterdam

Miller, KJ., Mundy, C.N., Chadderton, W.L. (2004) Ecological and genetic evidence of the vulnerability of the shallow-water populations of the stylasterid hydrocoral *Errina novaezelandiae* in New Zealand's fjords. *Aquat Conserv* **14**:75–94

Orejas, C., Gori, A., and Gili, J. M.(2008) Growth rates of live *Lophelia pertusa* and *Madrepora oculata* from the Mediterranean Sea maintained in aquaria, *Coral Reefs*, **27**, 255

Pace, M. L., 'Knauer, G. A., Karl D. M., and Martin, J. H. (1987) Primary production, new production, and vertical flux in the eastern Pacific Ocean. *Nature,* **325**, 803-804.

Miller, M. W (1995) Growth of a temperate coral: effects of temperature, light, depth, and heterotrophy. *Mar Ecol Progr Ser* **122**:217-225.

Mitsuguchi, T., Matsumoto, E., Abe, O., Uchida, T., Isdale, P.J. (1996) Mg/Ca thermometry in coral skeletons. *Science* **274**, 961-963

Orejas, C., Gori, A., and Gili, J. M. (2008): Growth rates of live *Lophelia pertusa* and *Madrepora oculata* from the Mediterranean Sea maintained in aquaria, *Coral Reefs*, 27, p. 255

Ribes, M., Coma, R.,and Gili, J. M. (1999) Heterogenus feeding n benthic suspension feeders : The natural diet and feeding rate of the temperate gorgonian *Paramuricea clavata* (Cnidaria:Octocorallia) over a year cycle . *Mar Ecol Prog Ser,*183,125-137

Ribes, M., Coma, R., and Rossi, S. (2003) Natural feeding of the temperate asymbiotic octocoral gorgonian *Leptogorgia sarmentosa* (Cnidaria:Octocorallia). *Mar Ecol Prog Ser* 254,141-15

Roark, E.B., Guilderson, T.P., Flood-Page, S.R., Dunbar, R.B., Ingram, B.L., Fallon, S.J. and McCulloch, M.T. (2005) Radiocarbon-based ages and growth rates for bamboo corals from the Gulf of Alaska. *Geophys Res Lett* **32**:L04606

Sherwood, O.A., Heikoop, J.M., Sinclair, D.J., Scott, D.B., Risk, M.J., Shearer, C. and Azetsu-Scott, K. (2005a) Skeletal Mg/Ca in *Primnoa resedaeformis*: relationship to temperature. In: Freiwald A, Murray JM (eds) *Cold-water corals and ecosystems*. Springer, Berlin, p 1061–1079

Sherwood, O.A., Heikoop, J.M., Scott, D.B., Risk, M.J., Guilderson, T.P. and McKinney, R.A. (2005b) Stable istopic composition of deep sea gorgonian corals *Primnoa* spp.: a new archive of surface processes. *Mar Ecol Prog Ser* **301**:135–148

Sherwood, O.A., Heikoop, J.M., Scott, D.B., Risk, M.J., Guilderson, T.P. and McKinney, R.A. (2005c) Stable istopic composition of deep sea gorgonian corals *Primnoa* spp.: a new archive of surface processes. *Mar Ecol Prog Ser* **301**:135–148

Sherwood, O.A., Scott, D.B. and Risk, M.J. (2006) Late Holocene radiocarbon and aspartic acid racemization dating of deep-sea octocorals. *Geochim Cosmochim Acta* **70**:2806–2814

Sherwood O.A., Jamieson, R.E., Edinger, E.N. and Wareham, V.E. (2008) Stable C and N isotopic composition of cold-water corals from the Newfoundland and Labrador continental slope: examination of trophic, depth and spatial effects. *Deep-Sea Res I* **55**:1392–1402

Sherwood, O.A. and Edinger E. (2009) Ages and growth rates of some deep-sea gorgonian and anthipatharian corals of Newfoundland and Labrador. *Can J Fish Aquat Sci* **66**: 142–152

Smith, S.V., Buddemeier, R.W., Redalje, R.C., Houck, J.E., (1979). Strontium-calcium thermometry in coral skeletons. *Science* **204** (4391), 404–407.

Smith, J.E, Risk, M.J., Schwarcz, H.P., McConnaughey, T.A. and Keller, N. (2000), Paleotemperatures From Deep-Sea Corals: Overcoming'Vital Effects' *Palaios*, **15**, 25–32

Tsounis, G., Orejas, C., Reynaud, S., Gili, J.M., Allemand, D. and Ferrier-Pagès, C. (2010) Prey-capture rates in four Mediterranean cold water corals. *Mar Ecol Prog Ser* **398**:149-155

Thomas, A. C., and Strub, P. T. (2001) Cross-shelf phytoplankton pigment variability in the California Current, *Cont. Shelf Res.*, **21**, 1157–1190.

Thomas, A. C., Strub, P. T. and Brickley, P. (2003), Anomalous satellite measured chlorophyll concentrations in the northern California Current in 2001 – 2002, *Geophys. Res. Lett.*, **30**(15), 8022

Weber, J. N. & Woodhead, P. M. J. (1972) Stable isotope ratio variations in nonscleractinian coelenterate carbonates as a function of temperature. *Mar. Biol.*, **15**, 293-297

Weinbauer, M. G., Brandstatter, F. and Velimirov, B. (2000), On the potential use of magnesium and strontium concentrations as ecological indicators in the calcite skeleton of the red coral (Corallium rubrum), *Mar. Biol.*, **137**, 801–809.

Wheeler, P. A., Huyer, A. and Fleischbein, J. (2003), Cold halocline, increased nutrients, and higher chlorophyll off Oregon in 2002, *Geophys. Res. Lett.*, **30**(15), 8021

Wisshak, M., L´opez Correa, M., Zibrowius, H., Jakobsen, J., and Freiwald, A.: Skeletal reorganisation affects geochemical signals, exemplified in the stylasterid hydrocoral *Errina dabneyi* (Azores Archipelago), *Mar. Ecol.-Prog. Ser.*, **397**, 197–208, 2009

Williams, A., Schlacher T.A., Rowden, A.A., Althaus, F., Clark, M.R., Bowden, D.A., Stewart R., Bax, N.J., Consalvey, M. and Kloser, R.J. (2010) Seamount megabenthic assemblages fail to recover from trawling impacts. *Mar Ecol*, **31**(Suppl. 1), 183–199.

**CHAPTER 3: Growth rate assessment, high resolution trace element microanalysis and potential paleoclimate proxies in *Primnoa pacifica*.**

**Chapter Status: For submission to Deep Sea Research**

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### 3.1 Abstract:

*Primnoa pacifica* is one of the most commonly observed habitat-forming deep sea corals in the Northeast Pacific Ocean (Edinger et al, 2008). Similar species of Primnoids in the North Atlantic have shown some promise as paleotemperature archives (Sherwood et al, 2005a). During the 2008 Canadian Healthy Oceans Network cruise to NW British Columbia, Canada and NW Washington State, USA several dead specimens of dead *Primnoa pacifica* were collected for the purpose of assessing their growth rate, longevity and their possible utility as paleoceanographic archives. Our study indicates that the Mg/Ca and Sr/Ca ratios in the calcite cortex region of the skeleton of *Primnoa pacifica* are likely modulated by surface-water productivity changes. One of the specimens of *Primnoa pacifica* analyzed shows extensive evidence of possible taphonomic alteration in its trace element chemistry after death, likely due to early stage

diagenesis. Thus, trace element microanalysis is also valuable in recognizing incipiently fossilized specimens of *Primnoa pacifica* that should not be used for paleoclimate reconstructions.

The radial growth rate of *P.pacifica* was assessed by counting growth bands in the skeletal cross sections, as this species is known to secrete annual growth bands (Andrews et al, 2002). Banding in the calcite cortex (calcitic part of skeleton) indicates a very similar growth rate to that calculated in the gorgonin/calcite mixed zone, despite the implied change in skeletal growth mode. The annual average radial growth rate for the specimens of *Primnoa pacifica* studied varies between 0.23 and 0.58 $mm.yr^{-1}$. These growth rates are more than four times higher than recorded growth rates for a closely related species (*Primnoa resedaeformis*) from the Hudson strait and Northeast channel in the North Atlantic. This higher growth rate can be attributed to the relatively higher productivity in the Northeast Pacific Ocean (Thomas et al, 2003b; Jones & Anderson 1994; Carr, 2002). The growth rates for *P. pacifica* reported in this study support previous studies in this region (Andrews et al, 2002), indicating that these corals are slow to recover from potential damage due to trawling and other disturbances.

**3.2 Introduction:**

*Primnoa pacifica*, like its Atlantic counterpart *Primnoa resedaeformis*, is a gorgonian coral with a skeleton composed of three distinct growth zones. It has an inner central rod, a middle zone composed of both calcite and gorgonin, and an outer zone, the calcite cortex, which contains very little gorgonin (Sherwood et al, 2005b; Figure 3.1).

Smaller colonies only display two growth zones - the calcite cortex being absent. The growth bands can be clearly seen as intercalations of calcite and gorgonin in the second growth zone. More diffuse growth bands can also be recognized in the calcite cortex. These growth bands are known to be annual in *Primnoa pacifica* (Andrews et al, 2002) as well as in *Primnoa resedaeformis* (a closely related species) based on radiometric dating (Sherwood, 2005b). Primnoids are known to have long life spans (up to 700 yrs; Sherwood et al, 2006). Recent analysis of $\delta^{18}O$ and Sr/Ca in the skeleton (calcite) of *Primnoa resedaeformis* has suggested that growth related kinetic effects might have a major impact on these variables (Heikoop et al, 2002). Preliminary studies on *Primnoa resedaeformis* indicate that the variation in Mg/Ca in its skeleton may be controlled by temperature (Sherwood et al, 2005b).

Their longevity, annual skeletal banding and wide geographic distribution makes Primnoids potentially interesting from the standpoint of paleoceanography. The purpose of this paper is to assess the paleoceanographic significance of *Primnoa pacifica* by studying the trace element (Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca) variation in the calcitic portion of the skeleton (cortex) coupled with an assessment of its growth rate and longevity. The regional variation in the growth rate of *P.pacifica* and *P.resedaeformis* is also studied herein. Since *P. pacifica* is known to be a habitat forming deep sea coral (Andrews et al, 2002); an accurate determination of its growth rate is extremely important in order to gauge habitat recovery time after damage occurs due to deep sea trawling and similar disturbances.

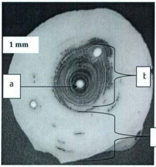



**Figure 3.1: The three growth zones in *Primnoa pacifica* (a) central rod (b) middle zone of alternating calcite and gorgonin (c) calcite cortex. UV light microscopy. Sample # R1165-002**

## 3.3 Materials and Methods:

### *3.3.1 Field collection of specimens:*

Several dead colonies of *Primnoa pacifica* were collected in July 2008 from Dixon Entrance and the Olympic Coast National Marine Sanctuary (OCNMS) using the Remotely Operated Vehicle (ROV) *ROPOS* deployed from the Canadian Coast Guard ship *John P. Tully* (Table 3.1 Figs. 3.2 & 3.3). The specimens were collected from a depth of approximately 300m and were frozen immediately after collection to prevent further degradation (Figure 3.3B). These corals were collected as a part of the Canadian Healthy Oceans Network (CHONE) Pacific Coral and Sponge Project.

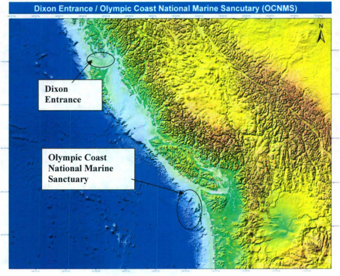



Figure 3.2: Coral collection sites in the Northeast Pacific

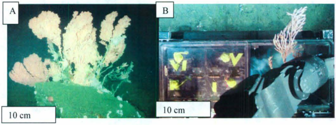



**Figure3. 3(A): A living colony of *Primnoa pacifica*. This picture was obtained by the *ROPOS* from the Dixon Entrance area. (B) The *ROPOS* collecting a dead colony of *Primnoa pacifica* from the Dixon Entrance area.**

### *3.3.2 Radiocarbon dating:*

Three colonies of *P. pacifica* were chosen for radiocarbon dating (Figure 3.4). These colonies were chosen for their relatively large calcite cortex region and macroscopically non-degraded skeletons- features that would permit detailed SIMS analysis of the calcite cortex along with corresponding $^{14}C$ dating of the gorgonin rings. All three colonies selected for $^{14}$ C dating were from the OCNMS, Washington State, USA. The colonies were dead when collected, and had almost no soft tissue on their outer surface. However, based on their relatively non-degraded appearance it was initially assumed that the colonies had died recently (within the last 10 years) (Fig. 3.4). Thus, it was expected that the colonies would record the radiocarbon bomb spike that occurred between 1958 and the early 1970s. Basal cross-sections of the three colonies were cut using a rock saw. Up to seven gorgonin rings were isolated from each cut sample using the method described by Sherwood et al (2005b) (Fig. 3.4). Each isolated gorgonin ring was packaged separately and then $^{14}C$ dated at the Center for Accelerator Mass Spectrometry at Lawrence Livermore National Laboratory, California. The quoted radiocarbon age in Table 3.2 is in radiocarbon years using the Libby half life (5568 years) and following the conventions of Stuiver and Polach (1977).

The radiocarbon age of marine organisms reflects the time of $CO_2$ uptake by the surrounding ocean rather than the time of death of the organism. This effect, called the marine reservoir effect has to be accounted for when calculating the calendar age (Stuiver et al., 1993). In order to convert the raw radiocarbon data into calendar years, a site specific reservoir effect was calculated. The site specific reservoir effect at the OCNMS was calculated as 693±76, based on the average reservoir effect documented for seven non-estuarine areas in the Northeast Pacific close to the area of collection (Table 3.1b) (McNeely et al, 2006). This reservoir age was subtracted from the ($\delta^{13}C$ -corrected) $^{14}C$ age and this resultant age was converted to calendar years using the Intcal09 calibration dataset (Reimer et al, 2009) via the CALIB 6.0 Radiocarbon Calibration Program (http://calib.qub.ac.uk/calib/calib.html).

| Sample number | Latitude | Longitude | Depth of collection (m) |
|---|---|---|---|
| **R1162-0015** | 48.143N | -125.182W | 310 |
| **R1162-0016** | 48.143N | -125.182W | 312 |
| **R1162-0005** | 48.147N | -125.238W | 266 |
| **R1165-0002** | 48.135 N | -125.183W | 290-300 |
| **R1153-0003** | 54.379N | -132.861W | 393 |
| **R1155-0012** | 54.444N | -133.142W | 201 |
| **R1155-0013** | 54.456N | -133.155W | 248 |
| **R1156-0004** | 54.569N | -133.023W | 381 |
| **R1156-0006** | 56.569N | -133.024W | 382 |

| Location | Latitude | Longitude | Reservoir Age |
|---|---|---|---|
| **Ucluelet, BC** | -125.55 | 48.93 | 630±20 |
| **Forbes Is., BC** | -125.5 | 48.94 | 680±30 |
| **Ucluelet, BC** | -125.55 | 48.93 | 810±50 |
| **David Channel, BC** | -125.32 | 48.99 | 670±50 |
| **Forbes Is., BC** | -125.5 | 48.94 | 580±50 |
| **Ucluelet Hbr., BC** | -125.55 | 48.93 | 760±50 |
| **Amphitrite Point, BC** | -125.54 | 48.92 | 720±50 |

**Table 3.1a (Left): Sample locations of the dead specimens of *Primnoa pacifica* collected in July, 2008 from the OCNMS. Table 3.1b: The areas, location and reservoir ages from which an average reservoir age was calculated for our study.**


**Figure 3.4: The three colonies of *Primnoa pacifica* chosen for radiocarbon dating and SIMS analyses and their corresponding basal cross-sections (photographed under UV light). Sample R1162-0016 (top), sample R1165-002 (middle) and sample R1162-0015 with red and yellow markers indicating the position of the gorgonin rings which were isolated for $^{14}C$ dating.**

### *3.3.3 Growth rate estimation:*

The radial growth banding in the second growth zone (consisting of alternating gorgonin and calcite) of *Primnoa pacifica* can be observed quite clearly in polished cross-sections when photographed under UV light (Figs. 3.1, 3.4). Since these growth bands are known to be annual (Andrews et al, 2002) longevity estimates were made by counting the number of bands in the gorgonin/calcite zone. Three independent readers counted rings in this zone for each colony. The average number of bands for each colony was then divided by the length of the traversing radius of this zone only to obtain the average annual radial growth rate. In order to determine longevity, the average annual growth rate was extrapolated over the length of the whole radius (including the calcite cortex region). Axial growth rates could not be determined accurately as most colonies were broken and fragmented after death and before collection.

Normal light and UV illuminated photomicroscopy were not successful in clearly imaging the bands in the outer calcite cortex region of *P. pacifica.* In order to better enumerate the banding in the calcite cortex region, cross sections from the base of the colonies were mounted on 25mm x 75mm or 50mm x75mm glass plates, (depending on the size of the section) thin sectioned to 100 μm and petrographically polished. These polished thin sections were then scanned using a HP Scanjet 3970 scanner. The scans were performed using the greyscale 'photograph' setting at 2400 DPI resolution.

### *3.3.4 Sample preparation for trace element analyses*:

Cross sections between 3mm and 5mm in thickness were rock sawn from the base of the same three colonies selected for radiocarbon analyses. These cross sections were then cut into transverse strips using a thin kerf Buehler Isomet low speed diamond blade saw (Fig.3.5A). The calcitic cortex portion was subsequently isolated by simply breaking the gorgonin portion off by hand from the transverse strips (Fig. 3.5B). A corresponding continuous strip of the calcitic cortex could then be mounted into the 1" diameter SIMS sample ring (Figure 3.5C) - an aluminum ring with an outer diameter of 1 inch (25.4mm). The SIMS samples were embedded in the ring using Buehler Epothin Epoxide (Resin:Hardener; 10:3.9). The casts were polished using Buehler CarbiMet 2 120-600 grit silicon carbide wet/dry sandpaper and then subsequently on a Struers TegraPol 31 lapping wheel using a 6μm Struers diamond polish. Following this they were manually polished on Buehler ChemoMet cloth using 0.5 μm and 0.03 μm Buehler Alpha Micropolish II deagglomerated alumina.

### *3.3.5 Trace element analysis:*

Mg/Ca and Sr/Ca in coral skeletons are very commonly used as proxies for sea surface temperatures in reef-forming tropical corals (e.g., Cohen et al, 2006; Mitsuguchi et al, 1996). Although their behaviour during skeletal growth, and their utility as proxies for seawater temperature or chemical variations, has been examined in far less detail in the available literature, Na/Ca and Ba/Ca also vary systematically in many types of marine biomineralization (Boyle, 1981; Lea et al, 1989; Lea & Boyle, 1990; Amiel et al, 1973).

A Cameca IMS 4f Secondary Ion Mass Spectrometer (SIMS) was used to perform high spatial resolution (<25 μm) spot analyses of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca in detailed traverses across the polished basal cross-sections from three specimens of *P. pacifica*.

Individual SIMS transects began at the outermost edge of the calcite cortex region and ended at the beginning of the gorgonin/calcite mixed zone. The traverses were 7 mm to 11mm long and individual SIMS spots were spaced 25μm apart. Visible gorgonin rings were avoided during analysis. Each coral consequently had between 303 and 367 SIMS analysis spots, depending on the length of the SIMS transect.

SIMS analyses utilized bombardment of the samples with primary $^{16}O^-$ ions accelerated through a nominal potential of 10 kV. A primary ion current of 3.0-6.0 nA was critically focused on the sample over a spot diameter of 10-20 μm.

Sputtered secondary ions were accelerated into the mass spectrometer through a nominal potential of 4500 V. Secondary ions were energy filtered using a sample offset voltage of -80 V and an energy window of 60eV to suppress isobaric interferences. Prior to each analysis, the spot was pre-sputtered for 120 s. This was designed to eliminate contamination from the 500Å gold coat and also to penetrate the damaged and homogenized surface layer of the mechanically polished sample. Analytical craters were thus typically < 20μm diameter and <2 μm deep at the completion of each analysis.

Each analysis involved repeated cycles of peak counting on $^{23}Na^+$ (2s), $^{24}Mg^+$ (6 s), $^{42}Ca^+$ (2 s), $^{88}Sr^+$ (4 s), $^{138}Ba^+$ (10 s), as well as counting on a background position (22.67 Da; 1s) to monitor detection noise. A small wait time (0.2 – 0.5 s) was added between each peak switch for magnet settling. For this study, 15 cycles of data were collected over 546 s, for total analysis times of <10 minutes per spot, including pre-sputtering. Typical signal on the $^{42}Ca^{+}$ reference peak was 10,000-25,000 cps.

The Memorial IMS 4f is equipped with a High Speed Counting System (Pulse Count Technology Inc.) that produces dark noise background of less than 0.03 cps (2 counts per minute) when used with an ETP133H discrete dynode electron multiplier. Overall system dead time in pulse-counting mode is 14 ns. This system also produces very low detection limits for the elements studied. The elemental detection limits based only on the uncertainty in correcting for detector dark noise (0.03 cps) are typically 1 ng $g^{-1}$, 2 ng $g^{-1}$ for Mg, 2 ng $g^{-1}$ for Sr and 2 ng $g^{-1}$ for Ba. The error of individual spot analyses was estimated using the standard error of the mean of n cyclical measurements of each ratio during an analysis (internal precision).

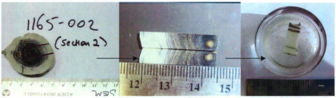



**Figure3. 5 (A): Black lines indicating where the cross section was cut (B) the pieces of the cross section obtained after cutting the cross section.(C) The calcite cortex of the cross section mounted in the SIMS sample holder**

### 3.4 Results:

#### *3.4.1 Radiocarbon results*:

Radiocarbon ages (Table 3.2) indicated that all of the rings analyzed, except sample 65-02 (A), were pre-bomb (i.e., formed prior to 1958). Almost all resultant reservoir corrected radiocarbon ages were within error of each other. Sample 65-02 (A) (Figure 3.6), the outermost ring in specimen R1165-002, was of modern (post-bomb) age. The reservoir corrected radiocarbon ages do indicate, however, that none of the samples died more recently than 30 years ago. Specimen # R1165-002 of *P. pacifica* has been dead for at least 30 years, specimen # R1162-0015 has been dead for at least 45 years, and specimen R1162-0016 has been dead for at least 50 years.

In aggregate, the samples belonging to coral R1162-0015 showed a discernible growth trend in radiocarbon age- with older radiocarbon ages for samples that were closer to the center of the coral (Table 3.2, Figure 3.7b). However, the slope of the growth trajectories obtained through fitting the reservoir corrected radiocarbon ages for this sample is steeper than that obtained from annual band counting (Figure 3.7 b; see discussion below). Sample R1165-0016 and Sample R1165-002 did not show any discernible trend in the radiocarbon years (Figure 3.7 a, c).

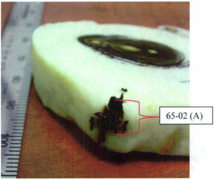



**Figure 3.6: 65-02 (A), the outer most ring dated on sample R1165-002.**

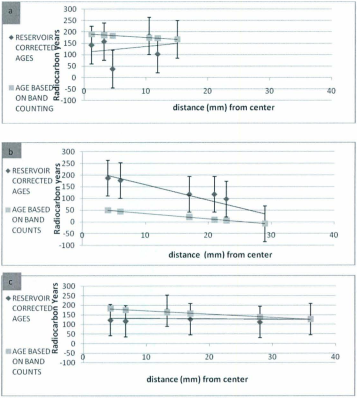



**Figure 3.7 (a) Sample R1165-002 (b) Sample R1162-0015 (c) Sample R1162-0016.**
**Distance (*From the center of the coral. Center is at 0 mm*) *vs* reservoir corrected radiocarbon years. The radiocarbon age of the outermost ring was considered valid in plotting the age based on band counting. The error bars (1σ) for the age based on band counts are smaller than the size of the symbol in the graph.**

| Sample number | Distance from the center of the coral(mm) | Band number from the center | $\Delta^{14}C$ | $^{14}C$ age | $^{14}C$ age error ± | $^{14}C$ age after reservoir correction 693± 76 | Calibrated age with 1 σ error |
|---|---|---|---|---|---|---|---|
| 65-02 A | 31.7 | 51 | 50.4 | >Modern | N/A | Modern- post 1958 | N/A |
| 65-02 (1) | 15.1 | 24 | -101.7 | 860 | 30 | 167±82 | 1663-1952 |
| 65-02 (2) | 11.9 | 19 | -94.2 | 795 | 30 | 102±82 | 1684-1954 |
| 65-02 (3) | 10.5 | 17 | -103.1 | 875 | 30 | 182±82 | 1650-1952 |
| 65-02 (4) | 4.6 | 8 | -86.7 | 730 | 30 | 37±82 | 1694-1955 |
| 65-02 (5) | 3.2 | 5 | -100.3 | 850 | 30 | 157±82 | 1666-1952 |
| 65-02 (6) | 1.2 | 1 | -98.5 | 835 | 30 | 142±82 | 1670-1952 |
| | | | | | | | |
| 62-15 (1) | 29.0 | 64 | -81.8 | 685 | 30 | -8±82 | N/A |
| 62-15 (4) | 22.9 | 51 | -93.6 | 790 | 30 | 97±82 | 1684-1954 |
| 62-15 (5) | 21.1 | 47 | -96.2 | 810 | 35 | 117±84 | 1682-1953 |
| 62-15 (6) | 17.0 | 35 | -96.1 | 810 | 30 | 117±82 | 1682-1953 |
| 62-15 (10) | 6.0 | 12 | -102.4 | 870 | 30 | 177±82 | 1654-1952 |
| 62-15 (11) | 4.0 | 7 | -103.6 | 880 | 30 | 187±82 | 1648-1952 |
| | | | | | | | |
| 62-16 (1) | 3.60 | 60 | -96.9 | 820 | 30 | 127±82 | 1681-1953 |
| 62-16 (2) | 2.80 | 46 | -95.1 | 805 | 30 | 112±82 | 1683-1953 |
| 62-16 (3) | 1.70 | 28 | -97.0 | 820 | 30 | 127±82 | 1681-1953 |
| 62-16 (4) | 1.33 | 22 | -102.4 | 865 | 30 | 172±82 | 1660-1952 |
| 62-16 (5) | 0.67 | 11 | -96.1 | 810 | 30 | 117±82 | 1682-1953 |
| 62-16 (6) | 0.46 | 2 | -96.6 | 815 | 30 | 122±82 | 1650-1952 |

**Table 3.2: Radiocarbon ages of the *P. pacifica* samples (gorgonin rings). Rings labelled 65-02 are from sample R1165-002, rings labelled 62-15 are from sample R1162-0015 and rings labelled 62-16 are from sample R1162-0016. Samples labelled (A) or (1) are from the outermost (towards the outer edge of the coral) gorgonin ring and then 2,3----etc are ring samples obtained in serial order moving towards the center of the coral.**

### *3.4.2 Growth rate results*:

All the growth rates listed in Table 3.3 and summarized in figure 3.8 are calculated from band counting results in the gorgonin/calcite mixed zone. The growth banding in the calcite cortex was also clearly imaged in only two of the six *P. pacifica* samples that were thin sectioned and scanned. Therefore a separate growth rate estimate involving the calcite cortex region was also possible for these samples. It was observed (Table 3.4) that the growth rate in the calcite cortex is quantitatively identical to the growth rate in the gorgonin/calcite zone in these samples.

The average radial growth rate of *Primnoa pacifica* specimens from the Dixon entrance is $0.323\pm 0.084$ mm.yr$^{-1}$ ($1\sigma$). The average growth rate of *Primnoa pacifica* from OCNMS is $0.362\pm0.023$mm.yr$^{-1}$ ($1\sigma$).

The lowest calculated average growth rates of *Primnoa pacifica* from the Dixon entrance in this study is similar to the growth rates calculated for *Primnoa pacifica* from the Gulf of Alaska by Andrews et al, (2002) (Table 3.5).

*Primnoa pacifica* was formerly thought to be the same species as *Primnoa resedaeformis* (Cairns & Bayer, 2009). Notwithstanding this, the growth rates of *Primnoa resedaeformis* from the Atlantic Ocean (Sherwood & Edinger, 2009; Table 3.5) is more than 4X lower than the growth rate of *Primnoa pacifica* determined in this study. Comparison of growth characteristics of *P. pacifica* and *P.resedaeformis* from various locations, as compiled in Figure 3.9, indicates that the samples from different locations follow similar logarithmic growth trajectories. A log fit titled 'model maximum' is fitted through the four specimens of *P.pacifica* with the largest radius in Fig. 3.9; indicating the upper limit of growth rates in our study.

| Sample number *P. pacifica* | Basal radius (mm) Maximum | Basal radius (mm) Minimum | Radius of gorgonin banded zone (mm) Maximum | Radius of gorgonin banded zone (mm) Minimum | Average number of bands counted (±1σ) | Band width (Max radius) (mm) | Band width- (Min radius) (mm) | Average radial growth rate ($mm.yr^{-1}$) | Age (years) ±1σ |
|---|---|---|---|---|---|---|---|---|---|
| ***OCNMS*** | | | | | | | | | |
| **R1162-0015** | 35.6 | 26.7 | 21.5 | 16.0 | 45±2 | 0.474 | 0.352 | 0.414±0.061 | 75±15 |
| **R1162-0016** | 17.0 | 16.0 | 12.0 | 21.0 | 31±2 | 0.381 | 0.258 | 0.319±0.061 | 51±11 |
| **R1162-0005** | 22.7 | 18.0 | 14.3 | 11.7 | 40±2 | 0.361 | 0.294 | 0.328±0.032 | 62±10 |
| **R1165-0002** | 35.0 | 32.0 | 9.7 | 6.5 | 21±4 | 0.462 | 0.309 | 0.386±0.076 | 87±4 |
| ***Dixon Entrance*** | | | | | | | | | |
| **R1153-0003** | 14.0 | 6.0 | 14.0 | 6.0 | 46±4 | 0.302 | 0.129 | 0.216±0.076 | 46±26 |
| **R1155-0012** | 24.0 | 15.0 | 24.0 | 15.0 | 34±2 | 0.713 | 0.446 | 0.579±0.132 | 34±11 |
| **R1155-0013** | 46.0 | 26.0 | 11.0 | 7.0 | 30±3 | 0.371 | 0.236 | 0.303±0.067 | 119±47 |
| **R1156-0004** | 6.0 | 4.0 | 6.0 | 4.0 | 22±2 | 0.277 | 0.185 | 0.231±0.046 | 22±6 |
| **R1156-0016(branch 1 )** | 16.7 | 11.5 | 5.9 | 3.3 | 16±1 | 0.368 | 0.206 | 0.288±0.08 | 49±13 |

**Table 3.3: Growth rate data and calculations for *P. pacifica*. The total number of bands calculated when the average growth rate is extrapolated over the entire radius of the *P. pacifica* is equal to the coral age in years.**

| Sample | Bands counted in a part of the calcite cortex | Radial length along which bands were counted (mm) | Radial growth rate (in calcite cortex) $mm.yr^{-1}$ | Radial growth rate (in gorgonin/calcite region) $mm.yr^{-1}$ |
|---|---|---|---|---|
| **R1156-0016** | **7** | **2.3** | **0.29±0.04** | **0.29 ±0.08** |
| **R1162-0015** | **24** | **10.0** | **0.38±0.04** | **0.41 ± 0.06** |

**Table 3.4: Comparison of the growth rate from the calcite cortex and the gorgonin/calcite part of the c oral skeleton for samples R1156-0016 and R1162-0015.**

| **Sample** | **Radial growth rate ($mm.yr^{-1}$)** | **Reference** |
|---|---|---|
| *Primnoa pacifica* Dixon entrance | **0.32 ±0.08** | This study |
| *Primnoa pacifica* OCNMS | **0.36 ± 0.02** | This study |
| *Primnoa pacifica* Gulf of Alaska | **0.18±0.03** | Andrews et al,2002 |
| *Primnoa resedaeformis* North Atlantic | **0.08±0.01** | Sherwood & Edinger, 2009 |

**Table 3.5: Growth rates of deep sea Primnoids**

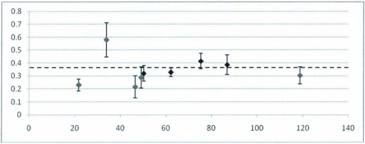



**Figure 3.8: Growth rate (mm.yr$^{-1}$) *vs* Age of the coral for *P. pacifica*. The error bars are 1σ. Dixon entrance samples are represented by grey markers and OCNMS samples are represented by black markers. The dotted line represents the average growth rate of all samples.**

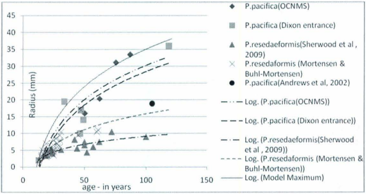



**Figure 3.9: Comparison of radial growth rates of *P.resedaeformis* {from the Hudson strait (Sherwood &Edinger, 2009) and the Northeast Channel (Mortensen& Buhl-Mortensen, 2005)} to radial growth rates of *P. pacifica* {from the Dixon Entrance (this study and Andrews et al, 2002) and Olympic Coast National Marine Sanctuary (this study). Logarithmic fits are used. All log fits were passed through the youngest and largest coral data points in the Mortensen & Buhl-Mortensen, 2005 data set. Andrews et al, 2002 provided radial growth data only for one colony of *P. pacifica* (Gulf of Alaska), thus only one data point for exists in the graph. The log fit titled 'model maximum', is the log fit for the four corals with the largest radius.**

### *3.4.3 Trace element analysis*:

In the three specimens analyzed in detail by SIMS, the Sr/Ca varied between 2.04 and 3.14 $mmol.mol^{-1}$, Mg/Ca varied between 70.6 and 136 $mmol.mol^{-1}$, Ba/Ca varied between 0.0036 and 0.0550 $mmol.mol^{-1}$ and Na/Ca varied between 16.4 and 53.1 $mmol.mol^{-1}$ (Table 3.6). These values are summarized, along with their means, in Table 3.6. Mean Mg/Ca and Na/Ca values are similar for Samples R1162-0015 and R1162-0016, but distinctly lower for Sample R1165-002. Table 3.7 shows that there is a weak, but statistically valid, inverse correlation between Mg/Ca and Sr/Ca for samples R1165-0015 and R1165-0016, but a positive correlation for sample R1162-005. The correlation coefficient (r) in these cases does not yield a perfect 0.99 value, nor is one necessarily expected, due to the large sample size (therefore large degree of freedom, {degree of freedom = sample size-2}). The p value for all samples is $\leq 0.05$; which indicates that the 'r' value is statistically significant at the 5 % level.

Detailed trace element profiles (Figs. 3.10-12) are plotted against a time axis (years before death; year of death= 0). Time was calculated based on the average annual radial growth rate. The smoothed data lines in Figures 3.10-3.12 were produced using a Savitzky-Golay type generalized moving average with filter coefficients determined by an unweighted linear least-squares regression and a second degree polynomial model.

| Sample number | Sr/Ca range (mmol. mol$^{-1}$) | Sr/Ca (mean) | Mg/Ca range (mmol.mol$^{-1}$) | Mg/Ca (mean) | Ba/Ca range (mmol. mol$^{-1}$) | Ba/Ca (mean) | Na/Ca range (mmol. mol$^{-1}$) | Na/Ca (mean) |
|---|---|---|---|---|---|---|---|---|
| R-1162-0015 | 2.27-3.14 | 2.71 | 81.3-125.8 | 103.5 | 0.0046-0.0313 | 0.0179 | 22.5-37.4 | 29.9 |
| R-1162-0016 | 2.04-2.97 | 2.50 | 76.2-136.6 | 106.4 | 0.0053-0.0115 | 0.0084 | 16.4-53.1 | 32.6 |
| R-1165-0002 | 2.18-2.61 | 2.39 | 70.6-92.2 | 81.4 | 0.0036-0.0550 | 0.0293 | 17.9-26.8 | 22.4 |

**Table 3.6: Summary of mean values and ranges of SIMS trace element results.**

| Sample number | R value | Degrees of freedom | P value |
|---|---|---|---|
| R1162-0015 | -0.18 | 368 | 0.0006 |
| R1162-0016 | -0.13 | 334 | 0.015 |
| R1165-0002 | 0.29 | 301 | 0.0001 |

**Table 3.7: Correlation coefficients for Sr/Ca and Mg/Ca in *P. pacifica* samples. The p values indicate that the R value is statistically significant at the 5% level in all cases.**

**Figure3.10: Sample R1162-0015- Mg/Ca and Sr/Ca ratios *vs* time (years). Time was calculated by extrapolating average annual radial growth rate over the calcite cortex. Error bars are ±1σ. The profile starts from the time of death of the organism (i.e. the outer edge). The data presented has been smoothed using a second degree Savitzky-Golay filter.**

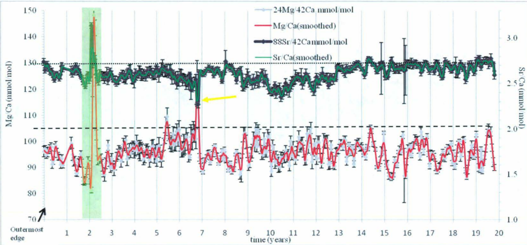


**Figure 3.11: Sample R1162-0016 –Mg/Ca and Sr/Ca ratios plotted *vs* time (years). Data is missing in the areas where visible gorgonin rings cut across the calcite cortex. Error bars are ±1σ. The data presented has been smoothed using a second degree Savitzky-Golay filter.**

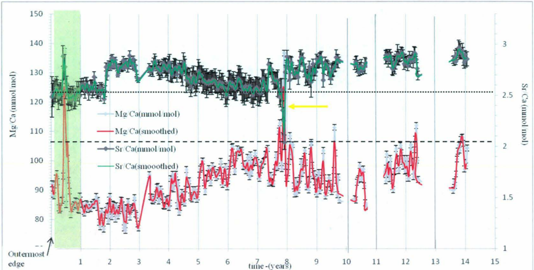
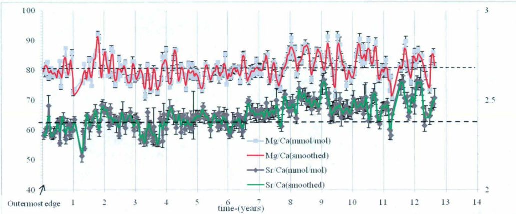


**Figure 3.12: Sample R1165-0002 –Mg/Ca and Sr/Ca ratios plotted *vs* time in years. Error bars are ±1σ. The data presented has been smoothed using a second degree Savitzky-Golay filter.**



In all three samples analyzed there appears to be some degree of cyclicity in the Mg/Ca and Sr/Ca profiles. The Mg/Ca and Sr/Ca ratios in sample R1162-0015 (Figure 3.10) show an obvious long period inverse correlation, which is also reflected in Table 3.7. A major simultaneous spike in Mg/Ca and Sr/Ca occurs at the beginning of the profile (green shaded area—between year 2 and 3). This spike corresponds to the SIMS analyses spots that passed over a thin gorgonin ring (Figure 3.13). These analyses spots were excluded from the statistical analysis in table 3.7 and the summary in table 3.6.

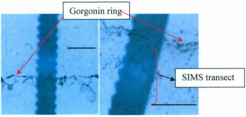



**Figure 3.13: SIMS transect that crossed over a thin gorgonin ring in Sample R1162-0015 (right) and R1162-0016(left). Both the gorgonin ring and the immediately surrounding area show an increased value of Mg/Ca and Sr/Ca in spot analyses. The black scale bar is 1mm long. The red arrows indicate the position of the gorgonin ring.**

In both samples R1162-0015 and R1162-0016 (Figure3.10-3.11) a single large dip in Sr/Ca values is noted, with a simultaneous spike in Mg/Ca (indicated by yellow arrows in the Figs. 3.10 & 3.11). This excursion in trace element values noted between year 6 and 7 in sample R1162-0015 and year 7 and 8 in R11162-0016, is not associated with any specific contamination or growth feature in the cross-section. It is very distinct from the profile obtained when the SIMS analyses spot crossed the gorgonin ring (green shaded area); as there is a negative excursion in Sr/Ca values; not a positive excursion as seen when the analyses crossed a gorgonin ring.

Ba/Ca and Na/Ca do not show any distinct cyclicity in the SIMS profiles of any of the samples analyzed. This lack of cyclicity is probably due to the fact that Na/Ca and Ba/Ca are not only dissolved in the skeletal material but are also present within the skeleton as surface contaminants and/or particulate inclusions. Their patterns do not seem as readily intepretable in *P. pacifica* as those observed for Mg/Ca and Sr/Ca.

## 3.5 Discussion

### *3.5.1 Trace elements*:

#### *3.5.1.1 Primary controls on trace element variation in P.pacifica:*

The skeletal morphology of *Primnoa resedaeformis* is indistinguishable from that of *Primnoa pacifica*, and they were formerly considered to be the same species (Cairns & Bayer, 2009). Sherwood et al (2005b) analyzed the bulk skeletal composition of several specimens of *Primnoa resedaeformis* from the North Atlantic and found that the average bulk skeletal Mg/Ca varied between 86 and 118 $mmol.mol^{-1}$. Comparison of individual sample values to hydrographic temperature at their sites of collection yielded the relationship Mg/Ca ($mmol.mol^{-1}$) = 5(±1.4) T (°C) + 64(±10).

The skeletal Mg/Ca in samples of *P. pacifica* analyzed in this study, varied between 70 and 136 $mmol.mol^{-1}$, with averages of 103, 106 and 81 $mmol.mol^{-1}$in the three samples studied in detail. If we simply apply the Sherwood et al (2005b) temperature relationship to Mg/Ca profiles obtained in this study we obtain implied temperature variation of ~3.5 °C to 12.4 °C in sample R1162-0015, ~2.4 to 14.4 in sample R1162-0016 and ~1.2 to 5.6°C in sample R1165-0002. Of course, the stated errors accuracy (not including intercept) of this equation exceeds the maximum temperature variation expected in the sampling area of the present study. In OCNMS the highest ever temperature recorded in the past 70 years, by CTD casts, is 6.9 °C, and the lowest is 5.4 °C (Boyer et al, 2009). Thus the Sherwood et al (2005) relationship seems unlikely to accurately discern temperature variations from our samples of *P. pacifica* Further, it would appear that temperature variation alone cannot account for the range of observed variation in Mg/Ca profiles of the samples studied herein.

The temperature dependence of Sr/Ca in most reef-forming tropical corals is between -0.08 and -0.10 $mmol.mol^{-1}/^{o}C$ (de Villiers et al, 1995; Gaetani & Cohen, 2006). Cold water scleractinian corals like *Lophelia pertusa* have a more extreme Sr/Ca sensitivity: approximately -0.18 $mmol.mol^{-1}$ (Cohen et al, 2006). The temperature dependence of Sr/Ca in abiogenic carbonate, however, is only -0.039 $mmol.mol^{-1}/^{o}C$ (Cohen et al, 2006).

If the variations of Sr/Ca reported in Table 3.6 were attributed solely to the observed temperature variation in the sampling areas, it would imply a temperature dependence of approximately -0.74 $mmol.mol^{-1}/^{o}C$, seven times more sensitive than observed in any tropical coral, and four times higher than that for the cold water scleractinian *L. pertusa*. It is implicit, therefore, that factors other than temperature may exert a major control on the variation in Sr/Ca ratios observed in *P. pacifica*.

A significant inverse correlation between Mg/Ca and Sr/Ca was noted in two of the three specimens of *P. pacifica* analyzed. Precipitation experiments carried out to investigate the partitioning of alkaline earth elements ($Mg^{2+}$, $Ca^{2+}$, $Sr^{2+}$ and $Ba^{2+}$) between abiogenic carbonate and sea water (as a function of temperature ) indicate that Mg/Ca and Sr/Ca both decrease with increasing temperature and are thus positively correlated (Gaetani & Cohen, 2006). However, a twelve month record of Mg/Ca, Sr/Ca and Ba/Ca from the skeleton of *Diploria labyrinthiformis* (a scleractinian zooxanthellate coral collected from Bermuda) showed that Mg/Ca and Sr/Ca ratios were inversely correlated to each other and Mg/Ca was positively correlated to SSTs recorded in the region (Gaetani &Cohen, 2006). In another study, on the cold water coral *Lophelia pertusa,* a similar inverse correlation between Mg/Ca and Sr/Ca was noted (Cohen et al, 2006). The magnitude of oscillations in both Mg/Ca and Sr/Ca ratios in *D. labyrinthiformis* and *L. pertusa* cannot be explained by the behaviour of abiogenic carbonate in the precipitation experiments described above (Gaetani & Cohen, 2006; Cohen et al, 2006).

Calculations performed by Gaetani & Cohen (2006) indicate that, at a constant temperature, when 'precipitation efficiency' (i.e. increase in the mass fraction of carbonate precipitated from the calcifying fluid) increases then Mg/Ca values increase and Sr/Ca and Ba/Ca values simultaneously decrease. In *L. pertusa* the oscillations in the Sr/Ca ratios could be reproduced by two-fold variation of the assumed precipitation efficiency, coupled with the observed temperature dependence of the partition coefficients determined from the abiogenic aragonite (Cohen at al, 2006).

Since only an extremely small portion of the variation observed in the Sr/Ca ratios in the *P. pacifica* can be attributed to temperature changes, the observed changes in Sr/Ca and Mg/Ca (Table 3.6) ratios would call for substantial variations of precipitation efficiency through the annual growth cycle.

In biogenic carbonate growth, a change in precipitation efficiency (i.e. mass of carbonate precipitated/growth rate of biogenic carbonate) occurs due to changes in the saturation state of the calcifying fluids. In tropical corals this change in saturation state is linked to zooxanthellate photosynthesis which is, in turn, linked to changes in temperature and sunlight (Cohen & McConnaughey, 2003; Cohen et al, 2006). Since any change in precipitation efficiency would be primarily reflected as a change in the observed growth rate of the coral, factors controlling growth rate are indirectly coupled to the trace element changes observed in *P. pacifica* and similar deep sea corals. Observations of Sr/Ca ratios in the deep sea coral *Corallium rubrum* indicate that Sr/Ca ratios vary with skeletal density; i.e., they are indirectly coupled to growth rate (Weinbauer et al, 2000). It has also been suggested that the cyclicity of Sr/Ca in deep sea bamboo corals can be used as an indicator of growth rate, rather than being coupled directly to temperature (Roark et al, 2005).

While no changes in light occur at depths of ~300m (from where *P. Pacifica* was collected), and the variations in temperature in the area of collection are negligible, the primary factor driving changes in the growth rate is most likely changes in food availability (Miller 1995; Ferrier-Pages, 2003; Houlbreque et al, 2003; Houlbreque et al, 2005).

Even though little is known about the feeding habits of most deep sea corals, it is well established that several corals, including zooxanthellate species, can meet part of their energy requirements by preying on zooplankton, phytoplankton, pico-nanplankton, dissolved organic matter and particulate organic matter (Tsounis et al, 2010; Ribes et al, 2003; Miller, 1995; Ferrier-Pages, 2003; Houlbrèque et al, 2003; Houlbrèque et al, 2004). Stable isotope analysis of two commonly occurring cold water corals, *Lophelia pertusa* and *Madrepora oculata*, indicated that they might be omnivores and may primarily feed on mesozooplankton (Duineveld et al., 2004; Kiriakoulakis et al, 2005). Stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analysis indicated that *P. resedaeformis* likely feeds on phytodetritus supplemented by mesozooplankton (Sherwood et al, 2008). A previous study on *P. pacifica* suggested that it likely feeds on the same trophic level as *P. resedaeformis* (Sherwood, 2005c). Since cold water corals cannot depend on any symbiotic algae for energy, they likely derive almost all of their nutrition from one or more of the other sources mentioned above.

In controlled laboratory experiments on *Stylophora pistillata* (a zooxanthellate scleractinian coral) it was noted that that an increase in plankton feeding under constant water temperature increased the rate of both skeletal and tissue growth of the coral. This occurred under both light and dark conditions, indicating that feeding has a direct effect on the mass fraction of skeletal material precipitated in the absence of light or temperature changes. (Miller,1995; Ferrier-Pages, 2003; Houlbrèque et al, 2003; Houlbrèque et al, 2005). It was also noted that in *Stylophora pistillata* the amount of food ingested was proportional to food density and that the coral never reached a saturation of feeding capacity in the experiments (Ferrier-Pages, 2003). Growth rates almost equivalent to tropical corals were noted in *Lophelia pertusa* and *Madrepora Oculata* specimens stored in dark conditions in aquaria and fed exclusively with zooplankton - with temperature variation during the experiments controlled to ~±0.5°C (Orejas et al, 2008).

Thus, in the absence of light, zooxanthellae, or substantial temperature variations, a change in the feeding of the coral should be the major factor modulating the skeletal precipitation efficiency and, consequently, the trace element values. If the mass fraction of carbonate precipitated increases at a fixed temperature then we would expect to observe a decrease in the Sr/Ca ratios and an increase in the Mg/Ca ratios of the carbonate (Gaetani & Cohen, 2006).

### *3.5.1.2 Oceanography of the Olympic Coast National Marine Sanctuary:*

The waters of OCNMS, are subject to changes in physical, chemical and biological properties due to the California Current system (CCS) (Hickey et al, 2006). The CCS mainly includes the southward California Current, the wintertime northward Davidson Current, and the northward California Undercurrent (Hickey & Banas, 2003). The California Undercurrent (CUC) is of special interest with respect to our samples because it is very active in the area of collection. It is continuous at depths of about 100-400 m and likely carries larval fish, invertebrates and even phytoplankton seed stock (Hickey & Banas, 2003). The intensity of the CUC is known to attain its maximum values in late spring and early autumn (Collins et al, 2003), and is the source of much of the nutrient-rich water supplied to the shelf during coastal upwelling (Hickey & Banas, 2003).

The seasonal upwelling (Huyer, 1983) in this area favours a large spring plankton bloom, followed by a smaller autumn plankton pulse (Anderson, 1964; Landry et al, 1989; Thomas & Strub, 2001). Landry et al (1989) have reported an increased concentration in chlorophyll twice a year offshore of Washington State (between 50 to 90 km); one of these episodes occurs between February and April and the other in October. Thomas & Strub (2001) observed that, in the Pacific Northwest, chlorophyll concentrations greater than 2.0 mg $m^{-3}$ extend further offshore in late spring-summer (May- June) and that a second offshore extension occurs in late summer (September).

### *3.5.1.3 Expected and observed Trace element variations in P.pacifca based on the oceanography of the region:*

Given that *P. pacifica* likely feeds on the downward flux of particulate organic matter, plankton and similar sources; the measured Sr/Ca and Mg/Ca ratios should respond to changes in the skeletal growth brought about by changes in food availability.

In reviews of the primary production, new production and vertical flux of organic carbon in the eastern Pacific it has been argued that production and vertical flux were directly related (Pace et al. 1987; Loubere & Fariduddin, 1999).

The biannual increase in food availability (due to the two plankton blooms per year) should theoretically be observed as two cycles per year in Mg/Ca and Sr/Ca profiles. While an inverse correlation is apparent in Sr/Ca and Mg/Ca profiles in Figures 3.10 and 3.11, a biannual cyclicity is not obviously resolved.

There are suggestions in our data that *P. pacifica* may also record more abrupt events. A particularly drastic decrease in Sr/Ca values is noted along the SIMS profile in R1162-0016 (between year 6 and 7) and R1162-0015 (between year 7 and 8) {indicated by the yellow arrows in Figs. 3.10 and 3.11}. This decrease in Sr/Ca is accompanied by a simultaneous increase in the Mg/Ca ratios. This could be attributed to a single period of increased growth due to substantial increase in the availability of food. This single period of increased growth occurs ~7 years before death in sample R1162-0015 and ~8 years before death in sample R1162-0016. The corals were collected during the same ROPOS dive from adjacent areas. It is likely that both *P. pacifica* samples have recorded the same event. Thus the trace element profiles may provide a unique method of correlating growth patterns in corals from proximal colonies.

A substantial, unusual increase in phytoplankton biomass was recorded in the waters off Washington, Oregon and British Columbia in the spring of 2002 (Wheeler et al, 2003; Thomas et al, 2003) due to the invasion of cool, saline subarctic waters (Freeland et al, 2003; Bograd & Lynn, 2003). A similar event could have occurred during the lifetime of R1162-0016 and -0015, leading to the spike in the Mg/Ca and decrease in the Sr/Ca. Thus, *Primnoa pacifica* may be useful in recording short term changes in productivity in the ocean, which reflect basin-scale changes in circulation. This attribute would be most useful in samples harvested live, where exact year of death is easily established.

The seasonal upwelling in this region is also influenced greatly by ENSO events, and a reduction in the nutrients and chlorophyll standing stock is known to occur in association with ENSO events (Carr, 2002; Corwith & Wheeler, 2002). A strong ENSO event should be recorded as a dramatic dip in the Mg/Ca ratios with a simultaneous spike in the Sr/Ca ratios in response to decreased productivity. Thus if a coral could survive through a strong ENSO event it might also record changes occurring in surface productivity due to the changes in upwelling.

In sample R1165-002 the Mg/Ca and Sr/Ca ratios show a significant positive correlation and lower mean values for Mg/Ca and Sr/Ca, respectively, than the other two samples. This relationship is the same as that expected as a consequence of abiogenic carbonate precipitation (Gaetani & Cohen, 2006). The positive correlation between Mg/Ca and Sr/Ca noted in sample R1165-002 is thus indicative of the possibility that the calcite has been modified after the death of the coral and abiogenic calcite has substantially altered or replaced virtually the entire primary calcitic skeleton of R1165-

002. This replacement most likely occurred due to diagenetic alteration after the death of the coral. Thus, such a sample of *P. pacifica* is generally undesirable for use in paleoceanographic reconstruction. Use of SIMS microanalysis to assess the polarity of correlation between Mg/Ca and Sr/Ca in this species appears to be a useful test to quickly assess if individual samples have undergone partial or wholesale taphonomic alteration. If the Mg/Ca and Sr/Ca ratios are positively correlated, then such samples should be avoided in geochemical studies.

### *3.5.2 Growth rate:*

The lowest radial growth rate recorded in this study was 0.22±0.09 $mm.yr^{-1}$ for a sample of *P. pacifica* from the Dixon entrance. This value closely matches the radial growth rate (0.18± 0.03 $mm,yr^{-1}$) for a colony of *P. pacifica* from the Dixon entrance studied by Andrews et al, 2002. The growth rates for *P. pacifica* reported here thus support the conclusions of this previous study that these corals are slow to recover from damage due to trawling and other disturbances

The average growth rate of *P. resedaeformis* from the North Atlantic (Table 3.4) are at least four times lower than the average growth rate of *P. pacifica* obtained in this study. Sherwood & Edinger (2009) attributed regional differences in growth rate of *P. resedaeformis* in the North Atlantic to differences in the intensity of tidal currents, suggesting that faster growth rates occur due to stronger tidal currents.

The California undercurrent is active in the region where samples of *P.pacifica* for this study were collected. The peak speed of this current is 30 to 50 cm $s^{-1.}$ This peak speed is generally lower than tidal current speeds reported for Hudson Strait and the NE

Channel (Sherwood & Edinger, 2009). Thus, current velocity alone cannot account for the large difference in growth rate with respect to the other locations.

The California current system is one of the most productive ecosystems in the world (Carr, 2002). Since growth of most deep sea corals is dependent on POM flux, it is likely that the relative higher productivity in the NE Pacific is the likely dominant cause of the higher growth rates of *P. pacifica* in comparison to *P. resedaeformis* from the Hudson strait and NE channel (Jones & Anderson, 1994; Carr, 2002; Thomas et al, 2003b).

#### *3.5.3: Radiocarbon dating:*

Since the radiocarbon ages of most of the samples were pre-bomb, and within error of each other, a precise age determination was not possible. It can be concluded, however, that none of the samples died recently (within the past 30 years).

### 3.6 Conclusions:

The annual radial growth rate of *Primnoa pacifica* calculated in this study is 0.23 to 0.58 $mm.yr^{-1}$. The lowest reported growth rate closely coincides with the previously reported growth rate for *P. pacifica* from the Dixon entrance (Andrews el al, 2002). This lends further support to studies indicating that recovery time from damage due to trawling and similar disturbances are high for this species (Andrews et al, 2002).

It was noted that growth rates in the calcite cortex and gorgonin/calcite mixed zone are virtually identical, thus indicating that the growth rate of the coral remains constant inspite of a change in the skeletal growth mode. Clear images of the growth rings in the calcite cortex region could not be obtained through traditional reflected light imaging. Scanning polished thin sections of *P. pacifica* using a HP Scanjet 3970 scanner proved to be of immense value in obtaining clear images of growth rings in the calcite cortex.

Because the growth rings that were isolated for radiocarbon dating were pre-bomb in age, it was extremely difficult to obtain a precise age for each ring, as calibrated most ages were well within error of each other. However, sample R1162-0015 appears to present a discernible growth trajectory (Figure 3.7) and this trajectory is not incompatible with the longevity of this sample deduced from growth ring counting.

The Mg/Ca and Sr/Ca ratios in this coral are likely controlled by surface water productivity changes rather than ocean bottom temperature. The changes in Mg/Ca and Sr/Ca thus have potential to record major changes in productivity, which in turn can provide evidence of other large scale annual and decadal changes in hydrographic conditions (e.g., El Nino).

The relationship between Mg/Ca and Sr/Ca ratios can be used as an indicator of whether sub-fossilized specimens are still useful for radiocarbon dating or geochemical analysis - a significant positive correlation between these ratios indicating an abiogenic alteration in the calcite skeleton after death. While performing geochemical analyses on the calcite in *P. pacifica* it is extremely important to recognize thin gorgonin rings in the calcite cortex, as analyses performed proximal to these rings show large and deceptive positive excursions in trace element values.

### 3.7 References:

Amiel, A. J., Friedman, G. M., and Miller, D. S. (1973) Distribution and nature of incorporation of trace elements in modern aragonitic corals. *Sedimentology* **20**, 1: 47-64.

Anderson, G. C. (1964) The seasonal and geographic distribution of primary productivity off the Washington and Oregon coasts. *Limnol Oceanogr*, **9**, 284-302.

Andrews, A.H., Cordes, E., Heifetz, J., Cailliet,G.M., Coale, K.H., Somerton, D., Munk, K. and Mahoney, B. M.(2002) Age and growth of a deep sea, habitat-forming octocorallian (*Primnoa* sp.) from the Gulf of Alaska, with radiometric age validation. *Hydrobiologia* **471:** 101-111

Boyer, T.P., J. I. Antonov, O. K. Baranova, H. E. Garcia, D. R. Johnson, R. A. Locarnini, A. V. Mishonov, D. Seidov, I. V. Smolyar, and M. M. Zweng, 2009: World Ocean Database 2009, Chapter 1: Introduction, ***NOAA Atlas NESDIS 66,*** Ed. S. Levitus, U.S. Gov. Printing Office, Wash., D.C. , 216 pp., DVD

Boyle, E. A., (1981) Cadmium, zinc, copper, and barium in foraminifera tests," *Earth. Planet. Sci. Lett.* **53**, 1: 11-35.

Bograd, S. J., and R. J. Lynn. (2003). Anomalous Subarctic influence in the southern California Current during 2002. *Geophys. Res. Lett.* **30** (15):8020.

Cairns S.D. and Bayer F.M. (2009). A generic revision and phylogenetic analysis of the Primnoidae (Cnidaria: Octocorallia). *Smithson Contrib Zool* **629**:1–79.

Carr, M.-E. (2002), Estimation of potential productivity in Eastern Boundary Currents using remote sensing, Deep Sea Res., Part II, **49**, 59– 80.

Cohen, A., McConnaughey, T. (2003) Geochemical perspectives on coral mineralization. *Rev Mineral Geochem* **54**:151-187

Cohen, A.L., Gaetani, G.A., Lundalv, T., Corliss, B.H., George, R.Y.,( 2006). Compositional variability in a cold-water scleractinian, *Lophelia pertusa*: new insights into "vital effects*". Geochem. Geophys. Geosyst.* **7**, Q12004

Collins, C. A., Ivanov, L.M. and Melnichenko, O.V. (2003), Seasonal Variability of the California Undercurrent: Statistical Analysis based on the Trajectories of Floats with Neutral Buoyancy, *Phys. Oceanogr.*, **13** (3), 135–147

Corwith, H., and Wheeler, P.A. (2002), El Nin˜o related variations in nutrient and chlorophyll distributions off Oregon, *Progr. Oceanogr.*, **54**, 361–380.

Duineveld, G.C.A., Lavaleye, M.S.S., Berghuis E.M. (2004) Particle flux and food supply to a seamount cold-water coral community (Galicia Bank, NW Spain). *Mar Ecol Prog Ser* **277**:13–23

Edinger. E., Boutillier. J., Workman, G. Coral Distributions around Learmonth Bank, Northern British Columbia, Canada: Influence of Surficial Geology and Tidal Currents Deep Sea Coral Symposium. $4^{th}$ *International Symposium on Deep Sea Corals*, 2008 Wellington, New Zealand p.98 Abstract nr **6.04**

Ferrier-Pagès C, Witting J, Tambutté E, Sebens KP (2003) Effects of natural zooplankton feeding on the tissue and skeletal growth of the scleractinian coral *Stylophora pistillata*. *Coral Reefs* **22**:229–240

Freeland, H. J., G. Gatien, A. Huyer, and R. L. Smith (2003), Cold halocline in the northern California Current: An invasion of subarctic water, *Geophys. Res. Lett.*, **30**(3), 1141.

Gaetani, G. A., and A. L. Cohen (2006), Element partitioning during precipitation of aragonite from seawater: A framework for understanding paleoproxies, *Geochim. Cosmochim. Acta*, **70**, 4617–463

Heikoop, J.M., Hickmott, D.D., Risk MJ, Shearer CK, Atudorei V (2002) Potential climate signals from the deep-sea gorgonian coral *Primnoa resedaeformis*. *Hydrobiologia* **471**: 117-124

Hickey, B.M., Banas, N.S., (2003). Oceanography of the Pacific Northwest coastal ocean and estuaries with application to coastal ecosystems. *Estuaries* **26** (48), 1010–1031.

Hickey, B., A. MacFadyen,W. Cochlan, R. Kudela, K. Bruland, and C. Trick (2006), Evolution of chemical, biological, and physical water properties in the northern California Current in 2005: Remote or local wind forcing?, *Geophys. Res. Lett.,* **33,** L22S02.

Houlbrèque, F., Tambutté, E. and Ferrier-Pagès, C. (2003). Effect of zooplankton availability on the rates of photosynthesis, tissue and skeletal growth of the scleractinian coral *Stylophora pistillata J. Exp. Mar. Biol. Ecol.* **296,** 145-166.

Houlbrèque, F., Tambutté E, Allemand D, Ferrier-Pagès C (2005) Interactions between zooplankton feeding, photosynthesis and skeletal growth in the scleractinian coral *Stylophora pistillata. J Exp Biol* **207**:1461–1469

Huyer, A. (1983) Coastal Upwelling in the California Current System. *Prog. Oceanogr.* **12**:3 259-284

Jones, E. P. & Anderson, L. G. (1994). Northern Hudson Bay and Foxe Basin water masses, circulation and productivity. *Atmos.Ocean* **32**: 361-374

Khripounoff, A., Vangriesheim, A. and Crassous, P. (1998) Vertical and temporal variations of particle fluxes in the deep tropical Atlantic. *Deep-Sea Res*. I, **45**, 193–216.

Kiriakoulakis, K., Fisher, E., WolV, G.A., Freiwald, A., Grehan, A. and Roberts, J.M (2005) Lipids and nitrogen isotopes of two deep-water corals from the North-East Atlantic: initial results and implications for their nutrition. In: Freiwald A, Roberts JM (eds) *Cold-water corals and ecosystems*. Springer, Berlin, pp 715–729

Layne, G.D. and Cohen, A.L.,( 2002), Advantages of Secondary Ion Mass Spectrometry for trace element studies of marine biomineralization, *Geochim. Cosmochim. Acta*,**66**,A436 (abstr.)

Lea D.W., Shen G.T., Boyle E.A., (1989) "Coralline barium records temporal variability in equatorial Pacific upwelling," *Nature* **340**, 6232: 373-376.

Lea, D.W. and Boyle, E.A. (1990), Foraminiferal reconstruction of barium distributions in water masses of the glacial oceans, *Paleoceanography* **5**: 719–742.

Loubere,P., Fariduddin, M.,(1999). Quantitative estimation of global patterns of surface ocean biological productivity and its seasonal variation on timescales from centuries to millennia. *Global Biogeochem. Cycles* **13**,115-133.

Landry, M.R., Postel, J.R., Peterson, W.K., Newman, J., (1989). Broad-scale distribution patterns of hydrographic variables on the Washington Oregon shelf. In: Landry, M.R., Hickey, B.M. (Eds.), *Coastal Oceanography of Washington and Oregon.* Elsevier, Amsterdam (Chapter 1).

McNeely, R., Dyke, A. S., and Southon, J. R. (2006) Canadian marine reservoir ages, preliminary data assessment, Open File 5049, pp. 3. Geological Survey Canada.

Miller, M. W. (1995). Growth of a temperate coral: effects of temperature, light, depth, and heterotrophy. *Mar. Ecol. Prog. Ser.* **122**:217-225.

Mitsuguchi, T., Matsumoto, E., Abe, O., Uchida, T., Isdale, P.J., (1996) Mg/Ca thermometry in coral skeletons. *Science* **274**, 961-963

Orejas, C., Gori, A., and Gili, J. M.(2008) Growth rates of live *Lophelia pertusa* and *Madrepora oculata* from the Mediterranean Sea maintained in aquaria, *Coral Reefs*, **27**, p. 255.

Pace, M. L., 'Knauer G. A., Karl, D. M., and Martin, J. H. (1987) Primary production, new production, and vertical flux in the eastern Pacific Ocean. *Nature,* **325**, 803-804.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey , C., Buck, C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser,K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R.,Talamo, S., Turney, C.S.M., van der Plicht, J. and Weyhenmeyer, C.E. (2009) INTCAL 09 and MARINE09 Raadiocarbon age calibration curves, 0-50,000 years Cal BP .*Radiocarbon*, **51** (4). 1111-115

Ribes,M., Coma,R.,and Gili,J.M. (1999)Heterogenus feeding n benthic suspension feeders : The natural diet and feeding rate of the temperate gorgonian *Paramuricea clavata* (Cnidaria:Octocorallia) over a year cycle . *Mar Ecol Prog Ser,*183,125-137

Ribes,M.,Coma,R., and Rossi,S. (2003) Natural feeding of the temperate asymbiotic octocoral gorgonian *Leptogorgia sarmentosa* (Cnidaria:Octocorallia). *Mar Ecol Prog Ser* **254**,141-15

Roark, E.B., Guilderson, T.P., Flood-Page, S.R., Dunbar, R.B., Ingram, B.L., Fallon, S.J. and McCulloch, M.T. (2005) Radiocarbon-based ages and growth rates for bamboo corals from the Gulf of Alaska. *Geophys Res Lett* **32**:L04606

Sherwood, O.A., Heikoop, J.M., Sinclair, D.J., Scott, D.B., Risk, M.J., Shearer, C. and Azetsu-Scott, K. (2005a) Skeletal Mg/Ca in *Primnoa resedaeformis*: relationship to temperature. In: Freiwald A, Murray JM (eds) *Cold-water corals and ecosystems.* Springer, Berlin, p 1061–1079

Sherwood, O.A., Heikoop, J.M., Scott, D.B., Risk, M.J., Guilderson, T.P. and McKinney, R.A. (2005b) Stable istopic composition of deep sea gorgonian corals *Primnoa* spp.: a new archive of surface processes. *Mar Ecol Prog Ser* **301**:135–148

Sherwood, O.A., Heikoop, J.M., Scott, D.B., Risk, M.J., Guilderson, T.P. and McKinney, R.A. (2005c) Stable istopic composition of deep sea gorgonian corals *Primnoa* spp.: a new archive of surface processes. *Mar Ecol Prog Ser* **301**:135–148

Sherwood, O.A., Scott, D.B. and Risk, M.J. (2006) Late Holocene radiocarbon and aspartic acid racemization dating of deep-sea octocorals. *Geochim Cosmochim Acta* **70**:2806–2814

Sherwood O.A., Jamieson, R.E., Edinger, E.N. and Wareham, V.E. (2008) Stable C and N isotopic composition of cold-water corals from the Newfoundland and Labrador continental slope: examination of trophic, depth and spatial effects. *Deep-Sea Res I* **55**:1392–1402

Sherwood, O.A. and Edinger E. (2009) Ages and growth rates of some deep-sea gorgonian and anthipatharian corals of Newfoundland and Labrador. *Can J Fish Aquat Sci* **66**: 142–152

Smith, S.V., Buddemeier, R.W., Redalje, R.C., Houck, J.E., (1979). Strontium-calcium thermometry in coral skeletons. *Science* **204** (4391), 404–407.

Stuiver, M., Polach, H.A., (1977). Discussion: reporting 14 C data. *Radiocarbon* **19**, 355–363

Tsounis, G., Orejas, C., Reynaud, S., Gili, J.M., Allemand, D., Ferrier-Pagès, C. (2010) Prey-capture rates in four Mediterranean cold water corals. *Mar Ecol Prog Ser* **398**:149-155

Thomas, A. C., and P. T. Strub, (2001) Cross-shelf phytoplankton pigment variability in the California Current, *Cont. Shelf Res*., **21**, 1157–1190.

Thomas, A. C., Strub, P. T. and Brickley, P. (2003a), Anomalous satellite measured chlorophyll concentrations in the northern California Current in 2001 – 2002, *Geophys. Res. Lett*., **30**(15), 8022

Thomas, A.C., Townsend, D.W., Weatherbee, R., (2003b). Satellite measured phytoplankton variability in the Gulf of Maine. *Cont. Shelf. Res* . **23**, 971–989

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R., Talamo, S., Turney, C.S.M., van der Plicht, J., Weyhenmeyer, C.E.( 2009). IntCal09 and Marine09 radiocarbon age calibration curves, 0– 50,000 years cal BP. *Radiocarbon* **51**(4):1111-1150.

Weber, J. N. & Woodhead, P. M. J. (1972) Stable isotope ratio variations in nonscleractinian coelenterate carbonates as a function of temperature. *Mar. Biol.*, **15**, 293-297

Weinbauer, M. G., Brandstatter, F., and Velimirov, B. (2000), On the potential use of magnesium and strontium concentrations as ecological indicators in the calcite skeleton of the red coral (Corallium rubrum), *Mar. Biol.*, **137**, 801–809.

Wheeler, P. A., Huyer, A. and Fleischbein J. (2003), Cold halocline, increased nutrients, and higher chlorophyll off Oregon in 2002, *Geophys. Res. Lett.*, **30**(15), 8021

## CHAPTER 4: SUMMARY AND CONCLUSIONS

Since many deep sea corals live in environments that are not subject to major temperature or illumination changes, identifying the dominant factors influencing changes in the composition of the skeletal material is of utmost importance in understanding their application as paleoceanographic archives. One of the aims of our research was to be able to identify these factors.

In our detailed study of two species of corals from the Dixon entrance and the Olympic Coast National Marine Sanctuary, we have determined that the changes in trace element geochemistry are highly reflective of surface water productivity changes. Since changes in productivity are greatly influenced by upwelling in the Northeast Pacific, it is highly likely that these corals are capable of preserving records of the basin scale changes in circulation patterns that directly or indirectly influence productivity changes.

### 4.1 Research highlights:

#### *4.1.1 Stylaster campylecus parageus:*

It was observed that *Stylaster campylecus parageus* remineralizes its skeleton as it grows. However, using SEM and SIMS it is possible to obtain useful trace element profiles from these corals, despite this remineralization.

SEM imaging on etched basal cross sections clearly revealed growth banding in the coral skeleton, otherwise not visible using traditional imaging methods.

Sr/Ca values seemed to increase twice within a distance covering approximately 12 growth bands, while the opposite behaviour was noted in Mg/Ca and Na/Ca. The temperature variation in the area of collection is less than ± 1 °C; and could not account for this observed variation in individual trace element values. These variations in trace element values were determined to be primarily influenced by surface water productivity. Based on the observed cyclicity in the Na/Ca, Mg/Ca and Sr/Ca profiles, and the reported biannual increase in productivity that occurs in the area of collection (Landry et al, 1989), it was determined that the growth bands are monthly.

The radial growth rate of *S. campylecus* was observed to be higher than those published for other deep sea corals. Its axial growth rate was comparable to other deep sea corals.

#### *4.1.2: Primnoa pacifica:*

The lowest reported growth rate for *P.pacifica* in this study is similar to that previously reported for *P.pacifica* from the Dixon entrance (Andrews et al, 2002).

It was demonstrated that clear images of the growth rings in the calcite cortex region of this Primnoid could only be obtained by transmissive scanning of polished thin sections of *P.pacifica* using a high resolution flat-bed scanner. An independent estimation of the growth rates could consequently be obtained from the calcite cortex, and indicated that growth rates of the calcite cortex are similar to the growth rates of the gorgonin/calcite mixed zone.

The relationship between Mg/Ca and Sr/Ca ratios can be used as indicator of whether the skeletal material has undergone early stage digenesis or alteration. A significant positive correlation between these ratios indicate abiogenic alteration of the calcite skeleton, probably during post-mortem early diagenesis. It was noted that SIMS analyses performed proximal to the gorgonin rings show large positive excursions in trace element values.

The Mg/Ca and Sr/Ca ratios in this coral are likely controlled by surface water productivity changes rather than ocean bottom temperature.

### 4.2 Implications of results:

#### *4.2.1: Stylaster campylecus parageus*:

The remineralization observed in the skeleton of *S.campylecus* precludes validating the age or growth rate of the coral through traditional radiometric methods. Using SIMS and SEM imaging appear to be the only viable method of obtaining geochemical profiles from *S.campylecus* exclusively from non-remineralized areas.

The identification of monthly periodicity of the growth banding in *S.campylecus* is especially valuable because it provides an alternative method to determine the lifespan of a species which cannot be dated through traditional radiometric methods.

The higher radial growth rate calculated in *S.campylecus* is empirically validated by the fact that Stylasterids are one of the earliest recolonizing species observed after an area has been bottom trawled (Althaus et al, 2009; Williams et al, 2010).

### *4.2.2: Primnoa pacifica*:

While performing geochemical analyses of the calcite in *P. pacifica* it is extremely important to recognize thin gorgonin rings in the calcite cortex, as analyses performed proximal to these rings show large positive excursions in trace element values. A significant positive correlation between Mg/Ca and Sr/Ca ratios indicate an abiogenic alteration in the calcite skeleton after death. If such an observation is noted in any specimen of *P. pacifica* it is likely unsuitable as a paleoceanographic archive.

The similar growth rate obtained in the gorgonin/calcite mixed zone and the calcite cortex indicates that the growth rate of the coral remains constant in spite of a change in the skeletal growth mode. This validates that this assumption can be used to extrapolate ages in growth ring and aging studies of Primnoid species where only mixed (gorgonin-calcite) zone rings are counted.

The close similarity in the growth rate reported in this study and the single previously determined growth rate for this species, lends further support to studies indicating that recovery time from damage due to trawling and similar disturbances are high for *P.pacifica* (Andrews et al, 2002).

The growth rate of *P.pacifica* determined in this study is at least 4 times higher than the growth rate reported for a similar gorgonian species in the North Atlantic. This higher growth rate is likely due to the relatively higher productivity in the area where our samples of *P.pacifica* were collected.

The changes in skeletal Mg/Ca and Sr/Ca have potential to record major changes in productivity, which in turn can provide evidence of other large scale changes in hydrographic conditions (eg: El Nino ).

### 4.3 Directions for future work:

It would be informative to analyze the $\delta^{18}O$ values using SIMS, in profiles that are coincident with the current trace element profiles in the samples of *S. campylecus* and *P. pacifica*. Such analyses would help confirm that there are no exclusive short duration changes in water temperature that are recorded by the coral. $\delta^{18}O$ is greatly sensitive to temperature variation (Smith et al , 1997) , if the $\delta^{18}O$ values are constant through the profile it would further clarify that surface biological productivity variation is the primary control on geochemistry in *S. campylecus*.

In order to confirm the monthly periodicity of the growth bands in *S.campylecus* it would be useful to perform a similar geochemical analyses as described in Chapter 2 on a specimen of Stylaster from an area with a different surface productivity and/ or temperature regime. It would also be useful to perform detailed radial sampling of individual *S.campylecus* colonies from a single location in order to search for matching patterns in growth banding and/or trace element profiles.

Timed harvesting experiments designed to determine the growth rate of the coral followed by detailed radial sampling and microanalysis could explicitly confirm the periodicity of the growth bands.

It would also be useful to perform trace element analyses, similar to those described in Chapter 3 of this thesis, on a sample of *P.pacifica* that was collected live (but was relatively long lived) from waters off Washington or Oregon and lived through the year 2002. In the spring of 2002 the phytoplankton biomass more than doubled due to an invasion of cold halocline waters (Wheeler et al, 2003; Thomas et al, 2003; Freeland et al, 2003; Bograd & Lynn, 2003). If one could perform a high resolution transect of Mg/Ca and Sr/Ca including the year 2002 in the calcite cortex of *P.pacifica*, it should show a spike in Mg/Ca values and a simultaneous drastic dip in Sr/Ca values corresponding to this year. Such an observation would confirm that *P.pacifica* is capable of recording basin scale changes in circulation patterns that directly or indirectly influence productivity changes.

**4.4 References:**

Althaus, F., Williams, A., Schlacher, T.A., Kloser, R.J. and others (2009) Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. *Mar Ecol Prog Ser* **397**:279-294

Andrews, A.H., Cordes, E., Heifetz, J., Cailliet, G.M., Coale, K.H., Somerton, D., Munk, K., Mahoney, B. M. (2002) Age and growth of a deep sea, habitat-forming octocorallian (*Primnoa* sp.) from the Gulf of Alaska, with radiometric age validation. *Hydrobiologia* **471**: 101-111

Bograd, S. J., and Lynn, R. J. (2003). Anomalous Subarctic influence in the southern California Current during 2002. *Geophys. Res. Lett.* 30 (15):8020.

Freeland, H. J., Gatien, G., Huyer, A. and Smith, R.L. (2003), Cold halocline in the northern California Current: An invasion of subarctic water, *Geophys. Res. Lett.*, **30**(3), 1141.

Landry, M.R., Postel, J.R., Peterson, W.K., Newman, J. (1989). Broad-scale distribution patterns of hydrographic variables on the Washington Oregon shelf. In: Landry, M.R., Hickey, B.M. (Eds.), *Coastal Oceanography of Washington and Oregon*. Elsevier, Amsterdam (Chapter 1).

Smith, J.E, Risk, M.J., Schwarcz, H.P. and McConnaughey, T.A. (1997) Rapid climate change in the North Atlantic during the Younger Dryas recorded by deep-sea corals. *Nature* **386**, 818 – 820

Thomas, A. C., Strub, P. T. and Brickley P. (2003), Anomalous satellite measured chlorophyll concentrations in the northern California Current in 2001 – 2002, *Geophys. Res. Lett.*, **30**(15), 8022.

Wheeler, P. A., Huyer, A. and Fleischbein, J. (2003), Cold halocline, increased nutrients, and higher chlorophyll off Oregon in 2002, *Geophys. Res. Lett.*, **30**(15), 8021

Williams, A., Schlacher, T.A., Rowden, A.A., Althaus, F., Clark, M.R., Bowden, D.A., Stewart, R., Bax, N.J., Consalvey, M. and Kloser, R.J. (2010) Seamount megabenthic assemblages fail to recover from trawling impacts. *Marine Ecology*, **31**(Suppl. 1), 183–199.

## Appendix A: X-ray diffracion patterns

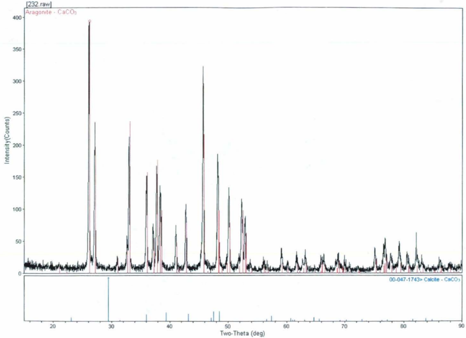



Figure 1: X-ray diffraction result for Sample 232

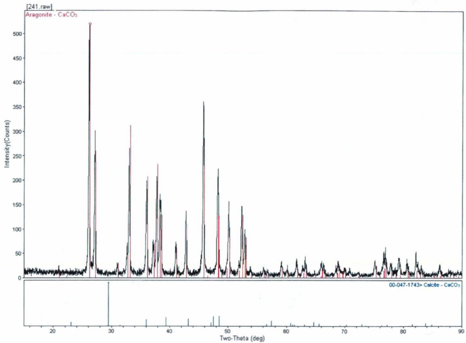



Figure 2: X-ray diffraction result for Sample 241

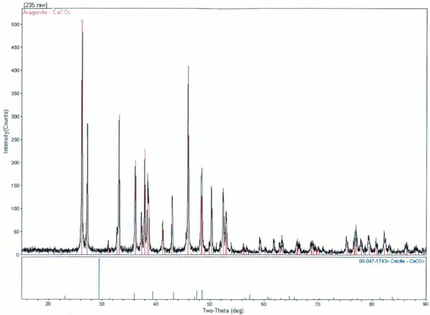



Figure 3: X-ray diffraction result for Sample 235

# APPENDIX B

**SEM images of *Stylaster campylecus parageus***

**Sample 241:**


Figure 1 :Composite SEM image of radial cross-section of Sample 241 of *Stylaster campylecus parageus* (etched for 70 minutes with 0.1N HCl).


Figure 2 :Composite SEM image of radial cross-section Sample 241 of *Stylaster campylecus parageus* (etched for more than70 minutes with 0.1N HCl).

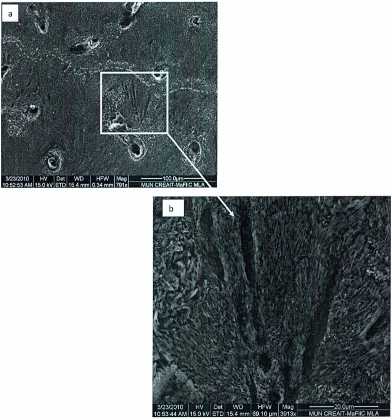



Figure 3 : SEM image of Sample 241 of *Stylaster campylecus parageus* (a) growth band (dotted lines are used to indicate the position of the growth band (b) fan shaped aragonite needles.

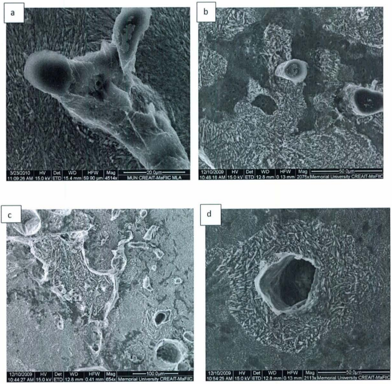



Figure 4: Sample 241 : (a) Edge of growth canal (b, c ) Center of the coral- extensively remineralized with aragonite overprinting primary growth (d) Image of a growth canal surrounded by secondary aragonite.

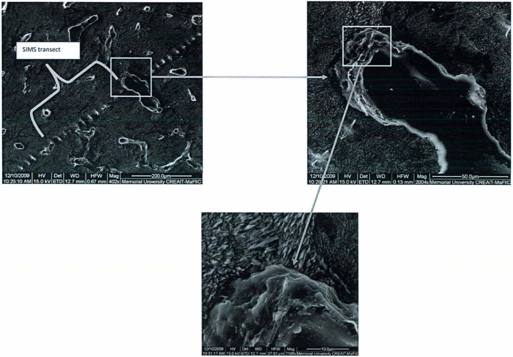



Figure 5: Sample 241 – SEM images of a growth canal over the SIMS transect

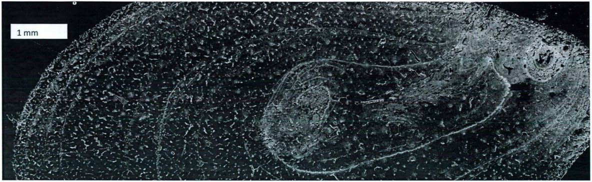



Figure 6 :Composite SEM image of radial cross-section Sample 232 of *Stylaster campylecus parageus* (etched for 70 minutes with 0.1N HCl).

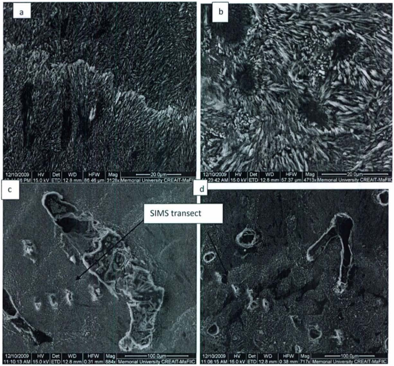



Figure 7: Sample 232 : (a) Growth band (b) Center of the coral- extensively remineralized with aragonite overprinting primary growth (c, d) Image of a growth canal next to the SIMS transect

Figure 8 :Composite SEM image of the radial cross-section of Sample 238 of *Stylaster campylecus parageus* (etched for 70 minutes with 0.1N HCl).

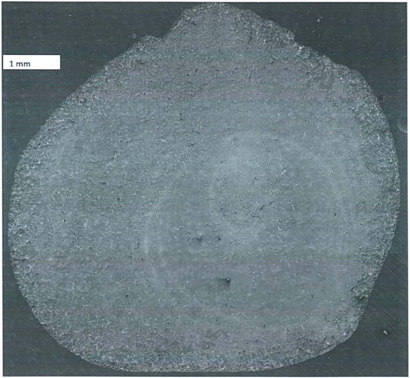
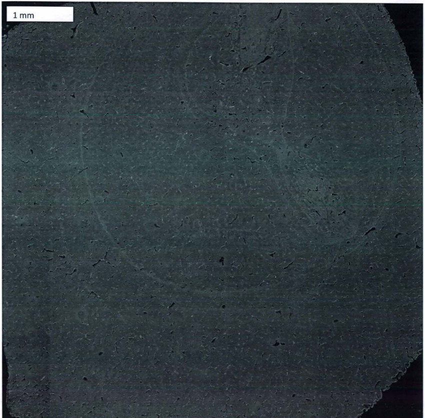


Figure 9 :Composite SEM image of radial cross-section  Sample 237 of *Stylaster campylecus parageus* (etched for 70 minutes with 0.1N HCl).



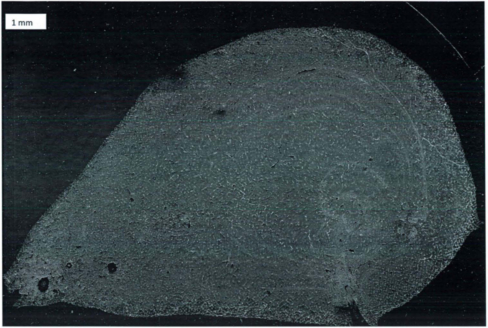



Figure 10 :Composite SEM image of radial cross-section of Sample 235 of *Stylaster campylecus parageus* (etched for 70 minutes with 0.1N HCl).

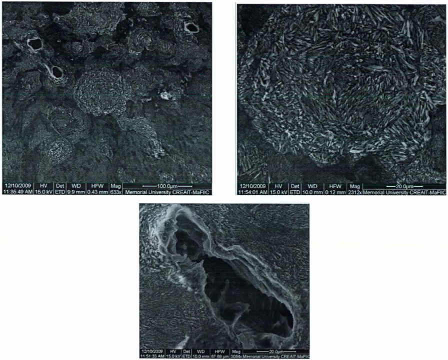



Figure 11 (a,b) Remineralization in the center of the cross section of Sample 235 (c) Growth canal in sample 235

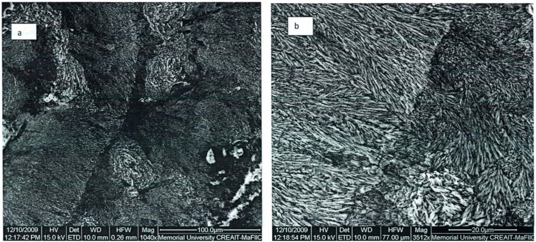



Figure 12: (a, b) Growth banding in Sample 235 of *S.campylecus*

## APPENDIX C: SIMS data for *P.pacifica* (R1162-0015 SIMS data)

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2_@1 | 2.7365 | 0.0779 | 96.0997 | 3.8933 | 0.0078 | 0.0025 | 31.1587 | 1.2124 | 0 |
| Primnoa_2_@2 | 2.6455 | 0.0573 | 97.0619 | 2.6840 | 0.0066 | 0.0073 | 30.7253 | 0.6189 | 25 |
| Primnoa_2_@3 | 2.7080 | 0.0734 | 94.7317 | 2.4985 | 0.0066 | 0.0037 | 29.7148 | 1.2427 | 50 |
| Primnoa_2_@4 | 2.7084 | 0.0671 | 95.8129 | 3.4716 | 0.0064 | 0.0025 | 29.4796 | 0.9438 | 75 |
| Primnoa_2_@5 | 2.6648 | 0.0649 | 96.5341 | 2.4992 | 0.0070 | 0.0036 | 29.4859 | 0.6357 | 100 |
| Primnoa_2_@6 | 2.6440 | 0.0823 | 97.2888 | 2.8526 | 0.0057 | 0.0017 | 29.9898 | 0.6707 | 125 |
| Primnoa_2_@7 | 2.6238 | 0.0729 | 98.0269 | 2.8536 | 0.0059 | 0.0008 | 30.0481 | 0.8066 | 150 |
| Primnoa_2_@8 | 2.6349 | 0.0613 | 91.2350 | 3.1489 | 0.0064 | 0.0015 | 27.8023 | 0.6205 | 175 |
| Primnoa_2_@9 | 2.5689 | 0.0670 | 92.6241 | 2.8664 | 0.0067 | 0.0010 | 29.3419 | 0.7355 | 200 |
| Primnoa_2_@10 | 2.5399 | 0.0546 | 97.6102 | 2.8568 | 0.0064 | 0.0015 | 31.4372 | 0.7387 | 225 |
| Primnoa_2_@11 | 2.6096 | 0.0466 | 98.4615 | 2.8680 | 0.0068 | 0.0010 | 32.1503 | 1.2738 | 250 |
| Primnoa_2_@12 | 2.6096 | 0.0409 | 95.5166 | 3.5592 | 0.0057 | 0.0011 | 31.3117 | 0.5416 | 275 |
| Primnoa_2_@13 | 2.5835 | 0.0415 | 94.2611 | 2.8891 | 0.0061 | 0.0013 | 29.6847 | 0.3771 | 300 |
| Primnoa_2_@14 | 2.5555 | 0.0563 | 93.8878 | 2.2470 | 0.0066 | 0.0013 | 29.6831 | 0.6213 | 325 |
| Primnoa_2_@15 | 2.5951 | 0.0930 | 91.1113 | 3.0259 | 0.0066 | 0.0009 | 30.1270 | 1.1576 | 350 |
| Primnoa_2_@16 | 2.6877 | 0.0802 | 93.4663 | 2.6203 | 0.0058 | 0.0009 | 31.1929 | 0.6551 | 375 |
| Primnoa_2_@17 | 2.6648 | 0.0705 | 90.9350 | 2.2004 | 0.0061 | 0.0012 | 29.5023 | 0.6457 | 400 |
| Primnoa_2_@18 | 2.6418 | 0.0959 | 99.2535 | 4.5733 | 0.0058 | 0.0011 | 32.8245 | 1.3240 | 575 |
| Primnoa_2_@19 | 2.6093 | 0.0744 | 94.9754 | 4.5344 | 0.0050 | 0.0012 | 31.3481 | 1.3902 | 600 |
| Primnoa_2_@20 | 2.6600 | 0.0707 | 92.2036 | 3.2140 | 0.0059 | 0.0009 | 32.2951 | 0.6500 | 625 |
| Primnoa_2_@21 | 2.6236 | 0.0649 | 92.6790 | 3.2185 | 0.0061 | 0.0016 | 32.1066 | 1.0918 | 650 |
| Primnoa_2_@22 | 2.6929 | 0.0652 | 87.7556 | 2.1979 | 0.0066 | 0.0013 | 31.4806 | 0.5918 | 675 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2_@23 | 2.6345 | 0.0813 | 87.8651 | 2.5920 | 0.0063 | 0.0024 | 29.9063 | 0.4025 | 700 |
| Primnoa_2_@24 | 2.6570 | 0.0718 | 91.9349 | 2.6561 | 0.0063 | 0.0020 | 30.2430 | 0.7824 | 725 |
| Primnoa_2_@25 | 2.6237 | 0.0488 | 92.1690 | 3.8503 | 0.0061 | 0.0021 | 29.6376 | 0.8704 | 750 |
| Primnoa_2_@26 | 2.5795 | 0.0430 | 95.1491 | 2.4806 | 0.0063 | 0.0024 | 32.1805 | 0.9377 | 775 |
| Primnoa_2_@27 | 2.5670 | 0.0465 | 91.5847 | 3.0122 | 0.0063 | 0.0011 | 31.2597 | 0.5105 | 800 |
| Primnoa_2_@28 | 2.5210 | 0.0663 | 84.8944 | 2.7171 | 0.0076 | 0.0016 | 27.1459 | 0.6503 | 825 |
| Primnoa_2_@29 | 2.4963 | 0.0564 | 84.8182 | 3.4199 | 0.0075 | 0.0017 | 28.4912 | 0.6972 | 850 |
| Primnoa_2_@30 | 2.4679 | 0.0531 | 84.9854 | 2.6046 | 0.0071 | 0.0020 | 29.0490 | 0.5604 | 875 |
| Primnoa_2_@31 | 2.5578 | 0.0622 | 88.5422 | 2.3065 | 0.0067 | 0.0014 | 29.3786 | 0.5844 | 900 |
| Primnoa_2_@32 | 2.6004 | 0.0549 | 92.1369 | 3.7326 | 0.0053 | 0.0012 | 30.2814 | 1.0370 | 925 |
| Primnoa_2_@33 | 2.5433 | 0.0829 | 91.1301 | 2.9436 | 0.0063 | 0.0013 | 30.4992 | 0.8367 | 950 |
| Primnoa_2_@34 | 2.5709 | 0.0929 | 84.5974 | 2.0279 | 0.0073 | 0.0036 | 29.1306 | 1.0938 | 975 |
| Primnoa_2_@35 | 3.1353 | 0.0628 | 81.3282 | 2.2259 | 0.0075 | 0.0012 | 31.1126 | 0.9269 | 1000 |
| Primnoa_2_@36 | 2.7086 | 0.0718 | 121.2402 | 8.3490 | 0.0065 | 0.0013 | 31.1982 | 1.0725 | 1025 |
| Primnoa_2_@37 | 2.8011 | 0.0706 | 148.2906 | 7.2698 | 0.0054 | 0.0016 | 26.1836 | 0.7813 | 1050 |
| Primnoa_2_@38 | 2.7644 | 0.0893 | 143.4280 | 5.9399 | 0.0052 | 0.0014 | 23.6886 | 0.4693 | 1075 |
| Primnoa_2_@39 | 2.6010 | 0.0800 | 102.4124 | 3.9033 | 0.0064 | 0.0014 | 25.0629 | 0.8804 | 1100 |
| Primnoa_2_@40 | 2.5367 | 0.0620 | 92.7346 | 3.3038 | 0.0071 | 0.0012 | 28.7706 | 0.7720 | 1125 |
| Primnoa_2_@41 | 2.5255 | 0.0905 | 95.9643 | 2.5598 | 0.0059 | 0.0010 | 29.8455 | 1.2812 | 1150 |
| Primnoa_2_@42 | 2.6060 | 0.0840 | 93.1799 | 3.1534 | 0.0058 | 0.0015 | 28.6744 | 1.1344 | 1175 |
| Primnoa_2_@43 | 2.5970 | 0.0696 | 93.6811 | 2.8708 | 0.0059 | 0.0012 | 29.5578 | 0.9638 | 1200 |
| Primnoa_2_@44 | 2.5705 | 0.0822 | 90.7910 | 4.3828 | 0.0062 | 0.0013 | 29.1143 | 1.4142 | 1225 |
| Primnoa_2_@45 | 2.5775 | 0.0915 | 87.4663 | 2.2021 | 0.0070 | 0.0021 | 28.1343 | 0.7713 | 1250 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__1@1 | 2.5638 | 0.1283 | 87.3744 | 5.2519 | 0.0059 | 0.0013 | 28.8212 | 1.1045 | 1275 |
| Primnoa_2__1@2 | 2.5713 | 0.0930 | 91.5578 | 4.0318 | 0.0056 | 0.0019 | 31.1013 | 0.7959 | 1300 |
| Primnoa_2__1@3 | 2.6026 | 0.1487 | 94.0290 | 3.6082 | 0.0056 | 0.0011 | 30.4337 | 0.8309 | 1325 |
| Primnoa_2__1@4 | 2.5311 | 0.0896 | 98.4652 | 3.9312 | 0.0061 | 0.0012 | 31.3376 | 1.0770 | 1350 |
| Primnoa_2__1@5 | 2.6168 | 0.0772 | 92.2841 | 3.7594 | 0.0057 | 0.0010 | 29.9360 | 1.0158 | 1375 |
| Primnoa_2__1@6 | 2.6294 | 0.0785 | 89.9141 | 3.7723 | 0.0061 | 0.0013 | 29.6745 | 1.2229 | 1400 |
| Primnoa_2__1@7 | 2.6004 | 0.0720 | 93.3355 | 3.9362 | 0.0060 | 0.0013 | 30.3378 | 0.6364 | 1425 |
| Primnoa_2__1@8 | 2.5463 | 0.0589 | 90.5579 | 3.8213 | 0.0070 | 0.0013 | 29.2674 | 0.9683 | 1450 |
| Primnoa_2__1@9 | 2.5339 | 0.0416 | 89.1851 | 4.5959 | 0.0071 | 0.0021 | 28.4193 | 0.4474 | 1475 |
| Primnoa_2__1@10 | 2.5342 | 0.0987 | 90.6569 | 3.3140 | 0.0065 | 0.0024 | 28.9648 | 0.6233 | 1500 |
| Primnoa_2__1@11 | 2.5043 | 0.0748 | 94.0982 | 3.3317 | 0.0056 | 0.0013 | 29.6447 | 1.4635 | 1525 |
| Primnoa_2__1@12 | 2.5299 | 0.0907 | 95.0509 | 3.9546 | 0.0058 | 0.0016 | 29.9655 | 0.8047 | 1550 |
| Primnoa_2__1@13 | 2.5343 | 0.0786 | 96.2799 | 4.1267 | 0.0056 | 0.0010 | 30.4007 | 0.9157 | 1575 |
| Primnoa_2__1@14 | 2.5628 | 0.0757 | 96.0103 | 3.6014 | 0.0060 | 0.0014 | 29.6595 | 1.1715 | 1600 |
| Primnoa_2__1@15 | 2.5819 | 0.0706 | 92.4335 | 4.8374 | 0.0062 | 0.0014 | 28.5910 | 0.7695 | 1625 |
| Primnoa_2__1@16 | 2.6106 | 0.0710 | 94.5828 | 5.0045 | 0.0058 | 0.0011 | 30.1093 | 0.5792 | 1650 |
| Primnoa_2__1@17 | 2.5589 | 0.0979 | 98.8035 | 4.7163 | 0.0056 | 0.0011 | 30.9428 | 0.7909 | 1675 |
| Primnoa_2__1@18 | 2.5778 | 0.1171 | 98.2927 | 3.8229 | 0.0060 | 0.0015 | 30.5630 | 1.3803 | 1700 |
| Primnoa_2__1@19 | 2.5479 | 0.1013 | 100.4366 | 3.2419 | 0.0242 | 0.1297 | 31.5385 | 1.4233 | 1725 |
| Primnoa_2__1@20 | 2.6039 | 0.1040 | 93.2417 | 4.9692 | 0.0087 | 0.0088 | 27.4281 | 1.2980 | 1750 |
| Primnoa_2__1@21 | 2.6125 | 0.1130 | 95.3727 | 4.0128 | 0.0063 | 0.0012 | 28.7377 | 0.8192 | 1775 |
| Primnoa_2__1@22 | 2.6455 | 0.1076 | 96.9022 | 4.3554 | 0.0052 | 0.0021 | 28.8156 | 1.1151 | 1800 |
| Primnoa_2__1@23 | 2.6394 | 0.1325 | 95.4628 | 3.4810 | 0.0058 | 0.0036 | 28.9208 | 1.5512 | 1825 |
| Primnoa_2__1@24 | 2.5617 | 0.1219 | 97.2905 | 4.4134 | 0.0056 | 0.0013 | 29.2614 | 0.9615 | 1850 |
| Primnoa_2__1@25 | 2.5372 | 0.0924 | 98.1080 | 3.9915 | 0.0060 | 0.0017 | 28.7271 | 1.2607 | 1875 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__1@26 | 2.5194 | 0.1341 | 96.6792 | 5.9928 | 0.0055 | 0.0012 | 30.0874 | 1.7083 | 1900 |
| Primnoa_2__1@27 | 2.6093 | 0.0971 | 96.8260 | 4.8481 | 0.0056 | 0.0014 | 30.8544 | 0.7570 | 1925 |
| Primnoa_2__1@28 | 2.5806 | 0.0923 | 99.6467 | 5.3840 | 0.0056 | 0.0019 | 32.3971 | 1.2475 | 1950 |
| Primnoa_2__1@29 | 2.5997 | 0.0795 | 97.5388 | 5.5001 | 0.0052 | 0.0019 | 31.0330 | 1.0110 | 1975 |
| Primnoa_2__1@30 | 2.6259 | 0.1407 | 96.3281 | 6.1248 | 0.0057 | 0.0012 | 30.8513 | 0.7264 | 2000 |
| Primnoa_2__1@31 | 2.6383 | 0.1056 | 96.4598 | 7.9009 | 0.0062 | 0.0015 | 30.7359 | 2.1215 | 2025 |
| Primnoa_2__1@32 | 2.5990 | 0.1268 | 97.5416 | 4.2577 | 0.0061 | 0.0016 | 31.5545 | 0.9164 | 2050 |
| Primnoa_2__1@33 | 2.5802 | 0.0945 | 97.3616 | 3.1244 | 0.0061 | 0.0020 | 31.4779 | 0.8448 | 2075 |
| Primnoa_2__1@34 | 2.6051 | 0.1022 | 93.1141 | 4.1882 | 0.0060 | 0.0017 | 29.3059 | 0.7116 | 2100 |
| Primnoa_2__1@35 | 2.5939 | 0.0919 | 94.0759 | 4.5762 | 0.0052 | 0.0012 | 31.7755 | 1.0675 | 2125 |
| Primnoa_2__1@36 | 2.5683 | 0.0860 | 96.5921 | 3.9144 | 0.0061 | 0.0079 | 32.6260 | 1.0670 | 2150 |
| Primnoa_2__1@37 | 2.6338 | 0.0966 | 96.9019 | 4.1340 | 0.0053 | 0.0019 | 31.3822 | 0.6614 | 2175 |
| Primnoa_2__1@38 | 2.6284 | 0.1023 | 95.8569 | 4.4059 | 0.0057 | 0.0011 | 31.0518 | 1.5364 | 2200 |
| Primnoa_2__1@39 | 2.6201 | 0.1190 | 92.8131 | 5.3689 | 0.0065 | 0.0012 | 29.2231 | 0.6786 | 2225 |
| Primnoa_2__1@40 | 2.6411 | 0.0995 | 94.2438 | 4.5359 | 0.0062 | 0.0010 | 28.8781 | 0.5975 | 2250 |
| Primnoa_2__1@41 | 2.6123 | 0.1088 | 97.6431 | 5.5774 | 0.0065 | 0.0017 | 30.2878 | 1.1780 | 2275 |
| Primnoa_2__1@42 | 2.5888 | 0.0958 | 98.1513 | 5.0051 | 0.0057 | 0.0016 | 30.6250 | 0.9951 | 2300 |
| Primnoa_2__1@43 | 2.6095 | 0.1114 | 94.4831 | 5.8587 | 0.0057 | 0.0015 | 28.9933 | 0.8874 | 2325 |
| Primnoa_2__1@44 | 2.6161 | 0.1481 | 95.8915 | 5.5010 | 0.0065 | 0.0087 | 29.3750 | 0.9562 | 2350 |
| Primnoa_2__1@45 | 2.6552 | 0.0923 | 92.6016 | 4.3098 | 0.0054 | 0.0009 | 29.2182 | 1.4863 | 2375 |
| Primnoa_2__1@46 | 2.6259 | 0.1214 | 96.4316 | 5.0001 | 0.0053 | 0.0014 | 31.0039 | 0.8315 | 2400 |
| Primnoa_2__1@47 | 2.5815 | 0.1349 | 98.3143 | 6.1649 | 0.0054 | 0.0015 | 30.1568 | 0.8787 | 2425 |
| Primnoa_2__1@48 | 2.6281 | 0.0733 | 95.3029 | 6.5409 | 0.0061 | 0.0013 | 30.7619 | 1.1176 | 2450 |
| Primnoa_2__1@49 | 2.6616 | 0.1308 | 92.8700 | 5.4583 | 0.0056 | 0.0017 | 30.5066 | 1.0782 | 2475 |
| Primnoa_2__1@50 | 2.6698 | 0.1779 | 94.2079 | 3.6384 | 0.0060 | 0.0013 | 30.3914 | 1.4136 | 2500 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__1@51 | 2.6597 | 0.0880 | 98.8512 | 4.6996 | 0.0054 | 0.0015 | 31.5655 | 1.4770 | 2525 |
| Primnoa_2__1@52 | 2.6371 | 0.1299 | 101.2050 | 4.1443 | 0.0056 | 0.0017 | 31.7636 | 1.4613 | 2550 |
| Primnoa_2__1@53 | 2.6310 | 0.1063 | 105.7117 | 6.9902 | 0.0048 | 0.0016 | 32.3607 | 0.8957 | 2575 |
| Primnoa_2__1@54 | 2.6450 | 0.1203 | 109.4276 | 6.6723 | 0.0052 | 0.0012 | 34.0171 | 1.0457 | 2600 |
| Primnoa_2__1@55 | 2.6037 | 0.0806 | 103.1957 | 5.9634 | 0.0050 | 0.0013 | 32.0800 | 1.5041 | 2625 |
| Primnoa_2__1@56 | 2.6405 | 0.1223 | 100.2300 | 6.1707 | 0.0057 | 0.0012 | 32.0481 | 1.1308 | 2650 |
| Primnoa_2__1@57 | 2.6499 | 0.1176 | 98.7658 | 5.2458 | 0.0055 | 0.0013 | 33.0679 | 1.0075 | 2675 |
| Primnoa_2__1@58 | 2.5548 | 0.1266 | 98.9856 | 6.0659 | 0.0061 | 0.0013 | 31.5536 | 1.2479 | 2700 |
| Primnoa_2__1@59 | 2.5940 | 0.1068 | 102.7687 | 5.7039 | 0.0052 | 0.0012 | 34.9034 | 1.7177 | 2725 |
| Primnoa_2__1@60 | 2.5553 | 0.1209 | 98.7191 | 4.3653 | 0.0060 | 0.0013 | 30.7486 | 1.2068 | 2750 |
| Primnoa_2__1@61 | 2.5835 | 0.0930 | 99.2964 | 6.0430 | 0.0056 | 0.0014 | 29.9441 | 1.5022 | 2775 |
| Primnoa_2__1@62 | 2.4981 | 0.1167 | 103.7728 | 5.9346 | 0.0054 | 0.0009 | 31.2320 | 1.3655 | 2800 |
| Primnoa_2__1@63 | 2.5524 | 0.1609 | 100.8215 | 5.5781 | 0.0054 | 0.0012 | 29.6352 | 1.6527 | 2825 |
| Primnoa_2__1@64 | 2.5328 | 0.1260 | 104.5334 | 6.6178 | 0.0057 | 0.0018 | 31.4046 | 1.4088 | 2850 |
| Primnoa_2__1@65 | 2.5866 | 0.1461 | 99.1657 | 5.7668 | 0.0058 | 0.0017 | 30.4299 | 1.5223 | 2875 |
| Primnoa_2__1@66 | 2.5862 | 0.1232 | 96.6331 | 5.4837 | 0.0065 | 0.0012 | 29.8208 | 1.2931 | 2900 |
| Primnoa_2__1@67 | 2.5405 | 0.1376 | 97.0235 | 5.7644 | 0.0063 | 0.0014 | 28.9876 | 1.4129 | 2925 |
| Primnoa_2__1@68 | 2.5525 | 0.0952 | 98.7465 | 8.0085 | 0.0062 | 0.0015 | 29.7983 | 1.2502 | 2950 |
| Primnoa_2__1@69 | 2.5326 | 0.1157 | 98.6134 | 6.9516 | 0.0057 | 0.0011 | 29.8031 | 1.2523 | 2975 |
| Primnoa_2__1@70 | 2.5062 | 0.1438 | 101.8439 | 6.6504 | 0.0047 | 0.0012 | 30.6911 | 1.0785 | 3000 |
| Primnoa_2__1@71 | 2.5275 | 0.1291 | 99.8410 | 6.7553 | 0.0061 | 0.0010 | 29.6290 | 1.6122 | 3025 |
| Primnoa_2__1@72 | 2.4886 | 0.1135 | 95.3200 | 6.6211 | 0.0064 | 0.0016 | 29.0128 | 1.2454 | 3050 |
| Primnoa_2__1@73 | 2.6017 | 0.0401 | 93.7998 | 1.9706 | 0.0063 | 0.0017 | 31.3912 | 0.6479 | 3075 |
| Primnoa_2__1@74 | 2.4262 | 0.2061 | 101.6928 | 9.3229 | 0.0058 | 0.0015 | 28.0991 | 1.4844 | 3100 |
| Primnoa_2__1@75 | 2.4852 | 0.1516 | 100.6516 | 7.8959 | 0.0059 | 0.0011 | 29.8524 | 1.2250 | 3125 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__1@76 | 2.4671 | 0.0895 | 103.6303 | 8.0522 | 0.0052 | 0.0012 | 31.2612 | 1.1775 | 3150 |
| Primnoa_2__1@77 | 2.5147 | 0.1093 | 102.9377 | 6.8031 | 0.0054 | 0.0010 | 30.6333 | 1.1142 | 3175 |
| Primnoa_2__1@78 | 2.5437 | 0.1045 | 100.9551 | 7.7038 | 0.0053 | 0.0016 | 29.1214 | 1.6342 | 3200 |
| Primnoa_2__1@79 | 2.2693 | 0.0462 | 125.8174 | 10.2005 | 0.0053 | 0.0016 | 27.3113 | 1.5666 | 3225 |
| Primnoa_2__1@80 | 2.2687 | 0.0785 | 120.2033 | 6.0175 | 0.0055 | 0.0070 | 26.9910 | 0.4764 | 3250 |
| Primnoa_2__2@1 | 2.6238 | 0.0509 | 93.8113 | 2.9513 | 0.0061 | 0.0011 | 26.7670 | 0.5043 | 3275 |
| Primnoa_2__2@2 | 2.6252 | 0.0449 | 92.3985 | 1.7458 | 0.0066 | 0.0014 | 24.2682 | 1.0352 | 3300 |
| Primnoa_2__2@3 | 2.6143 | 0.0531 | 89.3460 | 1.9779 | 0.0068 | 0.0016 | 24.5320 | 1.0510 | 3325 |
| Primnoa_2__2@4 | 2.5936 | 0.0417 | 88.1591 | 1.4587 | 0.0070 | 0.0016 | 26.2306 | 0.6558 | 3350 |
| Primnoa_2__2@5 | 2.6052 | 0.0646 | 92.6453 | 1.8908 | 0.0064 | 0.0012 | 25.4949 | 0.4034 | 3375 |
| Primnoa_2__2@6 | 2.6219 | 0.0629 | 93.0708 | 1.2353 | 0.0061 | 0.0018 | 25.6734 | 1.6713 | 3400 |
| Primnoa_2__2@7 | 2.6486 | 0.0513 | 93.9515 | 1.6812 | 0.0068 | 0.0013 | 28.4038 | 0.9696 | 3425 |
| Primnoa_2__2@8 | 2.6576 | 0.0375 | 95.4313 | 1.7664 | 0.0058 | 0.0014 | 25.3964 | 0.4117 | 3450 |
| Primnoa_2__2@9 | 2.6778 | 0.0491 | 95.7109 | 2.0699 | 0.0060 | 0.0007 | 24.8794 | 1.2168 | 3475 |
| Primnoa_2__2@10 | 2.6431 | 0.0493 | 91.9292 | 1.7689 | 0.0133 | 0.0365 | 25.4871 | 1.1926 | 3500 |
| Primnoa_2__2@11 | 2.6484 | 0.0458 | 93.4476 | 1.3917 | 0.0085 | 0.0095 | 26.4598 | 0.6455 | 3525 |
| Primnoa_2__2@12 | 2.6624 | 0.0544 | 95.0511 | 2.0190 | 0.0064 | 0.0009 | 26.0251 | 0.4038 | 3550 |
| Primnoa_2__2@13 | 2.5900 | 0.0608 | 97.5386 | 1.6223 | 0.0068 | 0.0013 | 27.8457 | 1.1723 | 3575 |
| Primnoa_2__2@14 | 2.6058 | 0.0321 | 98.2639 | 1.5719 | 0.0102 | 0.0283 | 28.4829 | 0.6362 | 3600 |
| Primnoa_2__2@15 | 2.6488 | 0.0474 | 94.8694 | 1.5931 | 0.0055 | 0.0011 | 24.8867 | 0.3712 | 3625 |
| Primnoa_2__2@16 | 2.6666 | 0.0325 | 94.4212 | 2.2280 | 0.0062 | 0.0013 | 25.3655 | 0.8988 | 3650 |
| Primnoa_2__2@17 | 2.6467 | 0.0601 | 91.2881 | 0.9002 | 0.0063 | 0.0011 | 26.9467 | 0.9981 | 3675 |
| Primnoa_2__2@18 | 2.6107 | 0.0314 | 92.7524 | 1.4388 | 0.0064 | 0.0011 | 25.2304 | 0.3354 | 3700 |
| Primnoa_2__2@19 | 2.5914 | 0.0381 | 93.4247 | 1.8871 | 0.0069 | 0.0009 | 24.5076 | 0.5572 | 3725 |
| Primnoa_2__2@20 | 2.5223 | 0.0420 | 96.4957 | 1.3252 | 0.0090 | 0.0149 | 27.5864 | 1.8773 | 3750 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__2@21 | 2.6123 | 0.0415 | 92.9818 | 1.1284 | 0.0060 | 0.0011 | 27.0720 | 0.6387 | 3775 |
| Primnoa_2__2@22 | 2.6221 | 0.0476 | 96.8572 | 1.7576 | 0.0057 | 0.0014 | 26.3042 | 0.6675 | 3800 |
| Primnoa_2__2@23 | 2.7412 | 0.2392 | 92.9136 | 2.1928 | 0.0124 | 0.0484 | 24.5474 | 1.0368 | 3825 |
| Primnoa_2__2@24 | 2.6863 | 0.0467 | 92.7559 | 1.6536 | 0.0232 | 0.0716 | 26.7266 | 0.7913 | 3850 |
| Primnoa_2__2@25 | 2.6892 | 0.0449 | 88.7953 | 1.1011 | 0.0067 | 0.0012 | 26.0712 | 0.3531 | 3875 |
| Primnoa_2__3@1 | 2.6760 | 0.0628 | 90.8418 | 1.7193 | 0.0135 | 0.0516 | 27.4041 | 0.8470 | 3900 |
| Primnoa_2__3@2 | 2.6653 | 0.0738 | 91.5713 | 1.7300 | 0.0121 | 0.0358 | 26.5383 | 0.5060 | 3925 |
| Primnoa_2__3@3 | 2.6883 | 0.0444 | 88.4799 | 2.1461 | 0.0108 | 0.0302 | 24.6979 | 1.3638 | 3950 |
| Primnoa_2__3@4 | 2.6323 | 0.0794 | 89.4450 | 1.4150 | 0.0108 | 0.0298 | 27.0382 | 1.3085 | 3975 |
| Primnoa_2__3@5 | 2.6345 | 0.0567 | 89.3225 | 1.8096 | 0.0082 | 0.0088 | 26.4507 | 0.7579 | 4000 |
| Primnoa_2__3@6 | 2.6069 | 0.0659 | 94.9319 | 1.1421 | 0.0067 | 0.0035 | 27.1120 | 0.9183 | 4025 |
| Primnoa_2__3@7 | 2.5323 | 0.0700 | 96.0389 | 1.6015 | 0.0070 | 0.0041 | 26.9858 | 1.4879 | 4050 |
| Primnoa_2__3@8 | 2.6339 | 0.0572 | 92.3640 | 1.2722 | 0.0064 | 0.0038 | 27.1386 | 0.4927 | 4075 |
| Primnoa_2__3@9 | 2.6152 | 0.0512 | 94.4993 | 1.9572 | 0.0060 | 0.0012 | 26.0805 | 0.3173 | 4100 |
| Primnoa_2__3@10 | 2.6403 | 0.0648 | 87.3244 | 3.7930 | 0.0075 | 0.0011 | 24.9228 | 0.8244 | 4125 |
| Primnoa_2__3@11 | 2.6030 | 0.1675 | 89.0253 | 9.1279 | 0.0066 | 0.0031 | 25.8530 | 4.1795 | 4150 |
| Primnoa_2__3@12 | 2.4691 | 0.0964 | 97.4505 | 4.5881 | 0.0067 | 0.0014 | 27.5144 | 0.7868 | 4175 |
| Primnoa_2__3@13 | 2.4760 | 0.1229 | 102.6032 | 5.5152 | 0.0062 | 0.0025 | 26.5245 | 0.6064 | 4200 |
| Primnoa_2__3@14 | 2.4992 | 0.1243 | 103.1920 | 4.4752 | 0.0116 | 0.0420 | 28.0382 | 1.8383 | 4225 |
| Primnoa_2__3@15 | 2.5331 | 0.1384 | 99.7170 | 5.1992 | 0.0061 | 0.0021 | 29.0388 | 1.1036 | 4250 |
| Primnoa_2__3@16 | 2.5577 | 0.2025 | 95.6718 | 3.7552 | 0.0064 | 0.0025 | 25.0091 | 1.0063 | 4275 |
| Primnoa_2__3@17 | 2.5695 | 0.1166 | 90.7081 | 3.6431 | 0.0101 | 0.0271 | 22.5181 | 1.2765 | 4300 |
| Primnoa_2__3@18 | 2.5380 | 0.0966 | 92.7172 | 5.4781 | 0.0083 | 0.0144 | 25.2578 | 1.2843 | 4325 |
| Primnoa_2__3@19 | 2.5089 | 0.0652 | 95.0736 | 5.2247 | 0.0078 | 0.0107 | 27.1003 | 0.7472 | 4350 |
| Primnoa_2__3@20 | 2.4944 | 0.1175 | 96.2362 | 5.2540 | 0.0070 | 0.0028 | 24.5015 | 0.5632 | 4375 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__3@21 | 2.5466 | 0.1081 | 101.0889 | 5.0685 | 0.0059 | 0.0027 | 28.4757 | 1.3866 | 4400 |
| Primnoa_2__3@22 | 2.5033 | 0.1105 | 98.8887 | 5.7130 | 0.0086 | 0.0182 | 26.2557 | 1.5286 | 4425 |
| Primnoa_2__3@23 | 2.5199 | 0.0803 | 105.1856 | 3.7690 | 0.0073 | 0.0137 | 28.7803 | 0.9282 | 4450 |
| Primnoa_2__3@24 | 2.5634 | 0.1258 | 98.0845 | 4.4460 | 0.0054 | 0.0018 | 24.9308 | 1.4839 | 4475 |
| Primnoa_2__3@25 | 2.5197 | 0.1362 | 104.2841 | 4.1273 | 0.0055 | 0.0026 | 28.7104 | 2.0459 | 4500 |
| Primnoa_2__3@26 | 2.5287 | 0.1237 | 101.4069 | 6.6186 | 0.0052 | 0.0020 | 26.4270 | 1.0097 | 4525 |
| Primnoa_2__3@27 | 2.5789 | 0.0804 | 97.9720 | 5.2633 | 0.0059 | 0.0019 | 24.3985 | 0.9866 | 4550 |
| Primnoa_2__3@28 | 2.6132 | 0.0906 | 95.7131 | 5.2882 | 0.0145 | 0.0609 | 25.3550 | 1.2214 | 4575 |
| Primnoa_2__3@29 | 2.5847 | 0.1488 | 94.8766 | 3.6351 | 0.0117 | 0.0194 | 25.0615 | 1.5162 | 4600 |
| Primnoa_2__3@30 | 2.5112 | 0.0961 | 100.8636 | 5.0021 | 0.0070 | 0.0018 | 27.0131 | 0.4932 | 4625 |
| Primnoa_2__3@31 | 2.5828 | 0.1141 | 95.9812 | 4.0479 | 0.0092 | 0.0056 | 23.5191 | 0.9441 | 4650 |
| Primnoa_2__3@32 | 2.5496 | 0.1054 | 95.9887 | 4.1651 | 0.0067 | 0.0035 | 25.2872 | 1.7756 | 4675 |
| Primnoa_2__3@33 | 2.4851 | 0.0968 | 101.9666 | 5.2527 | 0.0083 | 0.0121 | 29.5776 | 0.9581 | 4700 |
| Primnoa_2__3@34 | 2.4399 | 0.1062 | 100.9875 | 5.0349 | 0.0185 | 0.0453 | 25.6391 | 0.7973 | 4725 |
| Primnoa_2__3@35 | 2.4202 | 0.0512 | 94.4028 | 4.3063 | 0.0085 | 0.0036 | 23.3045 | 1.4260 | 4750 |
| Primnoa_2__3@36 | 2.4056 | 0.0782 | 88.4979 | 3.8797 | 0.0073 | 0.0032 | 24.9283 | 1.3041 | 4775 |
| Primnoa_2__3@37 | 2.4103 | 0.0974 | 98.1928 | 4.7956 | 0.0062 | 0.0025 | 26.5714 | 0.8783 | 4800 |
| Primnoa_2__3@38 | 2.4160 | 0.0777 | 95.9262 | 5.6371 | 0.0072 | 0.0071 | 25.8504 | 1.1229 | 4825 |
| Primnoa_2__3@39 | 2.4824 | 0.0747 | 92.0512 | 4.7600 | 0.0188 | 0.0495 | 23.9563 | 1.2539 | 4850 |
| Primnoa_2__3@40 | 2.3821 | 0.0947 | 94.2502 | 4.0757 | 0.0088 | 0.0152 | 24.7584 | 0.7808 | 4875 |
| Primnoa_2__3@41 | 2.4255 | 0.0843 | 92.6818 | 4.1789 | 0.0094 | 0.0147 | 22.9147 | 0.4490 | 4900 |
| Primnoa_2__3@42 | 2.4387 | 0.0746 | 91.0590 | 5.7914 | 0.0069 | 0.0015 | 24.0727 | 1.2692 | 4925 |
| Primnoa_2__3@43 | 2.4433 | 0.1252 | 90.2212 | 3.5446 | 0.0061 | 0.0018 | 25.2739 | 0.8152 | 4950 |
| Primnoa_2__3@44 | 2.3502 | 0.0957 | 93.7298 | 4.4963 | 0.0066 | 0.0020 | 26.0278 | 0.6019 | 4975 |
| Primnoa_2__3@45 | 2.3655 | 0.0715 | 92.4628 | 4.8510 | 0.0065 | 0.0046 | 24.7296 | 1.5623 | 5000 |
| Primnoa_2__3@46 | 2.4142 | 0.1115 | 94.0350 | 3.0147 | 0.0068 | 0.0049 | 26.0910 | 1.6357 | 5025 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__3@47 | 2.4279 | 0.0995 | 94.1677 | 4.6759 | 0.0054 | 0.0038 | 25.8268 | 1.1408 | 5050 |
| Primnoa_2__3@48 | 2.5034 | 0.1030 | 96.5804 | 3.6686 | 0.0051 | 0.0023 | 24.2989 | 0.7989 | 5075 |
| Primnoa_2__3@49 | 2.4232 | 0.1003 | 94.1713 | 4.1465 | 0.0124 | 0.0147 | 25.5862 | 1.5475 | 5100 |
| Primnoa_2__3@50 | 2.4438 | 0.0923 | 95.1686 | 3.2093 | 0.0065 | 0.0021 | 26.3158 | 1.3981 | 5125 |
| Primnoa_2__3@51 | 2.4171 | 0.1316 | 90.7296 | 4.0340 | 0.0107 | 0.0278 | 24.5801 | 0.3862 | 5150 |
| Primnoa_2__3@52 | 2.4778 | 0.1190 | 100.0807 | 4.0287 | 0.0102 | 0.0281 | 25.3076 | 1.5172 | 5175 |
| Primnoa_2__3@53 | 2.5064 | 0.1390 | 94.7526 | 3.4950 | 0.0061 | 0.0025 | 26.4757 | 1.8784 | 5200 |
| Primnoa_2__3@54 | 2.5180 | 0.0950 | 97.7183 | 4.3667 | 0.0061 | 0.0042 | 27.3994 | 0.7282 | 5225 |
| Primnoa_2__3@55 | 2.5323 | 0.0917 | 94.6422 | 3.5704 | 0.0062 | 0.0014 | 23.6969 | 0.6953 | 5250 |
| Primnoa_2__3@56 | 2.5687 | 0.1501 | 93.0273 | 3.7162 | 0.0067 | 0.0026 | 24.2826 | 1.4858 | 5275 |
| Primnoa_2__3@57 | 2.5634 | 0.0763 | 95.5037 | 5.2598 | 0.0089 | 0.0139 | 27.9803 | 0.8072 | 5300 |
| Primnoa_2__3@58 | 2.5806 | 0.0761 | 97.2989 | 5.5571 | 0.0069 | 0.0085 | 27.0982 | 0.4611 | 5325 |
| Primnoa_2__3@59 | 2.5753 | 0.0819 | 101.6598 | 4.7368 | 0.0061 | 0.0021 | 26.1351 | 1.5637 | 5350 |
| Primnoa_2__3@60 | 2.5436 | 0.0500 | 98.1679 | 4.5988 | 0.0089 | 0.0209 | 26.8536 | 1.4875 | 5375 |
| Primnoa_2__3@61 | 2.5728 | 0.1837 | 99.0552 | 4.6803 | 0.0067 | 0.0025 | 27.6766 | 0.6089 | 5400 |
| Primnoa_2__3@62 | 2.4936 | 0.1085 | 99.4718 | 4.3384 | 0.0069 | 0.0027 | 24.3364 | 0.5221 | 5425 |
| Primnoa_2__3@63 | 2.5066 | 0.0641 | 96.1940 | 4.5589 | 0.0067 | 0.0023 | 24.0381 | 1.2098 | 5450 |
| Primnoa_2__3@64 | 2.5715 | 0.0830 | 92.9360 | 4.1539 | 0.0133 | 0.0524 | 25.3238 | 0.5598 | 5475 |
| Primnoa_2__3@65 | 2.6079 | 0.1042 | 92.9559 | 4.0364 | 0.0313 | 0.1782 | 23.5937 | 0.5894 | 5500 |
| Primnoa_2__3@66 | 2.5520 | 0.0490 | 102.9192 | 5.4862 | 0.0067 | 0.0024 | 26.9429 | 1.3426 | 5525 |
| Primnoa_2__3@67 | 2.5715 | 0.0775 | 97.9918 | 5.0086 | 0.0070 | 0.0095 | 26.3418 | 1.3857 | 5550 |
| Primnoa_2__3@68 | 2.5036 | 0.0903 | 102.0356 | 5.3461 | 0.0063 | 0.0026 | 26.5115 | 0.5131 | 5575 |
| Primnoa_2__3@69 | 2.4754 | 0.0721 | 105.1205 | 4.3061 | 0.0134 | 0.0351 | 27.0501 | 1.1012 | 5600 |
| Primnoa_2__3@70 | 2.4407 | 0.0672 | 92.1776 | 5.2923 | 0.0117 | 0.0282 | 24.8284 | 1.3151 | 5625 |
| Primnoa_2__3@71 | 2.4437 | 0.1549 | 95.8087 | 2.7586 | 0.0078 | 0.0123 | 24.6285 | 0.8250 | 5650 |
| Primnoa_2__3@72 | 2.4143 | 0.0928 | 98.9676 | 4.0364 | 0.0067 | 0.0012 | 25.6934 | 0.9134 | 5675 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__3@73 | 2.5245 | 0.0846 | 95.1535 | 4.2806 | 0.0066 | 0.0017 | 23.8709 | 2.0101 | 5700 |
| Primnoa_2__3@74 | 2.5725 | 0.0730 | 93.2996 | 4.1597 | 0.0060 | 0.0019 | 26.0943 | 1.1395 | 5725 |
| Primnoa_2__3@75 | 2.5004 | 0.0975 | 99.6214 | 4.7699 | 0.0119 | 0.0408 | 27.4824 | 0.7988 | 5750 |
| Primnoa_2__3@76 | 2.5235 | 0.0695 | 99.6182 | 4.8250 | 0.0064 | 0.0026 | 26.5952 | 0.8706 | 5775 |
| Primnoa_2__3@77 | 2.5409 | 0.1205 | 93.6817 | 3.1187 | 0.0084 | 0.0095 | 25.0981 | 1.5972 | 5800 |
| Primnoa_2__3@78 | 2.5859 | 0.0650 | 91.6891 | 3.6671 | 0.0146 | 0.0217 | 25.0949 | 0.9239 | 5825 |
| Primnoa_2__3@79 | 2.6116 | 0.1305 | 93.5261 | 3.7861 | 0.0067 | 0.0022 | 24.3873 | 0.3754 | 5850 |
| Primnoa_2__3@80 | 2.5478 | 0.0578 | 100.4074 | 5.2882 | 0.0075 | 0.0063 | 26.3396 | 1.2769 | 5875 |
| Primnoa_2__3@81 | 2.5531 | 0.0776 | 99.7579 | 4.9595 | 0.0062 | 0.0016 | 27.2631 | 0.9757 | 5900 |
| Primnoa_2__3@82 | 2.5697 | 0.0843 | 100.5930 | 2.7867 | 0.0073 | 0.0066 | 28.0474 | 1.0609 | 5925 |
| Primnoa_2__3@83 | 2.5577 | 0.1156 | 99.8851 | 4.9092 | 0.0066 | 0.0045 | 25.3336 | 1.2465 | 5950 |
| Primnoa_2__3@84 | 2.4744 | 0.0604 | 91.2710 | 4.3138 | 0.0068 | 0.0018 | 24.9697 | 1.4323 | 5975 |
| Primnoa_2__3@85 | 2.5730 | 0.0732 | 91.4712 | 4.1207 | 0.0095 | 0.0197 | 27.5929 | 1.0761 | 6000 |
| Primnoa_2__3@86 | 2.5390 | 0.1111 | 98.5821 | 3.2294 | 0.0134 | 0.0457 | 27.4090 | 0.5866 | 6025 |
| Primnoa_2__3@87 | 2.5693 | 0.0760 | 94.0360 | 3.5748 | 0.0066 | 0.0040 | 24.7401 | 1.3392 | 6050 |
| Primnoa_2__3@88 | 2.5304 | 0.0742 | 90.5357 | 1.9302 | 0.0070 | 0.0020 | 25.4402 | 1.4552 | 6075 |
| Primnoa_2__3@89 | 2.5656 | 0.0854 | 90.5309 | 2.7944 | 0.0068 | 0.0017 | 26.2729 | 0.5057 | 6100 |
| Primnoa_2__3@90 | 2.5420 | 0.0440 | 95.8230 | 2.9057 | 0.0109 | 0.0340 | 26.1533 | 0.6999 | 6125 |
| Primnoa_2__3@91 | 2.6825 | 0.0369 | 96.3651 | 2.4628 | 0.0057 | 0.0013 | 26.9413 | 1.5716 | 6150 |
| Primnoa_2__3@92 | 2.6714 | 0.0808 | 96.5284 | 2.3149 | 0.0077 | 0.0158 | 27.7334 | 0.8320 | 6175 |
| Primnoa_2__3@93 | 2.6792 | 0.0826 | 97.6251 | 2.3327 | 0.0059 | 0.0017 | 25.5535 | 0.6583 | 6200 |
| Primnoa_2__3@94 | 2.6702 | 0.0572 | 99.1638 | 3.0874 | 0.0069 | 0.0047 | 27.9386 | 1.2054 | 6225 |
| Primnoa_2__3@95 | 2.6562 | 0.0591 | 99.4724 | 2.3653 | 0.0063 | 0.0011 | 30.3844 | 0.9479 | 6250 |
| Primnoa_2__3@96 | 2.6582 | 0.0925 | 97.8086 | 2.6629 | 0.0066 | 0.0016 | 29.2449 | 0.9250 | 6275 |
| Primnoa_2__3@97 | 2.6288 | 0.0903 | 100.8222 | 2.5430 | 0.0071 | 0.0036 | 29.3159 | 1.0572 | 6300 |
| Primnoa_2__3@98 | 2.6171 | 0.1037 | 100.4585 | 3.0527 | 0.0070 | 0.0013 | 29.7804 | 1.0690 | 6325 |

| File name | | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__3@99 | | 2.6739 | 0.0647 | 92.3571 | 3.1361 | 0.0086 | 0.0119 | 28.6975 | 0.4079 | 6350 |
| Primnoa_2__3@100 | | 2.6557 | 0.0654 | 95.4255 | 2.0454 | 0.0068 | 0.0015 | 28.5963 | 0.6649 | 6375 |
| Primnoa_2__4@1 | 2.6317 | 0.0428 | 98.8804 | 1.4935 | 0.0064 | 0.0052 | 30.1568 | 1.6436 | 6400 | 6375 |
| Primnoa_2__4@2 | | 2.6594 | 0.0676 | 96.0917 | 1.8926 | 0.0065 | 0.0015 | 28.9620 | 1.5304 | 6425 |
| Primnoa_2__4@3 | | 2.6507 | 0.0643 | 95.5146 | 1.8936 | 0.0079 | 0.0134 | 29.0031 | 0.4397 | 6450 |
| Primnoa_2__4@4 | | 2.6638 | 0.0792 | 97.7968 | 1.7997 | 0.0065 | 0.0063 | 28.1278 | 0.7999 | 6475 |
| Primnoa_2__4@5 | | 2.6930 | 0.0531 | 91.3160 | 2.4742 | 0.0061 | 0.0025 | 28.2815 | 1.1041 | 6500 |
| Primnoa_2__4@6 | | 2.6911 | 0.0940 | 96.2569 | 1.5234 | 0.0077 | 0.0125 | 30.0206 | 1.0829 | 6525 |
| Primnoa_2__4@7 | | 2.6848 | 0.0708 | 99.2247 | 2.5142 | 0.0059 | 0.0010 | 29.6979 | 0.5279 | 6550 |
| Primnoa_2__4@8 | | 2.7289 | 0.0450 | 99.1886 | 2.5974 | 0.0061 | 0.0013 | 28.2642 | 1.0237 | 6575 |
| Primnoa_2__4@9 | | 2.7156 | 0.0507 | 99.5455 | 3.2430 | 0.0057 | 0.0013 | 30.3613 | 1.1157 | 6600 |
| Primnoa_2__4@10 | | 2.6976 | 0.0450 | 97.4992 | 2.5664 | 0.0065 | 0.0014 | 28.9580 | 0.5498 | 6625 |
| Primnoa_2__4@11 | | 2.6698 | 0.0679 | 97.9984 | 2.8656 | 0.0073 | 0.0119 | 28.0300 | 0.3788 | 6650 |
| Primnoa_2__4@12 | | 2.6604 | 0.0422 | 97.6519 | 2.1160 | 0.0079 | 0.0118 | 28.9965 | 1.3864 | 6675 |
| Primnoa_2__4@13 | | 2.6406 | 0.0814 | 94.6506 | 0.9929 | 0.0066 | 0.0011 | 29.3900 | 1.4589 | 6700 |
| Primnoa_2__4@14 | | 2.5890 | 0.0732 | 96.4457 | 1.0996 | 0.0078 | 0.0111 | 28.6062 | 0.8135 | 6725 |
| Primnoa_2__4@15 | | 2.6185 | 0.0488 | 93.9669 | 2.3499 | 0.0073 | 0.0087 | 26.8862 | 1.0811 | 6750 |
| Primnoa_2__4@16 | | 2.7276 | 0.0547 | 98.2505 | 1.3208 | 0.0063 | 0.0010 | 28.8756 | 1.6892 | 6775 |
| Primnoa_2__4@17 | | 2.7743 | 0.0451 | 97.1874 | 1.6097 | 0.0062 | 0.0027 | 30.0726 | 0.5787 | 6800 |
| Primnoa_2__4@18 | | 2.7575 | 0.0455 | 102.3166 | 1.6803 | 0.0064 | 0.0024 | 30.9776 | 0.6661 | 6825 |
| Primnoa_2__4@19 | | 2.7665 | 0.0468 | 105.4446 | 1.4141 | 0.0058 | 0.0010 | 31.5940 | 1.6202 | 6850 |
| Primnoa_2__4@20 | | 2.7285 | 0.0697 | 103.9029 | 1.7345 | 0.0063 | 0.0010 | 32.3685 | 1.2777 | 6875 |
| Primnoa_2__4@21 | | 2.7091 | 0.0467 | 98.9024 | 1.7779 | 0.0067 | 0.0045 | 31.9543 | 0.7306 | 6900 |
| Primnoa_2__4@22 | | 2.7021 | 0.0377 | 98.9891 | 2.0972 | 0.0085 | 0.0150 | 29.8775 | 0.4643 | 6925 |
| Primnoa_2__4@23 | | 2.6912 | 0.0541 | 96.8861 | 1.4130 | 0.0068 | 0.0014 | 30.7621 | 1.4405 | 6950 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| | mmol/mol | | mmol/mol | | mmol/mol | | mmol/mol | | |
| Primnoa_2__4@24 | 2.6325 | 0.0500 | 90.0951 | 1.1901 | 0.0067 | 0.0016 | 28.3014 | 0.6253 | 6975 |
| Primnoa_2__4@25 | 2.6401 | 0.0582 | 91.2388 | 1.3396 | 0.0067 | 0.0009 | 27.2778 | 0.5494 | 7000 |
| Primnoa_2__4@26 | 2.6649 | 0.0381 | 89.5474 | 1.8204 | 0.0074 | 0.0076 | 27.3449 | 1.0271 | 7025 |
| Primnoa_2__4@27 | 2.7193 | 0.0414 | 92.7630 | 2.5238 | 0.0065 | 0.0010 | 29.5397 | 0.6354 | 7050 |
| Primnoa_2__4@28 | 2.6659 | 0.5683 | 96.2470 | 3.4770 | 0.0057 | 0.0046 | 30.2250 | 1.5272 | 7075 |
| Primnoa_2__4@29 | 2.7255 | 0.0391 | 95.7311 | 1.2307 | 0.0064 | 0.0012 | 29.0652 | 0.4368 | 7100 |
| Primnoa_2__4@30 | 2.6898 | 0.0430 | 103.3109 | 1.2880 | 0.0061 | 0.0018 | 32.2871 | 1.2702 | 7125 |
| Primnoa_2__5@1 | 2.5758 | 0.0713 | 94.6595 | 3.8252 | 0.0094 | 0.0192 | 26.6232 | 1.0245 | 7150 |
| Primnoa_2__5@2 | 2.6049 | 0.0528 | 90.7340 | 1.0176 | 0.0081 | 0.0096 | 27.8409 | 0.9474 | 7175 |
| Primnoa_2__5@3 | 2.5666 | 0.0479 | 91.0635 | 3.3434 | 0.0061 | 0.0011 | 29.5073 | 0.7042 | 7200 |
| Primnoa_2__5@4 | 2.6363 | 0.1269 | 86.7398 | 2.5339 | 0.0087 | 0.0170 | 29.0643 | 0.5894 | 7225 |
| Primnoa_2__5@5 | 2.6814 | 0.0695 | 87.1623 | 1.8989 | 0.0068 | 0.0019 | 29.3800 | 1.2929 | 7250 |
| Primnoa_2__5@6 | 2.7486 | 0.0799 | 85.9259 | 1.9476 | 0.0068 | 0.0010 | 31.0478 | 0.3240 | 7275 |
| Primnoa_2__5@7 | 2.7299 | 0.1182 | 86.5602 | 2.1991 | 0.0067 | 0.0018 | 31.7473 | 1.1928 | 7300 |
| Primnoa_2__5@8 | 2.6767 | 0.0878 | 87.2005 | 1.5752 | 0.0066 | 0.0015 | 29.7643 | 1.1476 | 7325 |
| Primnoa_2__5@9 | 2.6591 | 0.0956 | 93.0198 | 2.1076 | 0.0064 | 0.0022 | 31.3668 | 1.1926 | 7350 |
| Primnoa_2__5@10 | 2.6432 | 0.0554 | 91.6703 | 2.2971 | 0.0084 | 0.0138 | 32.0200 | 1.1363 | 7375 |
| Primnoa_2__5@11 | 2.6823 | 0.0642 | 90.8695 | 1.7947 | 0.0064 | 0.0012 | 30.1213 | 0.9155 | 7400 |
| Primnoa_2__5@12 | 2.6458 | 0.0642 | 95.9208 | 1.2628 | 0.0065 | 0.0013 | 31.3702 | 1.7214 | 7425 |
| Primnoa_2__5@13 | 2.6631 | 0.1028 | 96.7514 | 3.0660 | 0.0059 | 0.0016 | 32.3900 | 0.9345 | 7450 |
| Primnoa_2__5@14 | 2.6669 | 0.0574 | 95.8861 | 1.9304 | 0.0064 | 0.0015 | 32.4032 | 0.5175 | 7475 |
| Primnoa_2__5@15 | 2.6694 | 0.0539 | 100.3266 | 3.0974 | 0.0064 | 0.0017 | 30.2444 | 0.4573 | 7500 |
| Primnoa_2__5@16 | 2.6758 | 0.0666 | 102.5050 | 2.6247 | 0.0058 | 0.0015 | 30.8738 | 1.2076 | 7525 |
| Primnoa_2__5@17 | 2.6364 | 0.7171 | 86.9073 | 20.7123 | 0.0060 | 0.0035 | 28.7893 | 11.6966 | 7550 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| o | mmol/mol | | mmol/mol | | mmol/mol | | mmol/mol | | |
| Primnoa_2__5@18 | 2.6469 | 0.5468 | 87.0673 | 2.6679 | 0.0081 | 0.0127 | 31.5401 | 0.6050 | 7575 |
| Primnoa_2__5@19 | 2.7338 | 0.0547 | 92.2553 | 2.5684 | 0.0071 | 0.0011 | 33.6528 | 1.2162 | 7600 |
| Primnoa_2__5@20 | 2.7144 | 0.0749 | 97.3370 | 2.7803 | 0.0070 | 0.0012 | 35.2068 | 0.8393 | 7625 |
| Primnoa_2__5@21 | 2.7156 | 0.0875 | 95.0302 | 1.2140 | 0.0086 | 0.0105 | 35.0699 | 2.0734 | 7650 |
| Primnoa_2__5@22 | 2.7116 | 0.0990 | 98.2050 | 2.1214 | 0.0062 | 0.0013 | 33.4030 | 1.7868 | 7675 |
| Primnoa_2__5@23 | 2.7329 | 0.0908 | 94.6317 | 1.6456 | 0.0064 | 0.0014 | 31.9104 | 2.0223 | 7700 |
| Primnoa_2__5@24 | 2.7016 | 0.0894 | 98.6882 | 1.6082 | 0.0088 | 0.0174 | 32.4720 | 1.0884 | 7725 |
| Primnoa_2__5@25 | 2.7036 | 0.0660 | 98.5704 | 2.7711 | 0.0091 | 0.0288 | 29.4096 | 0.5774 | 7750 |
| Primnoa_2__5@26 | 2.7342 | 0.0565 | 100.5979 | 3.7206 | 0.0060 | 0.0011 | 30.9792 | 1.4110 | 7775 |
| Primnoa_2__5@27 | 2.7125 | 0.0794 | 100.7634 | 1.5576 | 0.0052 | 0.0009 | 33.1995 | 1.3401 | 7800 |
| Primnoa_2__5@28 | 2.6917 | 0.0588 | 100.5962 | 2.7073 | 0.0051 | 0.0008 | 32.3486 | 0.6716 | 7825 |
| Primnoa_2__5@29 | 2.7028 | 0.0520 | 97.0023 | 3.0246 | 0.0074 | 0.0099 | 29.2168 | 1.0555 | 7850 |
| Primnoa_2__5@30 | 2.7051 | 0.0585 | 94.2351 | 2.6999 | 0.0064 | 0.0029 | 28.1394 | 1.2424 | 7875 |
| Primnoa_2__5@31 | 2.6217 | 0.0790 | 103.6721 | 3.1911 | 0.0066 | 0.0019 | 33.1135 | 0.6530 | 7900 |
| Primnoa_2__5@32 | 2.6406 | 0.0433 | 100.3359 | 2.9635 | 0.0137 | 0.0203 | 30.7470 | 0.3772 | 7925 |
| Primnoa_2__5@33 | 2.6878 | 0.0950 | 95.9283 | 2.1090 | 0.0076 | 0.0038 | 33.7150 | 1.8885 | 7950 |
| Primnoa_2__5@34 | 2.7315 | 0.0500 | 99.9404 | 2.2121 | 0.0115 | 0.0149 | 37.3755 | 0.7561 | 7975 |
| Primnoa_2__5@35 | 2.7232 | 0.0561 | 99.8382 | 2.1861 | 0.0094 | 0.0089 | 31.3501 | 1.0989 | 8000 |
| Primnoa_2__5@36 | 2.7095 | 0.0649 | 102.0061 | 1.8227 | 0.0077 | 0.0083 | 34.9932 | 0.8383 | 8025 |
| Primnoa_2__5@37 | 2.6640 | 0.0811 | 95.2048 | 2.0141 | 0.0069 | 0.0017 | 31.8645 | 1.9016 | 8050 |
| Primnoa_2__5@38 | 2.6457 | 0.0861 | 90.4816 | 1.9381 | 0.0147 | 0.0265 | 28.1844 | 0.3757 | 8075 |
| Primnoa_2__5@39 | 2.6554 | 0.0631 | 95.3456 | 2.7434 | 0.0081 | 0.0069 | 29.4818 | 0.6220 | 8100 |
| Primnoa_2__5@40 | 2.6685 | 0.0400 | 94.1496 | 2.5346 | 0.0084 | 0.0149 | 30.7954 | 1.2540 | 8125 |
| Primnoa_2__5@41 | 2.6808 | 0.0396 | 95.1163 | 2.4454 | 0.0097 | 0.0140 | 32.7392 | 0.7514 | 8150 |
| Primnoa_2__5@42 | 2.6275 | 0.0620 | 94.3853 | 2.1918 | 0.0074 | 0.0057 | 30.6930 | 0.6701 | 8175 |
| Primnoa_2__5@43 | 2.7261 | 0.0650 | 90.6474 | 3.5362 | 0.0219 | 0.0365 | 28.3591 | 0.9759 | 8200 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__5@44 | 2.7019 | 0.0875 | 88.5787 | 1.7675 | 0.0071 | 0.0054 | 29.2133 | 1.1270 | 8225 |
| Primnoa_2__5@45 | 2.7240 | 0.0629 | 88.7522 | 1.0976 | 0.0076 | 0.0020 | 29.7917 | 0.5461 | 8250 |
| Primnoa_2__5@46 | 2.6438 | 0.1093 | 90.4562 | 2.3294 | 0.0123 | 0.0201 | 27.3813 | 0.6856 | 8275 |
| Primnoa_2__5@47 | 2.6534 | 0.0533 | 90.7771 | 2.3449 | 0.0098 | 0.0137 | 27.9876 | 1.0610 | 8300 |
| Primnoa_2__5@48 | 2.5716 | 0.0610 | 93.6541 | 2.4404 | 0.0129 | 0.0207 | 29.0223 | 1.0156 | 8325 |
| Primnoa_2__5@49 | 2.5682 | 0.0460 | 96.1216 | 1.6971 | 0.0087 | 0.0069 | 28.3768 | 0.5227 | 8350 |
| Primnoa_2__5@50 | 2.6621 | 0.0771 | 93.8268 | 2.1046 | 0.0063 | 0.0040 | 28.7865 | 0.9147 | 8375 |
| Primnoa_2__5@51 | 2.7433 | 0.0818 | 93.5524 | 2.6167 | 0.0061 | 0.0020 | 31.0626 | 0.9021 | 8400 |
| Primnoa_2__5@52 | 2.7233 | 0.0704 | 96.3417 | 2.9201 | 0.0067 | 0.0032 | 31.9685 | 0.5136 | 8425 |
| Primnoa_2__5@53 | 2.7162 | 0.0643 | 97.8945 | 2.0239 | 0.0093 | 0.0148 | 30.9653 | 0.5881 | 8450 |
| Primnoa_2__5@54 | 2.7111 | 0.0718 | 96.8418 | 3.3326 | 0.0128 | 0.0330 | 29.1415 | 1.2097 | 8475 |
| Primnoa_2__5@55 | 2.6647 | 0.0667 | 97.2008 | 1.7903 | 0.0062 | 0.0067 | 29.8903 | 1.1691 | 8500 |
| Primnoa_2__5@56 | 2.6598 | 0.0940 | 99.2022 | 2.0900 | 0.0107 | 0.0158 | 30.8374 | 0.6026 | 8525 |
| Primnoa_2__5@57 | 2.6485 | 0.0569 | 91.6531 | 2.0218 | 0.0071 | 0.0043 | 29.0296 | 1.1965 | 8550 |
| Primnoa_2__5@58 | 2.6864 | 0.0263 | 95.5989 | 2.3011 | 0.0077 | 0.0086 | 28.3922 | 0.4897 | 8575 |
| Primnoa_2__5@59 | 2.6974 | 0.0729 | 90.3851 | 2.2537 | 0.0061 | 0.0043 | 30.1291 | 0.5710 | 8600 |
| Primnoa_2__5@60 | 2.6808 | 0.2223 | 92.7874 | 2.8454 | 0.0114 | 0.0299 | 28.3626 | 0.5165 | 8625 |
| Primnoa_2__5@61 | 2.6062 | 0.0884 | 97.1336 | 3.0527 | 0.0108 | 0.0175 | 27.8820 | 1.3817 | 8650 |
| Primnoa_2__5@62 | 2.6142 | 0.1051 | 98.6457 | 2.8588 | 0.0063 | 0.0017 | 31.3164 | 1.6912 | 8675 |
| Primnoa_2__5@63 | 2.6867 | 0.0521 | 100.0537 | 1.7034 | 0.0059 | 0.0013 | 33.5956 | 0.4512 | 8700 |
| Primnoa_2__5@64 | 2.7239 | 0.0599 | 94.2401 | 3.8008 | 0.0085 | 0.0206 | 29.4275 | 0.7884 | 8725 |
| Primnoa_2__5@65 | 2.6835 | 0.0618 | 95.8953 | 3.3813 | 0.0059 | 0.0022 | 31.1439 | 1.0418 | 8750 |
| Primnoa_2__5@66 | 2.6562 | 0.0478 | 100.1996 | 2.7800 | 0.0061 | 0.0012 | 32.8683 | 0.8953 | 8775 |
| Primnoa_2__5@67 | 2.6822 | 0.0584 | 100.7731 | 2.3788 | 0.0100 | 0.0133 | 31.4141 | 0.7874 | 8800 |
| Primnoa_2__5@68 | 2.5447 | 0.0879 | 88.8900 | 1.9731 | 0.0076 | 0.0012 | 26.9468 | 1.6702 | 8825 |
| Primnoa_2__5@69 | 2.5671 | 0.0918 | 86.4227 | 1.8651 | 0.0077 | 0.0114 | 29.3967 | 0.9688 | 8850 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance from outer edge (um) |
|---|---|---|---|---|---|---|---|---|---|
| Primnoa_2__5@70 | 2.6116 | 0.0588 | 89.2495 | 3.3016 | 0.0074 | 0.0013 | 28.3123 | 0.6003 | 8875 |
| Primnoa_2__5@71 | 2.7128 | 0.0682 | 94.4955 | 3.1507 | 0.0059 | 0.0015 | 30.1104 | 0.7045 | 8900 |
| Primnoa_2__5@72 | 2.6735 | 0.0581 | 94.9475 | 2.6912 | 0.0057 | 0.0007 | 31.3783 | 1.0992 | 8925 |
| Primnoa_2__5@73 | 2.7143 | 0.0748 | 98.5396 | 3.2864 | 0.0091 | 0.0208 | 31.5303 | 0.7902 | 8950 |
| Primnoa_2__5@74 | 2.6688 | 0.0491 | 94.3532 | 1.2387 | 0.0059 | 0.0016 | 30.6613 | 0.5116 | 8975 |
| Primnoa_2__5@75 | 2.6290 | 0.0857 | 94.2624 | 2.2690 | 0.0061 | 0.0011 | 31.2353 | 1.4484 | 9000 |
| Primnoa_2__5@76 | 2.6432 | 0.0729 | 99.0467 | 2.4256 | 0.0060 | 0.0021 | 33.7976 | 1.0948 | 9025 |
| Primnoa_2__5@77 | 2.7540 | 0.0684 | 102.8642 | 2.1127 | 0.0076 | 0.0131 | 31.8913 | 0.8157 | 9050 |
| Primnoa_2__5@78 | 2.7199 | 0.0592 | 95.3567 | 2.7675 | 0.0078 | 0.0130 | 28.9822 | 0.7607 | 9075 |
| Primnoa_2__5@79 | 2.7840 | 0.0507 | 90.0108 | 2.9513 | 0.0069 | 0.0009 | 30.4220 | 0.9276 | 9100 |
| Primnoa_2__5@80 | 2.7463 | 0.1134 | 89.1301 | 1.9417 | 0.0082 | 0.0078 | 31.8104 | 0.8438 | 9125 |
| Primnoa_2__5@81 | 2.6800 | 0.0678 | 97.0300 | 1.6932 | 0.0087 | 0.0198 | 32.9649 | 0.5485 | 9150 |
| Primnoa_2__5@82 | 2.7377 | 0.0535 | 88.6592 | 2.1029 | 0.0088 | 0.0143 | 28.8240 | 1.4128 | 9175 |
| Primnoa_2__5@83 | 2.7498 | 0.0714 | 91.6654 | 1.7589 | 0.0060 | 0.0013 | 30.9262 | 1.1291 | 9200 |
| Primnoa_2__5@84 | 2.7410 | 0.0566 | 94.6814 | 2.9402 | 0.0103 | 0.0221 | 31.6705 | 0.7202 | 9225 |
| Primnoa_2__5@85 | 2.7593 | 0.0699 | 97.2937 | 2.6983 | 0.0064 | 0.0048 | 31.6866 | 0.4810 | 9250 |
| Primnoa_2__5@86 | 2.7498 | 0.0863 | 103.4267 | 2.5372 | 0.0059 | 0.0015 | 33.2887 | 1.9190 | 9275 |
| Primnoa_2__5@87 | 2.7257 | 0.1220 | 104.3090 | 4.5627 | 0.0082 | 0.0180 | 33.8920 | 2.4338 | 9300 |
| Primnoa_2__5@88 | 2.7289 | 0.0834 | 103.0582 | 2.7773 | 0.0059 | 0.0010 | 33.9888 | 0.8890 | 9325 |
| Primnoa_2__5@89 | 2.7760 | 0.0987 | 103.8500 | 3.5997 | 0.0067 | 0.0039 | 34.2616 | 1.8391 | 9350 |
| Primnoa_2__5@90 | 2.7117 | 0.0537 | 97.6412 | 2.7378 | 0.0069 | 0.0051 | 33.3555 | 1.0038 | 9375 |
| Primnoa_2__5@91 | 2.7203 | 0.0350 | 92.0732 | 3.4747 | 0.0070 | 0.0028 | 30.1956 | 0.9066 | 9400 |
| Primnoa_2__5@92 | 2.5928 | 0.0849 | 89.9960 | 2.3980 | 0.0100 | 0.0135 | 27.9396 | 0.4963 | |

------------------------------------**Rows highlighted in grey are the analyses corresponding to the gorgonin ring**------------------------------------

***P.pacifica* R1162-0016(SIMS data)**

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primno1@1 | 2.488113 | 0.199611 | 92.14039 | 7.59062 | 0.00704 | 0.001051 | 38.32427 | 0.43164 | 0 |
| primno1@2 | 2.505603 | 0.115302 | 88.57085 | 5.18562 | 0.007199 | 0.000807 | 36.94684 | 1.139458 | 25 |
| primno1@3 | 2.533055 | 0.114059 | 88.05946 | 4.728689 | 0.005833 | 0.000508 | 37.02369 | 0.447698 | 50 |
| primno1@4 | 2.53871 | 0.101993 | 91.72063 | 4.663393 | 0.005865 | 0.001334 | 36.39724 | 0.313127 | 75 |
| primno1@5 | 2.548418 | 0.113568 | 94.12588 | 4.738293 | 0.005709 | 0.000823 | 35.82802 | 1.541521 | 100 |
| primno1@6 | 2.579289 | 0.10776 | 95.64839 | 3.975503 | 0.005702 | 0.000996 | 36.36142 | 1.227153 | 125 |
| primno1@7 | 2.546681 | 0.107646 | 92.81929 | 3.666075 | 0.005798 | 0.000942 | 35.08953 | 0.77436 | 150 |
| primno1@8 | 2.487681 | 0.124284 | 83.88142 | 3.926998 | 0.006843 | 0.00096 | 34.24633 | 0.619491 | 175 |
| primno1@9 | 2.507715 | 0.090306 | 83.22673 | 3.79718 | 0.00649 | 0.000539 | 36.7538 | 1.538517 | 200 |
| primno1@10 | 2.539261 | 0.085905 | 83.73845 | 3.812861 | 0.006269 | 0.000751 | 35.46223 | 1.154915 | 225 |
| primno1@11 | 2.513599 | 0.111421 | 86.46207 | 3.8305 | 0.006329 | 0.000977 | 35.04498 | 0.472257 | 250 |
| primno1@12 | 2.531863 | 0.119907 | 86.54841 | 3.95445 | 0.006859 | 0.001021 | 32.23853 | 0.737069 | 275 |
| primno1@13 | 2.887763 | 0.100335 | 94.72446 | 5.431279 | 0.007103 | 0.00057 | 39.51254 | 0.319858 | 300 |
| primno1@14 | 2.771385 | 0.114776 | 122.9378 | 6.263274 | 0.00637 | 0.000819 | 40.81466 | 0.553036 | 325 |
| primno1@15 | 2.783147 | 0.11913 | 137.1684 | 6.536296 | 0.00637 | 0.000997 | 35.8676 | 0.927635 | 350 |
| primno1@16 | 2.544594 | 0.074621 | 85.0436 | 3.511876 | 0.006198 | 0.000383 | 33.06715 | 1.25312 | 375 |
| primno1@17 | 2.615313 | 0.07606 | 118.0975 | 6.313951 | 0.006407 | 0.00113 | 30.50633 | 0.301587 | 400 |
| primno1@18 | 2.509606 | 0.089945 | 100.766 | 4.443973 | 0.006539 | 0.000764 | 33.29258 | 0.420951 | 425 |
| primno1@19 | 2.461936 | 0.109845 | 93.27522 | 3.493109 | 0.006648 | 0.000951 | 38.87381 | 0.383355 | 450 |
| primno1@20 | 2.4866 | 0.082855 | 89.57371 | 3.900892 | 0.006397 | 0.000768 | 36.0793 | 0.416398 | 475 |
| primno2@1 | 2.497883 | 0.088073 | 81.55057 | 2.321814 | 0.006863 | 0.000633 | 32.823 | 0.298457 | 500 |
| primno2@2 | 2.460356 | 0.1021 | 83.58891 | 3.634587 | 0.006944 | 0.00085 | 32.71734 | 1.356041 | 525 |
| primno2@3 | 2.492442 | 0.097027 | 84.24592 | 3.34987 | 0.006687 | 0.000753 | 33.69078 | 1.075965 | 550 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primno2@4 | 2.526374 | 0.064269 | 84.83257 | 3.518204 | 0.006283 | 0.00076 | 35.28968 | 0.450114 | 575 |
| primno2@5 | 2.463884 | 0.09068 | 84.9939 | 3.230553 | 0.006475 | 0.000859 | 34.62912 | 0.51262 | 600 |
| primno2@6 | 2.450533 | 0.083133 | 86.2732 | 3.270498 | 0.006506 | 0.00112 | 34.68325 | 1.142847 | 625 |
| primno2@7 | 2.482326 | 0.089743 | 86.09291 | 3.327964 | 0.006377 | 0.000869 | 35.43978 | 0.625028 | 650 |
| primno2@8 | 2.558742 | 0.080665 | 84.51974 | 3.241744 | 0.006307 | 0.000594 | 34.87645 | 0.479236 | 675 |
| primno3@1 | 2.51623 | 0.071659 | 83.40127 | 3.033811 | 0.006301 | 0.000624 | 36.68447 | 0.335651 | 700 |
| primno3@2 | 2.555208 | 0.078273 | 83.09151 | 2.554261 | 0.006237 | 0.00067 | 36.57898 | 0.254159 | 725 |
| primno3@3 | 2.496997 | 0.086796 | 87.88264 | 2.222742 | 0.006299 | 0.000759 | 39.77813 | 0.4651 | 750 |
| primno3@4 | 2.573341 | 0.06567 | 86.54384 | 2.825787 | 0.006029 | 0.000607 | 37.29371 | 0.777686 | 775 |
| primno3@5 | 2.604978 | 0.061994 | 85.10047 | 2.591178 | 0.006334 | 0.000649 | 37.43075 | 0.919907 | 800 |
| primno3@6 | 2.58616 | 0.051567 | 85.07815 | 2.592367 | 0.00607 | 0.000543 | 37.85622 | 0.385054 | 825 |
| primno3@7 | 2.615341 | 0.0567 | 82.69702 | 2.138408 | 0.006833 | 0.000542 | 36.21031 | 0.658932 | 850 |
| primno3@8 | 2.575944 | 0.067035 | 82.03888 | 2.72003 | 0.007063 | 0.001123 | 35.98838 | 0.877996 | 875 |
| primno3@9 | 2.538992 | 0.064212 | 83.63567 | 2.781069 | 0.006902 | 0.000894 | 36.53196 | 0.825496 | 900 |
| primno3@10 | 2.605433 | 0.07453 | 85.32583 | 2.312752 | 0.006119 | 0.000549 | 38.7795 | 0.544198 | 925 |
| primno3@11 | 2.60797 | 0.069586 | 84.91313 | 1.949214 | 0.005891 | 0.00053 | 40.04705 | 0.465577 | 950 |
| primno3@12 | 2.592239 | 0.048469 | 83.30193 | 4.63866 | 0.007144 | 0.000391 | 49.46659 | 9.507675 | 975 |
| primno3@13 | 2.52743 | 0.07408 | 84.03276 | 1.886581 | 0.006682 | 0.000614 | 38.34981 | 0.587614 | 1000 |
| primno3@14 | 2.55113 | 0.044487 | 84.12056 | 2.018169 | 0.006093 | 0.000935 | 36.44124 | 0.306047 | 1025 |
| primno3@15 | 2.591223 | 0.056646 | 83.67726 | 1.925433 | 0.005782 | 0.000877 | 37.61268 | 0.38301 | 1050 |
| primno3@16 | 2.593315 | 0.062555 | 85.08157 | 1.944047 | 0.00564 | 0.000627 | 38.93495 | 0.425721 | 1075 |
| primno3@17 | 2.564697 | 0.086676 | 84.76291 | 2.261335 | 0.006187 | 0.000778 | 35.44015 | 0.828861 | 1100 |
| primno3@18 | 2.54797 | 0.047241 | 85.6664 | 1.80376 | 0.006165 | 0.00031 | 36.45578 | 0.798318 | 1125 |
| primno3@19 | 2.683514 | 0.050791 | 84.89647 | 2.026426 | 0.005577 | 0.00055 | 37.21099 | 0.7503 | 1150 |
| primno3@20 | 2.62216 | 0.053752 | 85.91297 | 1.750289 | 0.005864 | 0.000573 | 35.5012 | 0.454253 | 1175 |
| primno3@21 | 2.553616 | 0.043457 | 87.70886 | 2.579081 | 0.006108 | 0.000901 | 37.0502 | 0.692587 | 1200 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primno3@22 | 2.529122 | 0.047991 | 84.02558 | 1.661491 | 0.006119 | 0.00068 | 36.33518 | 0.308056 | 1225 |
| primno3@23 | 2.532006 | 0.062799 | 86.44154 | 1.637113 | 0.00625 | 0.000914 | 39.95834 | 0.933862 | 1250 |
| primno3@24 | 2.54615 | 0.056052 | 78.99382 | 1.351169 | 0.007263 | 0.000821 | 35.54101 | 0.350215 | 1275 |
| primno3@25 | 2.583001 | 0.042498 | 77.45322 | 2.089123 | 0.006897 | 0.000978 | 35.58835 | 0.30228 | 1300 |
| primno3@26 | 2.518492 | 0.073679 | 81.73123 | 1.692781 | 0.007049 | 0.000559 | 38.74897 | 0.922507 | 1325 |
| primno3@27 | 2.567989 | 0.057522 | 82.69884 | 2.09923 | 0.006911 | 0.000589 | 38.24275 | 0.652821 | 1350 |
| primno3@28 | 2.560187 | 0.049799 | 78.60191 | 1.346226 | 0.007383 | 0.000493 | 34.42236 | 0.49289 | 1375 |
| primno3@29 | 2.525923 | 0.054156 | 76.69165 | 1.917797 | 0.00749 | 0.000714 | 34.26821 | 0.189213 | 1400 |
| primno3@30 | 2.464992 | 0.043033 | 81.41566 | 1.436701 | 0.007058 | 0.000613 | 37.21601 | 0.276779 | 1425 |
| primno3@31 | 2.542364 | 0.054392 | 81.41596 | 1.674113 | 0.006453 | 0.000695 | 35.8798 | 0.553805 | 1450 |
| primnoa4@1 | 2.780376 | 0.03836 | 83.02832 | 1.5011 | 0.006974 | 0.000521 | 20.08249 | 0.515782 | 1475 |
| primnoa4@2 | 2.695043 | 0.045732 | 84.34995 | 0.617001 | 0.007244 | 0.000442 | 20.62044 | 0.179738 | 1500 |
| primnoa4@3 | 2.777378 | 0.03001 | 79.32925 | 1.011271 | 0.007922 | 0.000452 | 20.11945 | 0.143136 | 1525 |
| primnoa4@5 | 2.817445 | 0.022243 | 86.61233 | 1.386197 | 0.006424 | 0.000309 | 19.17344 | 0.291317 | 1550 |
| primnoa4@6 | 2.796551 | 0.029973 | 87.78746 | 1.590999 | 0.006498 | 0.000798 | 20.12012 | 0.314218 | 1575 |
| primnoa4@7 | 2.772043 | 0.027652 | 83.43754 | 1.758937 | 0.007615 | 0.000398 | 18.72479 | 0.27194 | 1600 |
| primnoa4@8 | 2.862753 | 0.026381 | 80.81078 | 1.48885 | 0.007083 | 0.00071 | 19.00471 | 0.237533 | 1625 |
| primnoa4@9 | 2.872909 | 0.030923 | 85.19525 | 0.966823 | 0.006239 | 0.000592 | 20.31243 | 0.388237 | 1650 |
| primnoa4@10 | 2.789774 | 0.030655 | 84.94721 | 1.799354 | 0.006548 | 0.000643 | 20.12931 | 0.437023 | 1675 |
| primnoa4@11 | 2.842003 | 0.029813 | 82.83353 | 0.848489 | 0.006888 | 0.000581 | 18.44191 | 0.138013 | 1700 |
| primnoa4@12 | 2.850942 | 0.024572 | 79.99298 | 0.441936 | 0.007266 | 0.00048 | 18.5898 | 0.128746 | 1725 |
| primnoa4@13 | 2.810196 | 0.037827 | 84.5677 | 1.645654 | 0.007355 | 0.000543 | 20.18134 | 0.130711 | 1750 |
| primnoa4@14 | 2.770291 | 0.02868 | 83.17149 | 1.176774 | 0.007087 | 0.00057 | 19.80957 | 0.256812 | 1775 |
| primnoa4@15 | 2.702064 | 0.020815 | 81.1564 | 0.631182 | 0.007954 | 0.000395 | 20.40403 | 0.252463 | 1800 |
| primnoa4@17 | 2.740994 | 0.02432 | 82.98373 | 1.004982 | 0.007247 | 0.000512 | 20.99602 | 0.242308 | 1825 |
| primnoa4@18 | 2.781608 | 0.02849 | 83.61921 | 0.724938 | 0.006989 | 0.000686 | 20.605 | 0.116821 | 1850 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa4@19 | 2.77175 | 0.034929 | 86.54061 | 1.86592 | 0.00683 | 0.000598 | 21.36221 | 0.300655 | 1875 |
| primnoa4@20 | 2.781603 | 0.049449 | 86.46383 | 2.376223 | 0.006782 | 0.000709 | 21.22577 | 0.390286 | 1900 |
| primnoa4@21 | 2.778961 | 0.036282 | 84.90769 | 1.50686 | 0.00716 | 0.000672 | 20.55337 | 0.185622 | 1925 |
| primnoa4@22 | 2.844137 | 0.039062 | 77.08022 | 1.852981 | 0.008683 | 0.000916 | 17.67757 | 0.195585 | 1950 |
| primnoa4@23 | 2.76831 | 0.024246 | 83.93368 | 0.500555 | 0.007236 | 0.000602 | 20.43737 | 0.195282 | 1975 |
| primnoa4@24 | 2.838394 | 0.021405 | 76.18587 | 0.379315 | 0.008501 | 0.000581 | 17.54924 | 0.091057 | 2000 |
| primnoa4@25 | 2.831905 | 0.031547 | 79.67025 | 1.022747 | 0.007384 | 0.000702 | 19.16865 | 0.085803 | 2025 |
| primnoa5@1 | 2.796755 | 0.027944 | 83.707 | 1.844195 | 0.006829 | 0.000589 | 19.41336 | 0.315176 | 2050 |
| primnoa5@2 | 2.78226 | 0.052857 | 86.06212 | 1.515596 | 0.007008 | 0.000851 | 19.40348 | 0.228064 | 2075 |
| primnoa5@3 | 2.809016 | 0.0485 | 83.27435 | 1.033108 | 0.007366 | 0.000671 | 19.01184 | 0.079749 | 2100 |
| primnoa5@4 | 2.891879 | 0.047497 | 80.74642 | 1.590054 | 0.007588 | 0.000733 | 18.59221 | 0.371107 | 2125 |
| primnoa5@5 | 2.835816 | 0.044493 | 83.32544 | 1.285459 | 0.007667 | 0.000774 | 19.33884 | 0.14512 | 2150 |
| primnoa5@6 | 2.815505 | 0.03165 | 83.99051 | 1.157096 | 0.007807 | 0.000637 | 19.37009 | 0.202002 | 2175 |
| primnoa5@7 | 2.799763 | 0.042469 | 83.85857 | 0.65791 | 0.007556 | 0.000767 | 18.71493 | 0.168236 | 2200 |
| primnoa5@8 | 2.858418 | 0.02941 | 84.32029 | 1.567421 | 0.007389 | 0.00044 | 19.19969 | 0.296501 | 2225 |
| primnoa5@9 | 2.773547 | 0.030015 | 87.38458 | 1.425598 | 0.007066 | 0.000555 | 20.11303 | 0.169488 | 2250 |
| primnoa5@10 | 2.797005 | 0.052217 | 81.8342 | 1.204846 | 0.007417 | 0.000592 | 18.63122 | 0.190689 | 2275 |
| primnoa5@11 | 2.742296 | 0.055095 | 81.37647 | 1.397413 | 0.007538 | 0.000627 | 18.89365 | 0.073894 | 2300 |
| primnoa5@12 | 2.673616 | 0.03211 | 78.36829 | 1.241011 | 0.007864 | 0.001226 | 19.16302 | 0.175295 | 2325 |
| primnoa5@13 | 2.650727 | 0.023872 | 77.00459 | 0.831045 | 0.008564 | 0.000454 | 19.88014 | 0.178648 | 2350 |
| primnoa5@22 | 2.769259 | 0.042795 | 95.20056 | 3.732109 | 0.007583 | 0.000691 | 16.35075 | 0.718748 | 2650 |
| primnoa5@25 | 2.738661 | 0.04762 | 87.66697 | 2.437379 | 0.007165 | 0.00055 | 20.04731 | 0.503809 | 2675 |
| primnoa5@26 | 2.755435 | 0.035694 | 87.504 | 1.386447 | 0.006845 | 0.000607 | 21.01105 | 0.24486 | 2700 |
| primnoa5@27 | 2.744071 | 0.037762 | 86.50773 | 2.422364 | 0.007317 | 0.000893 | 20.1457 | 0.311768 | 2725 |
| primnoa5@14 | 2.760452 | 0.073949 | 86.21702 | 1.520902 | 0.006588 | 0.000668 | 19.72611 | 0.234457 | 2750 |
| primnoa5@15 | 2.824449 | 0.041816 | 86.8136 | 1.611364 | 0.006487 | 0.000629 | 20.28481 | 0.233725 | 2775 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa5@16 | 2.834578 | 0.073406 | 87.48933 | 1.494016 | 0.006848 | 0.000181 | 20.64943 | 0.331006 | 2800 |
| primnoa5@17 | 2.826184 | 0.056914 | 88.36564 | 1.963385 | 0.006973 | 0.000327 | 20.70297 | 0.867328 | 2825 |
| primnoa6@2 | 2.770344 | 0.028736 | 90.90075 | 1.174133 | 0.006437 | 0.000917 | 21.23504 | 0.420059 | 2850 |
| primnoa6@1 | 2.758291 | 0.041468 | 91.20193 | 1.393595 | 0.006762 | 0.000593 | 20.80969 | 0.358659 | 2862 |
| primnoa6@3 | 2.774093 | 0.074389 | 86.17356 | 1.381502 | 0.007044 | 0.000871 | 19.38467 | 0.251501 | 2887 |
| primnoa6@4 | 2.743677 | 0.089364 | 87.96866 | 2.164476 | 0.007258 | 0.000988 | 20.84436 | 0.188955 | 2912 |
| primnoa6@6 | 2.727177 | 0.06893 | 90.29832 | 2.611759 | 0.00718 | 0.000561 | 20.10841 | 0.179327 | 2937 |
| primnoa6@8 | 2.757094 | 0.06448 | 89.23007 | 2.788591 | 0.007199 | 0.000791 | 20.58823 | 0.776132 | 2962 |
| primnoa6@9 | 2.754523 | 0.082124 | 87.64982 | 3.333058 | 0.007003 | 0.001055 | 21.43589 | 1.381914 | 2987 |
| primnoa6@10 | 2.82207 | 0.034472 | 84.72213 | 0.891289 | 0.006877 | 0.000651 | 20.08636 | 0.443493 | 3012 |
| primnoa6@11 | 2.785606 | 0.065859 | 84.39235 | 2.531429 | 0.006933 | 0.000799 | 19.5767 | 0.206183 | 3037 |
| primnoa6@12 | 2.793391 | 0.074512 | 84.50496 | 2.44619 | 0.006509 | 0.000646 | 19.86768 | 0.228865 | 3062 |
| primnoa6@13 | 2.768134 | 0.090535 | 86.72911 | 2.447991 | 0.006662 | 0.000755 | 20.22751 | 0.125884 | 3087 |
| primnoa6@14 | 2.761837 | 0.066139 | 86.27399 | 3.097892 | 0.006759 | 0.0008 | 19.78222 | 0.097116 | 3112 |
| primnoa6@15 | 2.751513 | 0.10538 | 87.12573 | 2.46456 | 0.007287 | 0.000867 | 19.94957 | 0.274026 | 3137 |
| primnoa6@16 | 2.800795 | 0.083364 | 84.05697 | 2.342637 | 0.007544 | 0.000806 | 19.38683 | 0.172191 | 3162 |
| primnoa6@17 | 2.825193 | 0.077555 | 85.51416 | 2.608837 | 0.00728 | 0.000532 | 18.72717 | 0.153819 | 3187 |
| primnoa6@18 | 2.730036 | 0.095646 | 93.82836 | 6.207583 | 0.0072 | 0.000777 | 19.44885 | 0.203207 | 3212 |
| primnoa6@19 | 2.724507 | 0.086864 | 90.70164 | 2.697767 | 0.007391 | 0.001069 | 19.98221 | 0.202339 | 3237 |
| primnoa6@20 | 2.697996 | 0.070704 | 95.32539 | 7.014975 | 0.006984 | 0.000595 | 20.71206 | 0.167192 | 3262 |
| primnoa6@21 | 2.756558 | 0.079291 | 90.32742 | 2.982163 | 0.006722 | 0.000282 | 20.78994 | 0.137088 | 3287 |
| primnoa6@22 | 2.764663 | 0.099099 | 94.25092 | 2.736573 | 0.006668 | 0.000987 | 21.73941 | 0.320997 | 3312 |
| primnoa6@23 | 2.764479 | 0.089676 | 94.20294 | 2.351829 | 0.00662 | 0.000672 | 22.04929 | 0.217816 | 3337 |
| primnoa6@24 | 2.774361 | 0.073787 | 95.35798 | 4.235421 | 0.006434 | 0.000862 | 20.29319 | 0.333159 | 3362 |
| primnoa6@25 | 2.708166 | 0.078604 | 84.63014 | 2.589635 | 0.007956 | 0.000945 | 17.77871 | 0.128729 | 3387 |
| primnoa6@26 | 2.780233 | 0.021738 | 92.39778 | 0.657572 | 0.006657 | 0.000841 | 20.14932 | 0.235044 | 3412 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa6@27 | 2.79317 | 0.023278 | 82.37812 | 0.913318 | 0.007808 | 0.000617 | 17.61602 | 0.238035 | 3437 |
| primnoa6@28 | 2.7622 | 0.082946 | 83.97897 | 2.664653 | 0.007194 | 0.000493 | 19.4656 | 0.207464 | 3462 |
| primnoa6@29 | 2.741038 | 0.07327 | 86.74911 | 2.413124 | 0.006606 | 0.000587 | 20.42781 | 0.199757 | 3487 |
| primnoa6@30 | 2.719376 | 0.088492 | 89.1429 | 3.407407 | 0.006549 | 0.000532 | 20.16782 | 0.309811 | 3512 |
| primnoa6@31 | 2.720427 | 0.124835 | 88.40476 | 2.385167 | 0.007324 | 0.001066 | 19.65342 | 0.193249 | 3537 |
| primnoa6@32 | 2.828184 | 0.090385 | 86.08597 | 3.143305 | 0.007492 | 0.000624 | 18.6415 | 0.198821 | 3562 |
| primnoa6@33 | 2.798991 | 0.081907 | 85.47143 | 2.569979 | 0.00719 | 0.000965 | 18.79541 | 0.123674 | 3587 |
| primnoa6@34 | 2.774268 | 0.081759 | 90.28872 | 2.377691 | 0.007154 | 0.000697 | 20.71718 | 0.120385 | 3612 |
| primnoa7@1 | 2.653086 | 0.124381 | 96.93193 | 5.531235 | 0.006959 | 0.000745 | 21.94953 | 0.435876 | 3637 |
| primnoa7@2 | 2.678348 | 0.092717 | 91.84136 | 3.182269 | 0.00696 | 0.000749 | 21.1231 | 0.362445 | 3662 |
| primnoa7@3 | 2.676636 | 0.084648 | 91.90452 | 4.850392 | 0.007098 | 0.000829 | 20.84859 | 0.303614 | 3687 |
| primnoa7@4 | 2.639032 | 0.087539 | 93.12422 | 3.177617 | 0.007175 | 0.001089 | 21.2148 | 0.361628 | 3712 |
| primnoa7@5 | 2.670685 | 0.096789 | 87.90472 | 3.134783 | 0.006756 | 0.000373 | 19.63721 | 0.743111 | 3737 |
| primnoa7@6 | 2.586973 | 0.096642 | 87.31952 | 3.787435 | 0.00797 | 0.001716 | 19.96035 | 1.049629 | 3762 |
| primnoa7@7 | 2.628929 | 0.106442 | 86.9034 | 3.581908 | 0.006852 | 0.001221 | 19.98379 | 1.009427 | 3787 |
| primnoa7@8 | 2.675731 | 0.095649 | 90.10769 | 3.254479 | 0.006874 | 0.000847 | 22.23169 | 0.76266 | 3812 |
| primnoa7@9 | 2.692958 | 0.096138 | 87.95196 | 3.806993 | 0.006752 | 0.000753 | 21.1403 | 0.742199 | 3837 |
| primnoa7@10 | 2.64976 | 0.085953 | 90.13959 | 3.339117 | 0.006834 | 0.000671 | 21.61484 | 0.914732 | 3862 |
| primnoa7@11 | 2.618006 | 0.122156 | 88.98132 | 3.119652 | 0.006637 | 0.001105 | 20.91082 | 0.763285 | 3887 |
| primnoa7@12 | 2.638531 | 0.100042 | 86.75674 | 3.054327 | 0.007045 | 0.001309 | 20.14724 | 1.076482 | 3912 |
| primnoa7@13 | 2.673031 | 0.10941 | 87.54896 | 3.382569 | 0.007556 | 0.000782 | 20.90628 | 1.718969 | 3937 |
| primnoa7@14 | 2.734817 | 0.115916 | 90.29055 | 3.879587 | 0.007176 | 0.000921 | 20.4414 | 1.012309 | 3962 |
| primnoa7@15 | 2.740322 | 0.083337 | 95.0873 | 5.511998 | 0.006482 | 0.000844 | 21.65381 | 1.289362 | 3987 |
| primnoa7@16 | 2.692407 | 0.09995 | 97.08824 | 3.734805 | 0.006274 | 0.000589 | 21.46989 | 0.852641 | 4012 |
| primnoa7@17 | 2.698617 | 0.088503 | 97.64072 | 3.69984 | 0.006207 | 0.000622 | 22.02921 | 1.226078 | 4037 |
| primnoa7@18 | 2.697461 | 0.090494 | 99.86794 | 3.790134 | 0.006469 | 0.000947 | 22.01395 | 1.097766 | 4062 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa7@19 | 2.640511 | 0.118538 | 99.77494 | 6.255005 | 0.007102 | 0.001095 | 21.14025 | 1.342967 | 4087 |
| primnoa7@20 | 2.649569 | 0.111752 | 92.33701 | 3.920206 | 0.007181 | 0.000865 | 20.93887 | 1.224247 | 4112 |
| primnoa8@1 | 2.64494 | 0.090349 | 89.35577 | 3.659623 | 0.00673 | 0.000485 | 20.08361 | 0.870973 | 4137 |
| primnoa8@2 | 2.626546 | 0.114428 | 93.86649 | 5.406862 | 0.006313 | 0.000484 | 21.18562 | 1.534786 | 4175 |
| primnoa8@3 | 2.619322 | 0.143207 | 94.03144 | 3.428559 | 0.006499 | 0.000544 | 21.36113 | 1.024057 | 4200 |
| primnoa8@4 | 2.631884 | 0.085209 | 95.58231 | 3.3561 | 0.006653 | 0.000646 | 21.72078 | 1.107053 | 4225 |
| primnoa8@5 | 2.618697 | 0.108546 | 97.27632 | 3.95172 | 0.006552 | 0.000662 | 22.39392 | 1.134286 | 4250 |
| primnoa8@6 | 2.642146 | 0.06562 | 95.46708 | 4.498705 | 0.006806 | 0.001073 | 22.07258 | 1.432129 | 4275 |
| primnoa8@7 | 2.626621 | 0.10157 | 92.32457 | 3.672226 | 0.00663 | 0.000426 | 21.24055 | 1.399213 | 4300 |
| primnoa8@8 | 2.636721 | 0.103417 | 95.90426 | 5.522048 | 0.006536 | 0.000751 | 22.05685 | 1.859999 | 4325 |
| primnoa8@9 | 2.626414 | 0.116875 | 98.21564 | 4.697233 | 0.006304 | 0.000596 | 24.66707 | 2.37004 | 4350 |
| primnoa8@10 | 2.656852 | 0.06307 | 96.80093 | 5.106635 | 0.006499 | 0.000442 | 21.51538 | 1.829854 | 4375 |
| primnoa8@11 | 2.644361 | 0.084779 | 97.0147 | 3.563925 | 0.006351 | 0.000521 | 20.41692 | 1.296537 | 4400 |
| primnoa8@12 | 2.644933 | 0.116226 | 95.16418 | 3.051393 | 0.00685 | 0.000781 | 19.62567 | 0.979495 | 4425 |
| primnoa8@13 | 2.626232 | 0.093591 | 94.14891 | 3.965113 | 0.006822 | 0.000767 | 20.27893 | 1.945377 | 4450 |
| primnoa8@14 | 2.606061 | 0.08596 | 94.77328 | 3.890571 | 0.006831 | 0.000779 | 21.13455 | 1.727756 | 4475 |
| primnoa8@15 | 2.5619 | 0.08321 | 95.82942 | 3.943025 | 0.007082 | 0.000929 | 21.45586 | 1.618629 | 4500 |
| primnoa8@16 | 2.600391 | 0.07203 | 95.80809 | 4.202337 | 0.006498 | 0.000841 | 20.91158 | 1.366267 | 4525 |
| primnoa8@17 | 2.634533 | 0.110142 | 96.57068 | 3.871485 | 0.006534 | 0.000715 | 19.89239 | 1.339244 | 4550 |
| primnoa8@18 | 2.596726 | 0.086898 | 99.71494 | 4.369624 | 0.006543 | 0.001014 | 21.50474 | 1.691718 | 4575 |
| primnoa9@1 | 2.588931 | 0.130158 | 92.7188 | 3.970178 | 0.006975 | 0.000756 | 19.8162 | 1.025433 | 4600 |
| primnoa9@2 | 2.624226 | 0.090752 | 91.86324 | 3.905554 | 0.007183 | 0.000854 | 20.11924 | 1.484493 | 4625 |
| primnoa9@3 | 2.583932 | 0.105046 | 94.68722 | 4.523675 | 0.007033 | 0.000587 | 22.04752 | 1.956811 | 4650 |
| primnoa9@4 | 2.576506 | 0.071271 | 96.64634 | 5.766037 | 0.006654 | 0.000679 | 22.13695 | 1.92419 | 4675 |
| primnoa9@5 | 2.521415 | 0.108161 | 97.94972 | 4.070951 | 0.008297 | 0.000748 | 21.76691 | 1.440764 | 4700 |
| primnoa9@6 | 2.496486 | 0.10457 | 92.51316 | 4.032203 | 0.007539 | 0.000817 | 21.50428 | 2.494711 | 4725 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa9@7 | 2.514537 | 0.10212 | 90.96797 | 3.759609 | 0.007563 | 0.000623 | 21.49309 | 1.922636 | 4750 |
| primnoa9@8 | 2.567712 | 0.11208 | 93.11848 | 3.935289 | 0.006697 | 0.00069 | 21.29485 | 1.574917 | 4775 |
| primnoa9@9 | 2.626078 | 0.112203 | 96.11565 | 3.976748 | 0.006668 | 0.000664 | 21.89297 | 1.612789 | 4800 |
| primnoa9@10 | 2.633747 | 0.112749 | 98.97396 | 4.776422 | 0.006643 | 0.000783 | 22.74988 | 1.702472 | 4825 |
| primnoa9@11 | 2.604746 | 0.109126 | 100.4751 | 5.175883 | 0.006602 | 0.000838 | 23.21094 | 1.856173 | 4850 |
| primnoa9@12 | 2.600651 | 0.099079 | 104.5539 | 5.12272 | 0.006496 | 0.000411 | 22.82346 | 1.638759 | 4875 |
| primnoa9@13 | 2.619609 | 0.082001 | 104.8037 | 5.527289 | 0.006496 | 0.000442 | 22.43795 | 1.70608 | 4900 |
| primnoa9@14 | 2.596977 | 0.134906 | 99.1681 | 4.470174 | 0.006878 | 0.000609 | 21.53084 | 1.814949 | 4925 |
| primnoa9@15 | 2.572821 | 0.103681 | 96.23846 | 4.299066 | 0.007358 | 0.000595 | 20.93141 | 1.889671 | 4950 |
| primnoa9@16 | 2.568047 | 0.088729 | 100.8325 | 6.291038 | 0.006723 | 0.000929 | 22.10311 | 2.62402 | 4975 |
| primnoa9@17 | 2.57405 | 0.12439 | 101.5379 | 5.264018 | 0.006246 | 0.000829 | 22.21496 | 1.928362 | 5000 |
| primnoa9@18 | 2.639794 | 0.085981 | 103.9449 | 4.415414 | 0.006148 | 0.000741 | 23.24288 | 1.356817 | 5025 |
| primnoa9@19 | 2.668081 | 0.123895 | 102.8389 | 4.612654 | 0.005882 | 0.001037 | 23.0136 | 1.763783 | 5050 |
| primnoa9@20 | 2.65961 | 0.096825 | 102.687 | 4.716887 | 0.005875 | 0.001115 | 22.28291 | 1.352889 | 5075 |
| primnoa9@21 | 2.644932 | 0.139961 | 103.1164 | 5.154881 | 0.005804 | 0.000399 | 21.9568 | 1.523116 | 5100 |
| primnoa9@22 | 2.633682 | 0.128462 | 103.5972 | 6.20256 | 0.006195 | 0.000722 | 23.05138 | 2.015524 | 5125 |
| primnoa9@23 | 2.5869 | 0.135787 | 103.5889 | 5.383676 | 0.006423 | 0.000502 | 22.83597 | 1.396995 | 5150 |
| primnoa9@24 | 2.553816 | 0.129743 | 98.06431 | 4.301334 | 0.006571 | 0.000699 | 23.19359 | 1.596407 | 5175 |
| primnoa9@25 | 2.563143 | 0.119691 | 97.89452 | 4.598235 | 0.007988 | 0.00097 | 45.6103 | 2.490311 | 5200 |
| primnoa9@26 | 2.539257 | 0.133839 | 98.92782 | 6.052867 | 0.007529 | 0.001177 | 37.36437 | 0.8603 | 5225 |
| primnoa9@27 | 2.594212 | 0.12381 | 96.54282 | 3.642481 | 0.007097 | 0.000936 | 23.53477 | 1.581052 | 5250 |
| primnoa9@28 | 2.537639 | 0.095804 | 97.73181 | 4.402329 | 0.006517 | 0.000639 | 22.10974 | 1.839243 | 5275 |
| primnoa9@29 | 2.537944 | 0.092949 | 101.0657 | 4.498055 | 0.00782 | 0.000909 | 21.99645 | 1.565957 | 5300 |
| primnoa9@30 | 2.561427 | 0.089544 | 95.96455 | 3.585921 | 0.007139 | 0.001116 | 21.77287 | 1.404447 | 5325 |
| primnoa9@31 | 2.589268 | 0.108609 | 94.45093 | 4.524362 | 0.007377 | 0.000671 | 21.59528 | 1.950282 | 5350 |
| primnoa9@32 | 2.592989 | 0.079083 | 101.9155 | 4.678134 | 0.007431 | 0.001403 | 21.57143 | 2.024019 | 5375 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa9@33 | 2.551018 | 0.122793 | 95.61935 | 4.482897 | 0.007127 | 0.001137 | 22.43966 | 2.466094 | 5400 |
| primnoa9@34 | 2.539108 | 0.120677 | 97.81152 | 4.245807 | 0.006722 | 0.00095 | 23.48004 | 2.642844 | 5425 |
| primnoa9@35 | 2.505096 | 0.124335 | 99.10788 | 4.763681 | 0.00653 | 0.000675 | 23.37714 | 2.263011 | 5450 |
| primnoa9@36 | 2.533866 | 0.116638 | 99.41644 | 4.579227 | 0.006314 | 0.000628 | 23.30617 | 1.949109 | 5475 |
| primnoa9@37 | 2.548062 | 0.085044 | 102.456 | 6.93914 | 0.006416 | 0.0008 | 23.14302 | 1.875342 | 5500 |
| primnoa9@39 | 2.568561 | 0.113329 | 99.94978 | 5.32015 | 0.006228 | 0.000567 | 23.41828 | 2.155283 | 5525 |
| primnoa9@40 | 2.58011 | 0.095188 | 99.92584 | 5.118187 | 0.006454 | 0.000685 | 22.91542 | 1.961984 | 5550 |
| primnoa9@41 | 2.540171 | 0.13882 | 99.27311 | 5.584411 | 0.006678 | 0.000413 | 22.52191 | 2.708477 | 5575 |
| primnoa9@42 | 2.548466 | 0.112066 | 94.71405 | 4.275249 | 0.006872 | 0.000667 | 20.97538 | 2.093736 | 5600 |
| primnoa9@43 | 2.526948 | 0.133108 | 93.87464 | 4.420745 | 0.007039 | 0.000718 | 21.91444 | 2.318985 | 5625 |
| primnoa9@44 | 2.523764 | 0.098513 | 96.80356 | 4.248528 | 0.006427 | 0.001003 | 23.95212 | 2.195237 | 5650 |
| primnoa9@45 | 2.5599 | 0.10878 | 98.28167 | 4.950238 | 0.006146 | 0.000568 | 23.62981 | 2.283498 | 5675 |
| primnoa9@46 | 2.619323 | 0.134377 | 98.67808 | 6.219898 | 0.005864 | 0.000733 | 22.61745 | 1.875331 | 5700 |
| primnoa9@47 | 2.663085 | 0.079291 | 99.49126 | 5.151835 | 0.006429 | 0.000873 | 22.31228 | 2.113886 | 5725 |
| primnoa9@48 | 2.631558 | 0.120398 | 99.80367 | 4.524078 | 0.006414 | 0.000688 | 22.48699 | 1.984927 | 5750 |
| primnoa9@49 | 2.592074 | 0.102921 | 102.0443 | 5.083185 | 0.006808 | 0.001065 | 23.21423 | 2.354687 | 5775 |
| primnoa9@50 | 2.580884 | 0.127294 | 102.1555 | 6.100303 | 0.006412 | 0.000858 | 22.67426 | 2.539835 | 5800 |
| primnoa9@51 | 2.556537 | 0.115318 | 103.396 | 5.969514 | 0.008562 | 0.001223 | 22.33958 | 2.999518 | 5825 |
| primnoa9@52 | 2.55097 | 0.128549 | 104.0124 | 5.180818 | 0.00688 | 0.000527 | 23.74754 | 2.643136 | 5850 |
| primnoa10@1 | 2.804028 | 0.056079 | 92.18957 | 1.335754 | 0.007726 | 0.002915 | 38.60116 | 0.872793 | 5875 |
| primnoa10@2 | 2.76207 | 0.060031 | 93.57651 | 1.624626 | 0.006921 | 0.002615 | 38.84261 | 1.001823 | 5900 |
| primnoa10@3 | 2.758319 | 0.056684 | 94.86282 | 2.529218 | 0.007378 | 0.002445 | 43.16836 | 1.34625 | 5925 |
| primnoa10@5 | 2.758372 | 0.055481 | 92.60593 | 2.132983 | 0.007217 | 0.002499 | 43.12334 | 1.530091 | 5950 |
| primnoa10@6 | 2.688675 | 0.059665 | 92.43972 | 2.892566 | 0.008322 | 0.003424 | 43.54162 | 1.223403 | 5975 |
| primnoa10@7 | 2.672059 | 0.062661 | 92.06661 | 1.771057 | 0.008751 | 0.003204 | 43.97798 | 1.299149 | 6000 |
| primnoa10@8 | 2.641993 | 0.084018 | 96.03199 | 2.075262 | 0.009041 | 0.003092 | 45.03233 | 1.433693 | 6025 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa10@9 | 2.64481 | 0.080375 | 97.47927 | 3.613591 | 0.007996 | 0.002987 | 45.18567 | 1.458087 | 6050 |
| primnoa10@10 | 2.642609 | 0.076082 | 101.9213 | 2.55581 | 0.007419 | 0.003612 | 44.17777 | 1.223006 | 6075 |
| primnoa10@11 | 2.651075 | 0.079339 | 97.60116 | 4.213887 | 0.006632 | 0.004814 | 44.82298 | 1.855274 | 6100 |
| primnoa10@12 | 2.618599 | 0.128733 | 98.10015 | 4.19605 | 0.008482 | 0.004243 | 42.38826 | 1.539747 | 6125 |
| primnoa10@13 | 2.560229 | 0.08404 | 109.935 | 5.869811 | 0.007556 | 0.002961 | 46.00046 | 3.099967 | 6150 |
| primnoa10@14 | 2.483807 | 0.079346 | 112.7846 | 8.137034 | 0.005894 | 0.002248 | 47.45421 | 3.562901 | 6175 |
| primnoa10@15 | 2.520995 | 0.136084 | 103.3741 | 5.331493 | 0.00849 | 0.004679 | 43.49186 | 3.131204 | 6200 |
| primnoa10@16 | 2.552422 | 0.112159 | 97.17026 | 4.25134 | 0.009348 | 0.003714 | 42.33087 | 2.179929 | 6225 |
| primnoa10@17 | 2.354427 | 0.091023 | 108.4376 | 10.2163 | 0.007468 | 0.005121 | 42.69064 | 1.975773 | 6250 |
| primnoa10@18 | 2.251454 | 0.127961 | 118.5733 | 8.768888 | 0.007833 | 0.006167 | 45.67001 | 5.685613 | 6275 |
| primnoa10@19 | 2.038944 | 0.071245 | 136.6116 | 9.157569 | 0.007306 | 0.007128 | 48.0786 | 15.11537 | 6300 |
| primnoa10@20 | 2.730009 | 0.067802 | 97.97825 | 5.58429 | 0.007407 | 0.003175 | 43.08029 | 1.239322 | 6325 |
| primnoa10@21 | 2.780143 | 0.065064 | 93.87371 | 1.515942 | 0.007521 | 0.002097 | 44.89156 | 1.791387 | 6350 |
| primnoa10@22 | 2.881479 | 0.058763 | 93.83244 | 2.793539 | 0.006799 | 0.002338 | 44.24458 | 2.065222 | 6375 |
| primnoa10@23 | 2.827195 | 0.041297 | 95.79368 | 3.049358 | 0.00659 | 0.001551 | 44.22233 | 2.202091 | 6400 |
| primnoa10@24 | 2.7635 | 0.124725 | 99.57954 | 2.452704 | 0.006536 | 0.002347 | 47.69633 | 2.048131 | 6425 |
| primnoa10@25 | 2.653074 | 0.092497 | 108.4677 | 5.989115 | 0.006496 | 0.003716 | 50.02121 | 4.49062 | 6450 |
| primnoa10@26 | 2.827613 | 0.055522 | 102.9351 | 1.838076 | 0.006626 | 0.002275 | 46.91407 | 0.569444 | 6475 |
| primnoa10@27 | 2.820785 | 0.052892 | 101.231 | 2.124725 | 0.006713 | 0.002901 | 45.93163 | 0.894402 | 6500 |
| primnoa10@28 | 2.759141 | 0.036157 | 105.3431 | 2.732485 | 0.006873 | 0.002206 | 48.58882 | 1.229437 | 6525 |
| primnoa10@29 | 2.7173 | 0.053178 | 91.31961 | 2.587697 | 0.00781 | 0.001254 | 40.74517 | 1.21957 | 6550 |
| primnoa10@30 | 2.697103 | 0.037079 | 88.5196 | 1.297721 | 0.007886 | 0.001592 | 40.23296 | 0.762558 | 6575 |
| primnoa10@31 | 2.711364 | 0.05098 | 93.16559 | 1.803696 | 0.007636 | 0.001703 | 41.70938 | 0.85913 | 6600 |
| primnoa10@32 | 2.736369 | 0.035921 | 88.74172 | 2.118643 | 0.007367 | 0.002095 | 39.98502 | 1.281978 | 6625 |
| primnoa10@33 | 2.73468 | 0.057525 | 91.77505 | 2.94343 | 0.007499 | 0.002214 | 37.9308 | 1.895414 | 6650 |
| primnoa10@34 | 2.679462 | 0.071999 | 89.8826 | 1.081789 | 0.00637 | 0.001064 | 42.24009 | 0.941369 | 6675 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa10@35 | 2.78966 | 0.052276 | 93.30119 | 2.523545 | 0.006866 | 0.001713 | 42.54306 | 0.992083 | 6700 |
| primnoa11@1 | 2.832496 | 0.095839 | 93.89441 | 2.921222 | 0.005874 | 0.000982 | 43.56202 | 0.80604 | 6725 |
| primnoa11@2 | 2.876247 | 0.07101 | 99.62021 | 2.581004 | 0.006173 | 0.00102 | 46.33501 | 1.08783 | 6750 |
| primnoa11@3 (version 1) | 2.851964 | 0.048497 | 95.51416 | 2.308395 | 0.006379 | 0.001433 | 44.38358 | 1.366395 | 6775 |
| primnoa11@4 (version 1) | 2.867502 | 0.04662 | 96.77321 | 2.509773 | 0.00615 | 0.002251 | 45.48581 | 0.93485 | 6800 |
| primnoa11@5 (version 1) | 2.797285 | 0.068512 | 100.321 | 2.105439 | 0.006158 | 0.001323 | 47.37709 | 1.254476 | 6825 |
| primnoa11@6 (version 1) | 2.744784 | 0.063734 | 103.3703 | 1.989683 | 0.006361 | 0.00103 | 47.97616 | 1.2558 | 6850 |
| primnoa11@7 (version 1) | 2.701584 | 0.108125 | 99.186 | 1.121359 | 0.006767 | 0.001795 | 46.35524 | 0.951338 | 6875 |
| primnoa11@8 | 2.690128 | 0.063876 | 90.96509 | 2.892591 | 0.007407 | 0.001478 | 43.17475 | 1.320318 | 6900 |
| primnoa11@9 | 2.670173 | 0.070215 | 93.44058 | 2.043325 | 0.007779 | 0.002927 | 44.84123 | 1.555993 | 6925 |
| primnoa11@10 | 2.681469 | 0.076046 | 89.88443 | 2.846703 | 0.006713 | 0.001687 | 45.23661 | 4.052216 | 6950 |
| primnoa11@12 | 2.780649 | 0.056222 | 93.57487 | 1.730218 | 0.007044 | 0.002451 | 46.21492 | 5.974663 | 6975 |
| primnoa11@13 | 2.634533 | 0.055286 | 103.0311 | 1.950967 | 0.006694 | 0.003225 | 48.57376 | 3.096099 | 7000 |
| primnoa11@14 ( | 2.633213 | 0.152208 | 106.1744 | 7.930141 | 0.006347 | 0.0031 | 47.70875 | 1.256017 | 7025 |
| primnoa11@15 | 2.714553 | 0.062874 | 98.31485 | 2.204765 | 0.008007 | 0.00209 | 45.39662 | 1.078488 | 7050 |
| primnoa11@16 | 2.808808 | 0.045082 | 94.85902 | 2.051805 | 0.006954 | 0.003099 | 41.46368 | 1.072027 | 7075 |
| primnoa11@17 | 2.724839 | 0.077944 | 95.51628 | 1.750856 | 0.007847 | 0.002046 | 44.03416 | 1.34766 | 7100 |
| primnoa11@18 | 2.744397 | 0.054957 | 92.58967 | 2.445286 | 0.007785 | 0.001814 | 45.03026 | 2.007451 | 7125 |
| primnoa11@19 | 2.732371 | 0.044121 | 89.3567 | 3.270202 | 0.006835 | 0.001406 | 44.56257 | 1.376149 | 7150 |
| primnoa11@20 | 2.857016 | 0.045581 | 88.52366 | 1.454587 | 0.007185 | 0.000978 | 43.96332 | 0.796342 | 7175 |
| primnoa11@21 | 2.824967 | 0.060622 | 94.06267 | 2.60133 | 0.007679 | 0.002756 | 46.81427 | 1.220965 | 7200 |
| primnoa11@22 | 2.830791 | 0.057429 | 95.92229 | 1.213151 | 0.006955 | 0.002294 | 45.38788 | 1.438668 | 7225 |
| primnoa11@23 (version 1) | 2.84281 | 0.07204 | 89.64473 | 1.540539 | 0.007283 | 0.001616 | 43.94623 | 1.329104 | 7250 |
| primnoa11@24 | 2.880205 | 0.03783 | 90.92922 | 1.413394 | 0.007004 | 0.001145 | 41.94397 | 1.407928 | 7275 |
| primnoa11@25 | 2.869283 | 0.061262 | 93.03824 | 1.157308 | 0.006352 | 0.001402 | 43.49002 | 0.930463 | 7300 |
| primnoa11@26 | 2.822817 | 0.052651 | 95.80292 | 1.623452 | 0.006835 | 0.002303 | 42.8052 | 1.407107 | 7325 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa11@27 (version 1) | 2.649794 | 0.068876 | 103.3386 | 2.15447 | 0.006662 | 0.002647 | 47.55121 | 1.269412 | 7350 |
| primnoa12@1 (version 1) | 2.76715 | 0.059933 | 94.04436 | 2.765186 | 0.006672 | 0.000808 | 47.37667 | 1.676488 | 7375 |
| primnoa12@2 (version 1) | 2.81591 | 0.060285 | 87.92784 | 1.253518 | 0.006813 | 0.001235 | 42.65513 | 0.730184 | 7400 |
| primnoa12@3 | 2.802984 | 0.033896 | 88.9378 | 0.927815 | 0.007218 | 0.00111 | 41.65601 | 0.683035 | 7425 |
| primnoa12@4 | 2.797855 | 0.049227 | 89.92407 | 2.094594 | 0.007171 | 0.001666 | 43.12887 | 1.950514 | 7450 |
| primnoa12@5 | 2.763757 | 0.070037 | 91.89612 | 1.245122 | 0.007375 | 0.001501 | 43.4039 | 0.750719 | 7475 |
| primnoa12@6 | 2.76598 | 0.049027 | 94.07833 | 1.590737 | 0.006676 | 0.000997 | 43.872 | 1.275082 | 7500 |
| primnoa12@7 (version 1) | 2.694402 | 0.040509 | 92.10839 | 1.318836 | 0.007021 | 0.001182 | 42.41658 | 1.073794 | 7525 |
| primnoa12@8 (version 1) | 2.666644 | 0.060209 | 90.76867 | 1.191172 | 0.007332 | 0.001097 | 40.95223 | 0.73043 | 7550 |
| primnoa12@9 (version 1) | 2.726335 | 0.07468 | 89.38303 | 1.462512 | 0.006742 | 0.001477 | 41.04797 | 1.016383 | 7575 |
| primnoa12@10 (version 1) | 2.746405 | 0.065766 | 90.20292 | 1.997467 | 0.006434 | 0.001815 | 41.11745 | 1.582916 | 7600 |
| primnoa12@11 (version 1) | 2.753579 | 0.065476 | 96.477 | 1.838012 | 0.005964 | 0.001286 | 43.74414 | 1.355039 | 7625 |
| primnoa12@12 (version 1) | 2.781706 | 0.051007 | 111.2328 | 3.563618 | 0.006301 | 0.001227 | 47.55879 | 1.37589 | 7650 |
| primnoa12@13 (version 1) | 2.783887 | 0.048141 | 102.4546 | 1.646946 | 0.005608 | 0.001405 | 47.5924 | 1.087719 | 7675 |
| primnoa12@14 (version 1) | 2.874049 | 0.070869 | 93.20549 | 1.550832 | 0.005994 | 0.001652 | 43.62549 | 1.401252 | 7700 |
| primnoa12@15 (version 1) | 2.838324 | 0.062269 | 88.31383 | 2.915779 | 0.006435 | 0.001736 | 41.54579 | 1.353691 | 7725 |
| primnoa12@16 (version 1) | 2.83322 | 0.064324 | 94.35294 | 0.924768 | 0.006536 | 0.002313 | 42.52586 | 0.562313 | 7750 |
| primnoa12@17 (version 1) | 2.844719 | 0.030766 | 86.42451 | 1.093595 | 0.0074 | 0.002449 | 41.35427 | 0.49297 | 7775 |
| primnoa13@1 (version 1) | 2.802166 | 0.047987 | 86.99466 | 0.731523 | 0.007444 | 0.002404 | 41.27472 | 0.618029 | 8200 |
| primnoa13@2 (version 1) | 2.828738 | 0.050313 | 86.52108 | 1.399234 | 0.006707 | 0.001399 | 40.12192 | 0.647035 | 8225 |
| primnoa13@3 (version 1) | 2.805808 | 0.080519 | 92.57845 | 1.927443 | 0.007453 | 0.001059 | 40.38064 | 0.700728 | 8250 |
| primnoa13@4 | 2.788254 | 0.056408 | 93.28324 | 2.560961 | 0.00679 | 0.001806 | 42.2608 | 1.465844 | 8275 |
| primnoa13@5 | 2.725835 | 0.035213 | 93.79831 | 1.742383 | 0.006278 | 0.000849 | 42.90328 | 1.423058 | 8300 |
| primnoa13@6 | 2.778156 | 0.044964 | 98.29728 | 1.178037 | 0.005663 | 0.000976 | 44.18912 | 0.962836 | 8325 |
| primnoa13@7 | 2.760683 | 0.063141 | 96.98678 | 1.431219 | 0.006059 | 0.000797 | 45.56855 | 0.953269 | 8350 |
| primnoa13@8 | 2.787893 | 0.063339 | 93.62141 | 1.503424 | 0.006228 | 0.001329 | 44.09722 | 1.322384 | 8375 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa13@9 (version 1) | 2.745985 | 0.041878 | 95.94677 | 1.260801 | 0.006238 | 0.001814 | 44.20654 | 0.986539 | 8400 |
| primnoa13@10 (Autosaved) | 2.756856 | 0.028438 | 97.03254 | 3.762863 | 0.005965 | 0.001242 | 42.40244 | 0.91816 | 8425 |
| primnoa13@11 (version 1) | 2.78101 | 0.039566 | 91.37147 | 1.093034 | 0.00709 | 0.001698 | 48.17267 | 2.644645 | 8450 |
| primnoa13@12 (version 1) | 2.792536 | 0.078279 | 85.58128 | 0.783968 | 0.007859 | 0.001705 | 42.75178 | 2.399575 | 8475 |
| primnoa13@13 (version 1) | 2.819547 | 0.041522 | 84.36379 | 1.626792 | 0.007276 | 0.0012 | 38.40894 | 0.518007 | 8500 |
| primnoa13@14 (version 1) | 2.872867 | 0.064497 | 97.33459 | 2.562376 | 0.00724 | 0.001928 | 53.06988 | 1.226525 | 9038 |
| primnoa13@15 | 2.895204 | 0.046577 | 93.05247 | 1.371312 | 0.007341 | 0.002173 | 48.65913 | 0.732736 | 9050 |
| primnoa13@16 (version 1) | 2.86325 | 0.054496 | 102.1312 | 1.855464 | 0.007019 | 0.001948 | 52.4957 | 1.30764 | 9075 |
| primnoa13@19 (version 1) | 2.892591 | 0.059107 | 95.27243 | 2.301525 | 0.006911 | 0.002147 | 48.49549 | 1.047053 | 9100 |
| primnoa13@20 (version 1) | 2.853742 | 0.078322 | 98.38732 | 1.945138 | 0.006451 | 0.001552 | 48.64974 | 1.077017 | 9125 |
| primnoa13@21 | 2.896129 | 0.050619 | 93.76341 | 1.57298 | 0.007223 | 0.001379 | 47.51187 | 1.769884 | 9150 |
| primnoa13@22 | 2.881676 | 0.067897 | 100.6132 | 4.692733 | 0.007108 | 0.001171 | 45.46224 | 1.165354 | 9175 |
| primnoa13@24 | 2.862917 | 0.060358 | 94.28494 | 2.202621 | 0.007488 | 0.004736 | 42.76558 | 0.720868 | 9200 |
| primnoa13@25 | 2.768676 | 0.068466 | 91.0349 | 2.37425 | 0.011588 | 0.00334 | 48.28857 | 0.865686 | 9225 |
| primnoa13@26 | 2.756104 | 0.062226 | 90.09728 | 2.127262 | 0.00745 | 0.001343 | 48.64211 | 1.35157 | 9250 |
| primnoa13@27 | 2.808008 | 0.078207 | 96.13174 | 1.231504 | 0.006675 | 0.00365 | 47.62159 | 1.262237 | 9275 |
| primnoa13@28 | 2.796722 | 0.086146 | 96.32861 | 2.003307 | 0.006217 | 0.001396 | 48.69085 | 0.708452 | 9300 |
| primnoa13@29 | 2.828299 | 0.072805 | 104.024 | 4.091308 | 0.00748 | 0.001993 | 78.48631 | 64.06148 | 9325 |
| primnoa13@30 | 2.866976 | 0.064567 | 99.89171 | 1.424441 | 0.006593 | 0.008048 | 52.0659 | 1.129458 | 9350 |
| primnoa13@31 | 2.900083 | 0.096509 | 100.4891 | 1.507424 | 0.006099 | 0.000793 | 50.07924 | 0.801852 | 9375 |
| primnoa13@32 | 2.873284 | 0.076871 | 96.51813 | 1.393259 | 0.006403 | 0.003979 | 47.67859 | 0.581206 | 9400 |
| primnoa13@33 | 2.876513 | 0.049666 | 100.4758 | 4.029408 | 0.005914 | 0.000893 | 47.39069 | 0.82622 | 9425 |
| primnoa13@34 | 2.890822 | 0.057451 | 105.0898 | 2.514983 | 0.006043 | 0.002023 | 51.04505 | 0.944209 | 9450 |
| primnoa13@35 | 2.925354 | 0.048564 | 102.6382 | 3.746725 | 0.006178 | 0.001773 | 48.30019 | 0.510943 | 9475 |
| primnoa13@36 | 2.913833 | 0.051424 | 99.61743 | 1.40218 | 0.006684 | 0.001121 | 45.29493 | 0.756348 | 9500 |
| primnoa13@37 | 2.892388 | 0.051921 | 98.0049 | 2.06429 | 0.006604 | 0.001956 | 44.79206 | 1.125636 | 9525 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa13@38 | 2.810741 | 0.058862 | 100.6808 | 2.50478 | 0.006408 | 0.001454 | 46.37533 | 0.800754 | 9550 |
| primnoa13@39 | 2.844819 | 0.056955 | 96.35489 | 1.815006 | 0.00659 | 0.001097 | 44.32098 | 0.738351 | 9575 |
| primnoa13@40 | 2.828152 | 0.05306 | 96.62964 | 1.444526 | 0.007009 | 0.001118 | 43.06748 | 0.698282 | 9600 |
| primnoa13@41 | 2.826865 | 0.052716 | 100.7216 | 1.884247 | 0.007345 | 0.001408 | 43.80095 | 1.002985 | 9625 |
| primnoa13@42 | 2.792853 | 0.050801 | 93.83441 | 1.971369 | 0.007369 | 0.002322 | 45.13436 | 0.725205 | 9650 |
| primnoa13@43 | 2.842724 | 0.048028 | 93.91526 | 1.354418 | 0.006586 | 0.00198 | 45.74336 | 0.621198 | 9675 |
| primnoa13@44 | 2.871006 | 0.058821 | 100.6392 | 1.682488 | 0.005957 | 0.001648 | 47.55832 | 1.106494 | 9700 |
| primnoa13@45 | 2.835176 | 0.05916 | 105.3125 | 2.409072 | 0.00644 | 0.003549 | 48.51185 | 1.376336 | 9725 |
| primnoa13@46 | 2.854503 | 0.032584 | 99.21819 | 1.189066 | 0.006231 | 0.000869 | 49.40467 | 0.741412 | 9750 |
| primnoa13@61 | 2.872081 | 0.059514 | 99.71321 | 2.586697 | 0.006314 | 0.001664 | 51.1615 | 1.811712 | 9775 |
| primnoa13@62 | 2.837463 | 0.069325 | 94.41665 | 4.550651 | 0.006562 | 0.000852 | 42.3289 | 1.855793 | 9800 |
| primnoa13@47 | 2.919126 | 0.056393 | 103.5835 | 3.147326 | 0.005948 | 0.001146 | 49.5776 | 1.332778 | 9825 |
| primnoa13@48 | 2.90575 | 0.062699 | 107.2319 | 1.559105 | 0.006307 | 0.001482 | 49.45715 | 0.928533 | 9850 |
| primnoa13@49 | 2.852738 | 0.031911 | 111.8962 | 1.266518 | 0.011283 | 0.016691 | 50.50143 | 1.450277 | 9875 |
| primnoa13@50 | 2.764125 | 0.054516 | 100.0015 | 1.611786 | 0.007058 | 0.00162 | 43.72577 | 0.57907 | 9900 |
| primnoa13@51 | 2.693697 | 0.042874 | 93.51257 | 1.423609 | 0.006246 | 0.001457 | 42.72116 | 1.415777 | 9925 |
| primnoa13@52 | 2.847116 | 0.03641 | 89.84075 | 1.227775 | 0.007579 | 0.001071 | 41.62647 | 0.641278 | 10806 |
| primnoa13@53 | 2.840512 | 0.048054 | 92.77709 | 1.503078 | 0.007319 | 0.001363 | 43.64303 | 0.951868 | 10825 |
| primnoa13@54 | 2.884486 | 0.056832 | 91.43887 | 2.72648 | 0.006958 | 0.001623 | 43.78297 | 1.020404 | 10850 |
| primnoa13@55 | 2.833446 | 0.033499 | 95.34317 | 2.200979 | 0.006755 | 0.001206 | 45.14959 | 0.95073 | 10875 |
| primnoa13@56 | 2.903105 | 0.054336 | 100.4312 | 1.554691 | 0.006415 | 0.001504 | 47.10175 | 1.125669 | 10900 |
| primnoa13@57 | 2.915454 | 0.031332 | 103.1295 | 2.240876 | 0.007983 | 0.002977 | 50.67911 | 0.626721 | 10925 |
| primnoa13@58 | 2.968243 | 0.072917 | 105.2084 | 2.751761 | 0.006464 | 0.002652 | 48.03516 | 0.900057 | 10950 |
| primnoa13@59 | 2.946326 | 0.080017 | 103.4249 | 2.076881 | 0.006 | 0.003374 | 45.66655 | 1.016784 | 10975 |
| primnoa13@60 | 2.929606 | 0.075472 | 107.0808 | 1.344628 | 0.005985 | 0.002777 | 46.65507 | 1.18707 | 11000 |
| primnoa14@1 | 2.909962 | 0.045637 | 107.763 | 1.226431 | 0.005904 | 0.001392 | 47.1586 | 0.795863 | 11025 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance µm |
|---|---|---|---|---|---|---|---|---|---|
| primnoa14@2 | 2.935471 | 0.072232 | 107.8661 | 2.455648 | 0.005348 | 0.002054 | 47.05596 | 0.875643 | 11050 |
| primnoa14@3 | 2.881742 | 0.088087 | 105.7869 | 2.286999 | 0.006017 | 0.001551 | 46.52779 | 0.875787 | 11075 |
| primnoa14@4 | 2.824178 | 0.059034 | 97.04151 | 1.849205 | 0.006443 | 0.001206 | 46.24647 | 1.034127 | 11100 |
| primnoa14@5 | 2.900385 | 0.036166 | 99.32627 | 2.078886 | 0.00639 | 0.001381 | 45.61429 | 1.145379 | 11125 |
| primnoa14@6 | 2.851585 | 0.075805 | 98.074 | 2.727811 | 0.006579 | 0.001469 | 45.09642 | 1.633389 | 11150 |
| primnoa14@7 | 2.857591 | 0.067603 | 104.2094 | 3.7006 | 0.006208 | 0.001703 | 47.31688 | 1.532943 | 11175 |

------------------------------------**Rows highlighted in grey are the analyses corresponding to the gorgonin ring**------------------------------------

*P.pacifica* SIMS data (R1165-002)

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_2@1 | 2.302624 | 0.037579 | 80.76357 | 1.160322 | 0.005777 | 0.001804 | 20.53702 | 0.195987 | 0 |
| prim_5_2@2 | 2.317904 | 0.045607 | 79.24076 | 2.765157 | 0.005507 | 0.000954 | 21.01578 | 0.862697 | 25 |
| prim_5_2@3 | 2.326854 | 0.047224 | 81.74069 | 1.591654 | 0.007731 | 0.01395 | 22.40508 | 0.407478 | 50 |
| prim_5_2@4 | 2.351142 | 0.042165 | 82.80044 | 0.805478 | 0.006278 | 0.002701 | 21.17351 | 0.320168 | 75 |
| prim_5_2@5 | 2.469093 | 0.114962 | 77.48177 | 1.752047 | 0.006558 | 0.006004 | 20.5551 | 0.280181 | 100 |
| prim_5_2@6 | 2.344671 | 0.063308 | 80.09677 | 0.749472 | 0.005931 | 0.000791 | 19.28211 | 0.500983 | 125 |
| prim_5_2@7 | 2.301889 | 0.023307 | 80.72352 | 1.166186 | 0.006867 | 0.002091 | 20.32398 | 0.740077 | 150 |
| prim_5_2@8 | 2.301366 | 0.041043 | 78.20721 | 2.140717 | 0.018319 | 0.053863 | 20.06977 | 0.331257 | 175 |
| prim_5_2@9 | 2.314328 | 0.058203 | 79.09071 | 1.952341 | 0.005767 | 0.001119 | 21.14844 | 0.239401 | 200 |
| prim_5_2@10 | 2.323295 | 0.057081 | 79.63985 | 1.735202 | 0.005296 | 0.000582 | 20.36581 | 0.878641 | 225 |
| prim_5_2@11 | 2.326579 | 0.02879 | 78.29855 | 1.361698 | 0.005967 | 0.000729 | 20.19446 | 0.556914 | 250 |
| prim_5_2@12 | 2.375208 | 0.045441 | 77.96192 | 1.386153 | 0.006637 | 0.013681 | 18.89807 | 0.267928 | 275 |
| prim_5_2@13 | 2.383423 | 0.038919 | 78.49422 | 2.277961 | 0.005564 | 0.002397 | 19.58927 | 0.256596 | 300 |
| prim_5_2@14 | 2.260096 | 0.028462 | 83.13858 | 0.925138 | 0.005377 | 0.001221 | 20.65598 | 0.262885 | 325 |
| prim_5_2@15 | 2.389709 | 0.038531 | 74.5149 | 1.617355 | 0.006248 | 0.001328 | 20.4865 | 0.527858 | 350 |
| prim_5_2@16 | 2.385897 | 0.040049 | 80.40978 | 1.823263 | 0.005388 | 0.000819 | 23.14515 | 0.239273 | 375 |
| prim_5_2@17 | 2.400874 | 0.060249 | 79.61094 | 1.144951 | 0.005624 | 0.001089 | 21.13954 | 0.378375 | 400 |
| prim_5_2@18 | 2.331458 | 0.073745 | 83.16452 | 3.205249 | 0.005033 | 0.001703 | 21.80279 | 0.608803 | 425 |
| prim_5_2@19 | 2.281502 | 0.05198 | 87.45864 | 0.84114 | 0.005852 | 0.005665 | 22.01703 | 0.398419 | 450 |
| prim_5_2@20 | 2.376573 | 0.044559 | 78.46752 | 1.714853 | 0.006976 | 0.002938 | 19.1018 | 0.358033 | 475 |
| prim_5_2@21 | 2.355683 | 0.02588 | 78.78856 | 1.194966 | 0.005538 | 0.002453 | 21.05677 | 0.80671 | 500 |
| prim_5_2@22 | 2.302919 | 0.042466 | 81.18499 | 1.870132 | 0.006334 | 0.008287 | 20.60406 | 0.325773 | 525 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_2@23 | 2.367256 | 0.056819 | 80.72508 | 1.360249 | 0.015416 | 0.040647 | 21.6163 | 0.627938 | 550 |
| prim_5_2@24 | 2.328904 | 0.083864 | 85.92163 | 1.996011 | 0.005661 | 0.001347 | 22.89948 | 0.571373 | 575 |
| prim_5_2@25 | 2.331807 | 0.016221 | 72.49452 | 1.97788 | 0.006028 | 0.00085 | 19.9315 | 0.250002 | 600 |
| prim_5_2@26 | 2.39155 | 0.034572 | 73.70462 | 1.087233 | 0.006262 | 0.003315 | 19.53699 | 0.370963 | 625 |
| prim_5_3@1 | 2.187379 | 0.063249 | 76.55419 | 1.285615 | 0.005916 | 0.004251 | 20.76671 | 0.289761 | 750 |
| prim_5_3@2 | 2.326625 | 0.032301 | 75.81195 | 0.98511 | 0.00522 | 0.003972 | 18.27353 | 0.280427 | 775 |
| prim_5_3@3 | 2.229817 | 0.024844 | 82.13593 | 1.145295 | 0.005986 | 0.004032 | 21.69968 | 0.407972 | 800 |
| prim_5_3@4 | 2.372097 | 0.028054 | 78.20803 | 2.07896 | 0.00476 | 0.002341 | 20.49805 | 0.362708 | 825 |
| prim_5_3@5 | 2.413698 | 0.035835 | 78.3802 | 1.167637 | 0.005411 | 0.002006 | 18.8698 | 0.142345 | 850 |
| prim_5_3@6 | 2.409893 | 0.043959 | 77.11242 | 0.783514 | 0.005567 | 0.004628 | 19.24427 | 0.386112 | 875 |
| prim_5_3@7 | 2.34312 | 0.12178 | 83.7657 | 1.83195 | 0.005745 | 0.002716 | 20.70233 | 0.160381 | 900 |
| prim_5_3@8 | 2.351981 | 0.057544 | 78.36334 | 2.143693 | 0.006055 | 0.002912 | 19.53926 | 0.184503 | 925 |
| prim_5_3@9 | 2.400705 | 0.021156 | 74.81362 | 0.816219 | 0.006626 | 0.003438 | 19.44159 | 0.406662 | 950 |
| prim_5_3@10 | 2.378542 | 0.036977 | 83.76643 | 1.107768 | 0.007774 | 0.02098 | 22.51634 | 0.49735 | 975 |
| prim_5_3@11 | 2.418162 | 0.036547 | 81.6263 | 2.034648 | 0.03058 | 0.187975 | 21.3282 | 0.265356 | 1000 |
| prim_5_3@12 | 2.442237 | 0.065519 | 85.10204 | 1.098747 | 0.004668 | 0.004185 | 22.96517 | 0.33952 | 1025 |
| prim_5_3@13 | 2.429911 | 0.039863 | 86.5745 | 1.373416 | 0.005573 | 0.002556 | 22.57233 | 0.314966 | 1050 |
| prim_5_3@14 | 2.353338 | 0.03213 | 92.15477 | 2.034652 | 0.003617 | 0.002748 | 24.07212 | 0.347139 | 1075 |
| prim_5_3@15 | 2.32413 | 0.052651 | 90.62097 | 2.904661 | 0.004757 | 0.002933 | 23.21984 | 0.489867 | 1100 |
| prim_5_3@16 | 2.389433 | 0.077056 | 79.2951 | 3.367978 | 0.005999 | 0.003286 | 21.68542 | 0.687919 | 1125 |
| prim_5_3@17 | 2.471929 | 0.045651 | 78.10775 | 1.266957 | 0.004651 | 0.003252 | 21.66102 | 0.274166 | 1150 |
| prim_5_3@18 | 2.467857 | 0.068669 | 80.76674 | 1.906967 | 0.005614 | 0.003395 | 20.78191 | 0.185583 | 1175 |
| prim_5_3@19 | 2.432456 | 0.046049 | 86.21486 | 1.879994 | 0.00507 | 0.001769 | 21.51193 | 0.361575 | 1200 |
| prim_5_3@20 | 2.454651 | 0.064927 | 85.44491 | 1.497968 | 0.003828 | 0.002408 | 21.09622 | 0.313684 | 1225 |
| prim_5_3@21 | 2.444037 | 0.03006 | 83.93325 | 1.156594 | 0.005584 | 0.003091 | 20.88417 | 0.341805 | 1250 |
| prim_5_3@22 | 2.424238 | 0.036511 | 78.16825 | 0.774885 | 0.006074 | 0.003081 | 19.03557 | 0.323179 | 1275 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_3@23 | 2.358091 | 0.044662 | 82.39016 | 1.817182 | 0.005813 | 0.00292 | 21.79568 | 0.321651 | 1300 |
| prim_5_3@24 | 2.455346 | 0.048974 | 78.55621 | 2.412921 | 0.004907 | 0.003643 | 20.90675 | 0.39391 | 1325 |
| prim_5_3@25 | 2.375287 | 0.03918 | 87.29126 | 2.036753 | 0.005045 | 0.00193 | 22.61993 | 0.6742 | 1350 |
| prim_5_3@26 | 2.381256 | 0.033261 | 86.22973 | 1.018668 | 0.005276 | 0.001715 | 21.89562 | 0.452199 | 1375 |
| prim_5_3@27 | 2.397089 | 0.048901 | 77.76923 | 2.855928 | 0.005572 | 0.002762 | 20.24977 | 0.402385 | 1400 |
| prim_5_3@28 | 2.397275 | 0.027008 | 75.04757 | 1.613129 | 0.005615 | 0.002555 | 19.66779 | 0.404887 | 1425 |
| prim_5_3@29 | 2.36613 | 0.095348 | 80.08589 | 1.157445 | 0.005971 | 0.005045 | 20.92415 | 0.497008 | 1450 |
| prim_5_3@30 | 2.389584 | 0.024056 | 76.95546 | 0.834478 | 0.007529 | 0.004045 | 20.61459 | 0.288546 | 1475 |
| prim_5_3@31 | 2.300898 | 0.030719 | 84.0938 | 1.971515 | 0.005845 | 0.002667 | 22.74008 | 0.384734 | 1500 |
| prim_5_3@32 | 2.40379 | 0.049021 | 78.12953 | 0.584919 | 0.004929 | 0.002635 | 20.11739 | 0.509953 | 1525 |
| prim_5_3@33 | 2.422887 | 0.053166 | 79.56296 | 1.845162 | 0.004735 | 0.002379 | 21.11637 | 0.263407 | 1550 |
| prim_5_3@34 | 2.422681 | 0.135832 | 81.68842 | 1.267881 | 0.006398 | 0.002485 | 21.93715 | 0.474903 | 1575 |
| prim_5_3@35 | 2.393064 | 0.052021 | 79.47136 | 1.292498 | 0.005396 | 0.002781 | 21.51461 | 0.376748 | 1600 |
| prim_5_3@36 | 2.344349 | 0.068838 | 82.74772 | 1.307202 | 0.005282 | 0.002673 | 22.52305 | 0.412613 | 1625 |
| prim_5_3@37 | 2.407356 | 0.046708 | 76.85246 | 1.731226 | 0.00632 | 0.002483 | 21.55223 | 0.327278 | 1650 |
| prim_5_3@38 | 2.397275 | 0.031166 | 75.44449 | 1.176175 | 0.005303 | 0.00294 | 20.30072 | 0.20424 | 1675 |
| prim_5_3@39 | 2.407862 | 0.052338 | 77.46142 | 1.876337 | 0.005928 | 0.002972 | 21.95172 | 0.320132 | 1700 |
| prim_5_3@40 | 2.432957 | 0.047993 | 74.93944 | 1.624704 | 0.005493 | 0.002132 | 19.22697 | 0.309467 | 1725 |
| prim_5_3@41 | 2.389219 | 0.030396 | 77.90024 | 1.546691 | 0.006364 | 0.003785 | 20.72453 | 0.25346 | 1750 |
| prim_5_3@42 | 2.378491 | 0.067403 | 83.01871 | 3.096243 | 0.004866 | 0.003537 | 20.82502 | 0.361908 | 1775 |
| prim_5_3@43 | 2.331228 | 0.075166 | 82.41626 | 1.39773 | 0.005109 | 0.004339 | 20.91718 | 0.696317 | 1800 |
| prim_5_3@44 | 2.385874 | 0.066075 | 76.97761 | 1.819659 | 0.006977 | 0.004324 | 19.4538 | 0.439472 | 1825 |
| prim_5_3@45 | 2.403361 | 0.051164 | 77.54309 | 1.967344 | 0.005592 | 0.004361 | 20.45176 | 0.336387 | 1850 |
| prim_5_3@46 | 2.349139 | 0.040727 | 78.04525 | 1.924275 | 0.00637 | 0.002666 | 22.09154 | 0.392117 | 1875 |
| prim_5_3@47 | 2.371741 | 0.042689 | 78.73806 | 1.992076 | 0.005616 | 0.00135 | 20.81444 | 0.584917 | 1900 |
| prim_5_3@48 | 2.280659 | 0.049304 | 80.45894 | 2.731539 | 0.005216 | 0.002628 | 21.24142 | 0.576531 | 1925 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_3@49 | 2.3002 | 0.048247 | 77.98915 | 1.002706 | 0.00695 | 0.003926 | 21.19603 | 0.400047 | 1975 |
| prim_5_3@50 | 2.265407 | 0.043292 | 76.51845 | 1.975465 | 0.006124 | 0.004122 | 20.89932 | 0.254263 | 2000 |
| prim_5_3@51 | 2.308828 | 0.063851 | 71.2436 | 2.406012 | 0.006767 | 0.002684 | 19.20009 | 0.503104 | 2025 |
| prim_5_3@52 | 2.263825 | 0.036772 | 78.17226 | 1.327876 | 0.006986 | 0.003576 | 21.31484 | 0.30905 | 2050 |
| prim_5_3@53 | 2.432249 | 0.045281 | 81.94821 | 1.500817 | 0.004506 | 0.002401 | 20.12819 | 0.210588 | 2075 |
| prim_5_3@54 | 2.304309 | 0.044331 | 77.78529 | 2.041595 | 0.005083 | 0.002231 | 20.71352 | 0.474886 | 2100 |
| prim_5_3@55 | 2.374624 | 0.028096 | 73.12557 | 1.901202 | 0.00537 | 0.002417 | 18.91413 | 0.251522 | 2125 |
| prim_5_3@56 | 2.327704 | 0.030363 | 73.05049 | 1.319581 | 0.006017 | 0.00363 | 18.64214 | 0.235724 | 2150 |
| prim_5_3@57 | 2.269887 | 0.033238 | 77.67509 | 1.255916 | 0.006897 | 0.003397 | 20.43216 | 0.180027 | 2175 |
| prim_5_3@58 | 2.351056 | 0.212994 | 80.46021 | 2.352261 | 0.005001 | 0.003196 | 20.0325 | 0.2524 | 2200 |
| prim_5_3@59 | 2.284569 | 0.080642 | 80.45999 | 0.874921 | 0.00555 | 0.003433 | 20.83954 | 0.408624 | 2225 |
| prim_5_3@60 | 2.282354 | 0.054846 | 75.07141 | 1.305418 | 0.006282 | 0.002901 | 19.30065 | 0.373545 | 2250 |
| prim_5_3@61 | 2.259463 | 0.03741 | 72.56006 | 1.963856 | 0.006492 | 0.003571 | 18.58242 | 0.202655 | 2275 |
| prim_5_3@62 | 2.263814 | 0.041177 | 75.67879 | 1.994706 | 0.005705 | 0.002757 | 20.24807 | 0.262929 | 2300 |
| prim_5_3@63 | 2.397514 | 0.080352 | 75.68656 | 1.417852 | 0.005656 | 0.00231 | 19.41517 | 0.389094 | 2325 |
| prim_5_3@64 | 2.380756 | 0.058757 | 77.18383 | 1.751812 | 0.0557 | 0.36674 | 19.94252 | 0.400144 | 2350 |
| prim_5_3@65 | 2.270887 | 0.068824 | 84.60367 | 2.741412 | 0.006581 | 0.001749 | 22.08316 | 0.445792 | 2375 |
| prim_5_3@66 | 2.421235 | 0.123667 | 80.98661 | 2.234174 | 0.01556 | 0.079278 | 20.67598 | 0.226541 | 2400 |
| prim_5_3@67 | 2.369704 | 0.056027 | 81.88779 | 1.799145 | 0.005061 | 0.00255 | 21.1475 | 0.34187 | 2425 |
| prim_5_3@68 | 2.339344 | 0.063634 | 87.09259 | 1.783471 | 0.029266 | 0.163438 | 24.2127 | 0.48954 | 2450 |
| prim_5_3@69 | 2.417614 | 0.055191 | 77.07217 | 1.495052 | 0.00597 | 0.002438 | 19.59343 | 0.295031 | 2475 |
| prim_5_3@70 | 2.417229 | 0.050087 | 78.14321 | 2.06907 | 0.005309 | 0.003188 | 19.93143 | 0.379786 | 2500 |
| prim_5_3@71 | 2.457018 | 0.091882 | 74.29153 | 1.118587 | 0.00548 | 0.003931 | 18.03842 | 0.448031 | 2525 |
| prim_5_3@72 | 2.450844 | 0.036406 | 76.22489 | 2.173608 | 0.005096 | 0.003725 | 18.76706 | 0.249382 | 2550 |
| prim_5_3@73 | 2.436342 | 0.063392 | 80.70811 | 1.81442 | 0.004935 | 0.002047 | 19.84184 | 0.688656 | 2575 |
| prim_5_3@74 | 2.400157 | 0.07489 | 84.15548 | 1.810877 | 0.005595 | 0.004337 | 20.43886 | 0.19371 | 2600 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_3@75 | 2.406152 | 0.026877 | 86.57844 | 2.012379 | 0.005365 | 0.002437 | 20.71064 | 0.318505 | 2625 |
| prim_5_3@76 | 2.345784 | 0.073679 | 86.80787 | 1.442384 | 0.0047 | 0.0026 | 21.47381 | 0.475247 | 2650 |
| prim_5_3@77 | 2.392744 | 0.052519 | 80.46686 | 2.81514 | 0.005822 | 0.001151 | 18.37957 | 0.372023 | 2675 |
| prim_5_3@78 | 2.414475 | 0.052133 | 76.25564 | 1.094525 | 0.006217 | 0.003105 | 18.52875 | 0.400534 | 2700 |
| prim_5_3@79 | 2.410155 | 0.033728 | 77.01968 | 1.389952 | 0.006604 | 0.003032 | 19.32609 | 0.43956 | 2725 |
| prim_5_3@80 | 2.319926 | 0.069957 | 81.75388 | 1.797087 | 0.006073 | 0.002682 | 20.83962 | 0.228548 | 2750 |
| prim_5_3@81 | 2.394554 | 0.062122 | 80.81873 | 1.220809 | 0.005566 | 0.002562 | 21.31333 | 0.363524 | 2775 |
| prim_5_3@82 | 2.417021 | 0.071604 | 78.79176 | 1.240266 | 0.006345 | 0.00349 | 19.52098 | 0.645185 | 2800 |
| prim_5_3@83 | 2.337214 | 0.055362 | 77.98475 | 1.415897 | 0.024075 | 0.130639 | 20.22716 | 0.321481 | 2825 |
| prim_5_3@84 | 2.363878 | 0.071934 | 73.59313 | 1.554332 | 0.005648 | 0.003317 | 20.22374 | 0.269348 | 2850 |
| prim_5_3@85 | 2.400848 | 0.05521 | 77.04155 | 1.255454 | 0.0057 | 0.00596 | 20.08557 | 0.308851 | 2875 |
| prim_5_3@86 | 2.37096 | 0.033284 | 82.27887 | 1.666189 | 0.005659 | 0.003404 | 20.84204 | 0.270978 | 2900 |
| prim_5_3@87 | 2.343999 | 0.048653 | 77.98545 | 1.935095 | 0.005571 | 0.002495 | 17.92913 | 0.166164 | 2925 |
| prim_5_3@88 | 2.3941 | 0.093054 | 78.30302 | 1.106146 | 0.005765 | 0.002442 | 19.1428 | 0.607974 | 2950 |
| prim_5_3@89 | 2.340378 | 0.047701 | 81.9486 | 1.9237 | 0.006517 | 0.002623 | 21.5422 | 0.567907 | 2975 |
| prim_5_3@90 | 2.415923 | 0.266275 | 77.35047 | 1.421198 | 0.005734 | 0.002696 | 20.27288 | 0.527601 | 3000 |
| prim_5_3@91 | 2.387295 | 0.049055 | 80.09632 | 2.358668 | 0.004932 | 0.002192 | 20.00241 | 0.226784 | 3025 |
| prim_5_3@92 | 2.400006 | 0.090683 | 77.38071 | 0.971972 | 0.005702 | 0.003559 | 21.31738 | 0.703916 | 3050 |
| prim_5_3@93 | 2.413519 | 0.054793 | 79.45586 | 1.539816 | 0.004942 | 0.002511 | 20.7626 | 0.301574 | 3075 |
| prim_5_3@94 | 2.41913 | 0.044937 | 77.83776 | 2.595253 | 0.006726 | 0.004127 | 19.97752 | 0.385157 | 3100 |
| prim_5_3@95 | 2.397306 | 0.043083 | 74.79294 | 1.492339 | 0.005884 | 0.002625 | 18.25821 | 0.318712 | 3125 |
| prim_5_3@96 | 2.420303 | 0.04692 | 75.25319 | 1.306562 | 0.006038 | 0.004071 | 18.9968 | 0.472093 | 3150 |
| prim_5_3@97 | 2.437665 | 0.056939 | 73.51431 | 2.067476 | 0.005636 | 0.002956 | 19.44285 | 0.321957 | 3175 |
| prim_5_3@98 | 2.463795 | 0.043598 | 74.7316 | 1.614432 | 0.005917 | 0.003694 | 18.93169 | 0.329403 | 3200 |
| prim_5_3@99 | 2.397916 | 0.058179 | 78.75624 | 1.66278 | 0.005665 | 0.002653 | 20.67558 | 0.249787 | 3225 |
| prim_5_3@100 | 2.420698 | 0.046387 | 82.00368 | 2.507945 | 0.005571 | 0.005243 | 20.85049 | 0.316355 | 3250 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_4@1 | 2.405477 | 0.03756 | 81.01332 | 0.864326 | 0.014624 | 0.056166 | 20.47247 | 0.350243 | 3275 |
| prim_5_4@2 | 2.394123 | 0.043785 | 80.92751 | 1.459895 | 0.005491 | 0.000726 | 20.5647 | 0.3327 | 3300 |
| prim_5_4@3 | 2.370025 | 0.042931 | 77.71874 | 1.409355 | 0.00608 | 0.000932 | 19.60828 | 0.545134 | 3325 |
| prim_5_4@4 | 2.331049 | 0.083277 | 77.05795 | 1.884102 | 0.006119 | 0.00099 | 19.94526 | 1.106334 | 3350 |
| prim_5_4@5 | 2.379794 | 0.041103 | 77.24435 | 1.982942 | 0.006228 | 0.004597 | 20.28992 | 0.261682 | 3375 |
| prim_5_4@6 | 2.399205 | 0.05431 | 79.57372 | 1.437467 | 0.009444 | 0.025523 | 21.45358 | 0.334205 | 3400 |
| prim_5_4@7 | 2.418723 | 0.046259 | 79.66865 | 1.863465 | 0.011587 | 0.02631 | 21.43179 | 0.214191 | 3425 |
| prim_5_4@8 | 2.417866 | 0.023448 | 79.57315 | 2.555832 | 0.005204 | 0.000924 | 20.38567 | 0.462082 | 3450 |
| prim_5_4@9 | 2.381165 | 0.060144 | 81.15604 | 2.048732 | 0.005423 | 0.001216 | 20.73872 | 0.281274 | 3475 |
| prim_5_4@10 | 2.348883 | 0.052823 | 82.72024 | 1.262184 | 0.005488 | 0.000912 | 20.21595 | 0.458181 | 3500 |
| prim_5_4@11 | 2.430015 | 0.064033 | 77.41634 | 3.45449 | 0.007539 | 0.01335 | 19.31917 | 0.334173 | 3525 |
| prim_5_4@12 | 2.360648 | 0.058021 | 78.02539 | 2.131137 | 0.006183 | 0.00061 | 19.25493 | 0.431317 | 3550 |
| prim_5_4@13 | 2.360906 | 0.044302 | 80.49141 | 2.092035 | 0.005874 | 0.001106 | 19.92533 | 0.415727 | 3575 |
| prim_5_4@14 | 2.412833 | 0.048643 | 78.68715 | 2.117089 | 0.005744 | 0.000873 | 20.09415 | 0.225885 | 3600 |
| prim_5_4@15 | 2.418731 | 0.081096 | 81.06181 | 1.503059 | 0.005821 | 0.000606 | 21.21932 | 0.416913 | 3625 |
| prim_5_4@16 | 2.357213 | 0.048306 | 85.45032 | 1.784017 | 0.005156 | 0.000971 | 21.99211 | 0.391921 | 3650 |
| prim_5_4@17 | 2.417325 | 0.062646 | 75.25575 | 1.388281 | 0.006051 | 0.000898 | 18.22836 | 0.495277 | 3675 |
| prim_5_4@18 | 2.340538 | 0.054456 | 78.53629 | 1.936874 | 0.006176 | 0.001023 | 20.38951 | 0.308797 | 3700 |
| prim_5_4@19 | 2.30733 | 0.042093 | 79.2646 | 1.720961 | 0.008109 | 0.012607 | 21.29302 | 0.542624 | 3725 |
| prim_5_4@20 | 2.333592 | 0.039988 | 77.67309 | 2.096864 | 0.006469 | 0.000755 | 20.37535 | 0.356423 | 3750 |
| prim_5_4@21 | 2.322153 | 0.057667 | 77.97645 | 2.022232 | 0.008047 | 0.01938 | 20.61663 | 0.262245 | 3775 |
| prim_5_4@22 | 2.376732 | 0.108828 | 80.14009 | 2.070085 | 0.005718 | 0.000989 | 21.96266 | 0.312298 | 3800 |
| prim_5_4@23 | 2.376162 | 0.093683 | 80.94158 | 2.465367 | 0.008351 | 0.019331 | 21.78058 | 0.252396 | 3825 |
| prim_5_4@24 | 2.380314 | 0.056087 | 80.12415 | 2.571197 | 0.008406 | 0.02099 | 21.68744 | 0.299923 | 3850 |
| prim_5_4@25 | 2.36259 | 0.040744 | 79.81915 | 2.272108 | 0.006037 | 0.000956 | 20.99136 | 0.467202 | 3875 |
| prim_5_4@26 | 2.421385 | 0.069695 | 79.23905 | 0.892541 | 0.00533 | 0.000867 | 20.55523 | 0.421048 | 3900 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_4@27 | 2.364589 | 0.088633 | 80.94251 | 1.424927 | 0.005665 | 0.005039 | 21.39632 | 0.493389 | 3925 |
| prim_5_4@29 | 2.404786 | 0.038696 | 76.07158 | 1.863632 | 0.007772 | 0.0164 | 19.3789 | 0.313191 | 3950 |
| prim_5_4@30 | 2.347833 | 0.098086 | 80.63341 | 1.604752 | 0.006313 | 0.00066 | 21.17763 | 0.419525 | 3975 |
| prim_5_5@1 | 2.324159 | 0.076399 | 84.74105 | 2.749031 | 0.012953 | 0.056589 | 21.5965 | 1.054973 | 4000 |
| prim_5_5@2 | 2.396474 | 0.024061 | 85.23745 | 2.23957 | 0.004909 | 0.000563 | 23.13916 | 0.381407 | 4025 |
| prim_5_5@3 | 2.386868 | 0.10464 | 82.14426 | 2.067917 | 0.005116 | 0.000799 | 22.09677 | 0.268682 | 4050 |
| prim_5_5@4 | 2.416782 | 0.09553 | 78.09696 | 1.976837 | 0.005811 | 0.001078 | 20.96594 | 0.381113 | 4075 |
| prim_5_5@5 | 2.486513 | 0.04136 | 76.98019 | 2.289035 | 0.005833 | 0.00099 | 20.7128 | 0.292758 | 4100 |
| prim_5_5@6 | 2.496167 | 0.045028 | 76.40094 | 2.475855 | 0.007946 | 0.01455 | 21.88485 | 0.411156 | 4125 |
| prim_5_5@7 | 2.42438 | 0.063982 | 80.10008 | 2.874334 | 0.008325 | 0.018373 | 22.60468 | 0.329419 | 4150 |
| prim_5_5@8 | 2.444298 | 0.056278 | 78.06746 | 2.147121 | 0.006267 | 0.000678 | 22.48719 | 0.27927 | 4175 |
| prim_5_5@9 | 2.44757 | 0.070017 | 80.85435 | 2.261663 | 0.005729 | 0.001345 | 22.77401 | 0.474068 | 4200 |
| prim_5_5@10 | 2.424139 | 0.053988 | 79.88205 | 2.304748 | 0.010456 | 0.036719 | 21.34304 | 0.463342 | 4225 |
| prim_5_5@11 | 2.422485 | 0.071895 | 78.70994 | 2.290919 | 0.00584 | 0.00126 | 21.30201 | 0.49501 | 4250 |
| prim_5_5@12 | 2.410061 | 0.072171 | 83.34141 | 2.162766 | 0.007731 | 0.019903 | 22.22377 | 0.370267 | 4275 |
| prim_5_5@13 | 2.440692 | 0.078108 | 79.11699 | 1.649038 | 0.007423 | 0.015174 | 21.01825 | 0.494936 | 4300 |
| prim_5_5@14 | 2.408478 | 0.061676 | 80.79109 | 3.149061 | 0.00531 | 0.00117 | 21.52586 | 0.293947 | 4325 |
| prim_5_5@15 | 2.418514 | 0.056529 | 80.96619 | 2.305247 | 0.008693 | 0.022868 | 21.97698 | 0.29885 | 4350 |
| prim_5_5@16 | 2.450154 | 0.043207 | 78.72387 | 2.366616 | 0.0151 | 0.040065 | 20.99724 | 0.243864 | 4375 |
| prim_5_5@17 | 2.416501 | 0.056428 | 81.26667 | 2.058074 | 0.013115 | 0.029674 | 22.49383 | 0.262717 | 4400 |
| prim_5_5@18 | 2.417046 | 0.073193 | 81.68659 | 2.850913 | 0.005581 | 0.001755 | 22.45161 | 0.302531 | 4425 |
| prim_5_5@19 | 2.401037 | 0.053358 | 84.12521 | 2.612527 | 0.01186 | 0.028365 | 24.17465 | 0.52093 | 4450 |
| prim_5_5@20 | 2.483583 | 0.066935 | 83.27769 | 1.750964 | 0.00561 | 0.002488 | 23.01848 | 0.385601 | 4475 |
| prim_5_5@21 | 2.423177 | 0.055876 | 85.24792 | 2.566291 | 0.005577 | 0.000844 | 23.87724 | 0.365118 | 4500 |
| prim_5_5@22 | 2.416048 | 0.074562 | 76.43337 | 2.539008 | 0.009793 | 0.029288 | 20.7963 | 0.268306 | 4525 |
| prim_5_5@23 | 2.419411 | 0.051601 | 76.50062 | 1.406745 | 0.006905 | 0.003592 | 21.57868 | 0.499401 | 4550 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_5@24 | 2.449372 | 0.090427 | 77.7667 | 1.992755 | 0.006019 | 0.000925 | 21.65145 | 0.463051 | 4575 |
| prim_5_5@25 | 2.431941 | 0.059072 | 81.34167 | 2.783241 | 0.008004 | 0.018366 | 22.39402 | 0.405058 | 4600 |
| prim_5_5@26 | 2.431141 | 0.077561 | 82.7277 | 2.357356 | 0.00676 | 0.00948 | 22.09215 | 0.366925 | 4625 |
| prim_5_5@27 | 2.429797 | 0.045847 | 81.28267 | 2.12728 | 0.007902 | 0.016511 | 21.61699 | 0.468 | 4650 |
| prim_5_5@28 | 2.498894 | 0.13489 | 78.00921 | 3.012452 | 0.010421 | 0.031747 | 19.26796 | 0.179713 | 4675 |
| prim_5_5@29 | 2.443699 | 0.058152 | 74.63938 | 2.344009 | 0.006249 | 0.001126 | 19.73912 | 0.687092 | 4700 |
| prim_5_5@30 | 2.377107 | 0.048114 | 77.15476 | 2.515114 | 0.008298 | 0.016191 | 21.51428 | 0.346342 | 4725 |
| prim_5_5@31 | 2.366014 | 0.051665 | 73.64531 | 2.134914 | 0.012525 | 0.02147 | 19.8647 | 0.44046 | 4750 |
| prim_5_5@32 | 2.353539 | 0.056417 | 79.30257 | 2.956443 | 0.006027 | 0.000632 | 22.52928 | 0.275183 | 4775 |
| prim_5_5@33 | 2.454764 | 0.072103 | 79.45457 | 2.89925 | 0.00728 | 0.01063 | 22.8226 | 0.168651 | 4800 |
| prim_5_5@34 | 2.515793 | 0.070278 | 80.96467 | 2.117121 | 0.007949 | 0.020177 | 22.90134 | 0.40941 | 4825 |
| prim_5_5@35 | 2.531632 | 0.051417 | 81.35903 | 1.92827 | 0.005613 | 0.001085 | 22.97872 | 0.428805 | 4850 |
| prim_5_5@36 | 2.476141 | 0.043066 | 82.69298 | 2.918282 | 0.012494 | 0.027305 | 21.80633 | 0.251495 | 4875 |
| prim_5_5@37 | 2.46938 | 0.059098 | 84.74192 | 2.374015 | 0.005575 | 0.000927 | 22.91806 | 0.446431 | 4900 |
| prim_5_5@38 | 2.437546 | 0.06659 | 87.05151 | 2.323271 | 0.007263 | 0.015398 | 24.24349 | 0.453316 | 4925 |
| prim_5_5@39 | 2.482232 | 0.070449 | 84.24341 | 1.74355 | 0.005151 | 0.000768 | 23.43138 | 0.551023 | 4950 |
| prim_5_5@40 | 2.442446 | 0.065479 | 90.88999 | 2.908061 | 0.005607 | 0.001066 | 24.16548 | 0.539562 | 4975 |
| prim_5_5@41 | 2.493951 | 0.074499 | 85.94863 | 2.786282 | 0.005541 | 0.00085 | 22.70927 | 0.146086 | 5000 |
| prim_5_5@42 | 2.473903 | 0.055627 | 84.32533 | 2.401032 | 0.005552 | 0.000974 | 21.51578 | 0.263356 | 5025 |
| prim_5_5@43 | 2.438187 | 0.068944 | 87.51033 | 1.945618 | 0.005434 | 0.000975 | 22.08526 | 0.566334 | 5050 |
| prim_5_5@44 | 2.396694 | 0.058498 | 78.61571 | 2.526231 | 0.007781 | 0.017139 | 22.23808 | 0.386443 | 5075 |
| prim_5_5@45 | 2.514516 | 0.065573 | 80.14952 | 2.831283 | 0.005582 | 0.000604 | 23.16273 | 0.282159 | 5100 |
| prim_5_5@46 | 2.564884 | 0.077127 | 83.23147 | 2.148804 | 0.006497 | 0.011949 | 25.46004 | 0.317771 | 5125 |
| prim_5_5@47 | 2.537444 | 0.056408 | 83.33609 | 2.400191 | 0.005166 | 0.002746 | 25.3053 | 0.243345 | 5150 |
| prim_5_5@48 | 2.50068 | 0.060076 | 82.68257 | 1.955812 | 0.01255 | 0.050433 | 25.21922 | 0.371166 | 5175 |
| prim_5_5@49 | 2.527959 | 0.069066 | 87.38374 | 2.179455 | 0.005755 | 0.000907 | 26.79602 | 0.374379 | 5200 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_5@50 | 2.5323 | 0.048947 | 86.47301 | 2.465584 | 0.00506 | 0.000892 | 25.28938 | 0.332838 | 5225 |
| prim_5_5@51 | 2.529521 | 0.074029 | 88.92023 | 2.437927 | 0.005207 | 0.000958 | 25.99306 | 0.509445 | 5250 |
| prim_5_5@52 | 2.481167 | 0.07805 | 87.77197 | 2.55779 | 0.005662 | 0.001324 | 25.96107 | 0.437938 | 5275 |
| prim_5_5@53 | 2.497108 | 0.076324 | 87.89312 | 1.983515 | 0.005611 | 0.000854 | 26.0032 | 0.474322 | 5300 |
| prim_5_5@54 | 2.503808 | 0.077323 | 86.32967 | 1.792207 | 0.009427 | 0.016402 | 24.64999 | 0.462048 | 5325 |
| prim_5_5@55 | 2.490478 | 0.065338 | 81.63287 | 2.968546 | 0.009356 | 0.028522 | 23.05829 | 0.288112 | 5350 |
| prim_5_5@56 | 2.44832 | 0.061315 | 76.7425 | 2.460662 | 0.006584 | 0.000966 | 24.1635 | 0.336494 | 5375 |
| prim_5_5@57 | 2.4753 | 0.063022 | 81.08365 | 2.080074 | 0.005828 | 0.000908 | 25.81357 | 0.421899 | 5400 |
| prim_5_5@58 | 2.509775 | 0.069266 | 83.09303 | 2.138936 | 0.005381 | 0.000747 | 23.73108 | 0.45378 | 5425 |
| prim_5_5@59 | 2.484735 | 0.056067 | 81.31876 | 2.872022 | 0.005173 | 0.002235 | 23.23594 | 0.289203 | 5450 |
| prim_5_5@60 | 2.481239 | 0.054431 | 86.66935 | 2.200368 | 0.005774 | 0.008571 | 24.51901 | 0.305245 | 5475 |
| prim_5_5@61 | 2.469116 | 0.06497 | 86.84295 | 1.693753 | 0.014254 | 0.036326 | 23.66855 | 0.520807 | 5500 |
| prim_5_5@62 | 2.450635 | 0.056769 | 86.0645 | 3.019433 | 0.004633 | 0.00126 | 24.60347 | 0.458632 | 5525 |
| prim_5_5@63 | 2.513212 | 0.065797 | 85.66985 | 1.471694 | 0.009651 | 0.034773 | 24.83179 | 0.717187 | 5550 |
| prim_5_5@64 | 2.58193 | 0.053222 | 84.23889 | 2.578357 | 0.007627 | 0.01179 | 24.1989 | 0.468736 | 5575 |
| prim_5_5@65 | 2.586268 | 0.107043 | 79.73334 | 1.207351 | 0.005194 | 0.000743 | 23.1509 | 0.971698 | 5600 |
| prim_5_5@66 | 2.612794 | 0.069533 | 81.44213 | 2.22522 | 0.005197 | 0.000724 | 23.64561 | 0.382363 | 5625 |
| prim_5_5@67 | 2.587331 | 0.057025 | 80.73102 | 3.058502 | 0.013955 | 0.034628 | 22.74064 | 0.350674 | 5650 |
| prim_5_5@68 | 2.538679 | 0.058888 | 85.2859 | 2.308514 | 0.006664 | 0.011962 | 23.6945 | 0.584272 | 5675 |
| prim_5_5@69 | 2.482353 | 0.060868 | 91.35262 | 3.423538 | 0.005224 | 0.000625 | 24.23277 | 0.471164 | 5700 |
| prim_5_5@70 | 2.538161 | 0.065047 | 86.06241 | 2.82794 | 0.008187 | 0.022054 | 22.42156 | 0.458507 | 5725 |
| prim_5_5@71 | 2.417493 | 0.097979 | 83.47975 | 4.106372 | 0.005632 | 0.000888 | 21.93652 | 0.722009 | 5750 |
| prim_5_5@72 | 2.429353 | 0.084344 | 83.20778 | 1.90608 | 0.00605 | 0.001121 | 21.97282 | 0.752977 | 5775 |
| prim_5_5@73 | 2.437368 | 0.10936 | 79.13852 | 2.384163 | 0.010998 | 0.022078 | 21.01959 | 0.479886 | 5800 |
| prim_5_5@74 | 2.430012 | 0.11287 | 76.9061 | 3.22318 | 0.006071 | 0.00103 | 20.13178 | 0.524411 | 5825 |
| prim_5_5@75 | 2.448477 | 0.058725 | 71.37857 | 3.213275 | 0.006953 | 0.001137 | 18.7517 | 0.322185 | 5850 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_5@76 | 2.478905 | 0.123611 | 81.66327 | 2.995697 | 0.008153 | 0.019651 | 21.22758 | 0.349267 | 5875 |
| prim_5_5@77 | 2.447388 | 0.059906 | 91.43396 | 3.021581 | 0.005342 | 0.001428 | 24.27129 | 0.388397 | 5900 |
| prim_5_5@78 | 2.453615 | 0.088619 | 85.54269 | 3.35327 | 0.005365 | 0.000762 | 21.98412 | 0.59856 | 5925 |
| prim_5_5@79 | 2.507531 | 0.067665 | 88.67763 | 4.768244 | 0.009201 | 0.029217 | 23.95053 | 0.774763 | 5950 |
| prim_5_5@80 | 2.400647 | 0.092749 | 84.17948 | 2.740792 | 0.005917 | 0.000971 | 23.54028 | 0.474723 | 5975 |
| prim_5_5@81 | 2.444189 | 0.073398 | 81.74544 | 3.3262 | 0.005699 | 0.001048 | 23.70221 | 0.71575 | 6000 |
| prim_5_5@82 | 2.442387 | 0.103996 | 81.32788 | 2.909807 | 0.006277 | 0.007347 | 23.26305 | 0.475216 | 6025 |
| prim_5_5@83 | 2.428629 | 0.06438 | 81.04021 | 2.106555 | 0.007407 | 0.010922 | 22.7614 | 0.605798 | 6050 |
| prim_5_5@84 | 2.467613 | 0.068255 | 74.79154 | 3.137261 | 0.006557 | 0.000771 | 21.27495 | 0.458593 | 6075 |
| prim_5_5@85 | 2.450104 | 0.101174 | 78.05801 | 1.371108 | 0.006188 | 0.001063 | 21.34017 | 0.917015 | 6100 |
| prim_5_5@86 | 2.431061 | 0.06779 | 79.82828 | 2.283354 | 0.0059 | 0.001219 | 21.54507 | 0.492523 | 6125 |
| prim_5_5@87 | 2.437428 | 0.059213 | 79.89398 | 3.443088 | 0.013423 | 0.046933 | 20.50648 | 0.251491 | 6150 |
| prim_5_5@88 | 2.427015 | 0.066539 | 76.62446 | 2.783956 | 0.006254 | 0.001111 | 19.12112 | 0.341486 | 6175 |
| prim_5_5@89 | 2.483274 | 0.085845 | 78.29464 | 1.914414 | 0.007855 | 0.020441 | 21.86604 | 0.54062 | 6200 |
| prim_5_5@90 | 2.506597 | 0.092181 | 78.4427 | 2.202379 | 0.005048 | 0.000927 | 21.75372 | 0.73119 | 6225 |
| prim_5_5@91 | 2.486832 | 0.033319 | 79.69528 | 2.778253 | 0.008561 | 0.014455 | 22.03794 | 0.314585 | 6250 |
| prim_5_5@92 | 2.467067 | 0.073763 | 84.44247 | 2.996127 | 0.008176 | 0.022889 | 22.9186 | 0.503416 | 6275 |
| prim_5_5@93 | 2.449116 | 0.048544 | 86.16584 | 2.208101 | 0.007829 | 0.019288 | 23.3989 | 0.551191 | 6300 |
| prim_5_5@94 | 2.484135 | 0.048681 | 87.90599 | 2.695317 | 0.004626 | 0.002478 | 24.41528 | 0.479003 | 6325 |
| prim_5_5@95 | 2.458867 | 0.046986 | 90.48068 | 3.670524 | 0.005256 | 0.000951 | 24.80147 | 0.286663 | 6350 |
| prim_5_5@96 | 2.483263 | 0.069619 | 83.65596 | 2.334482 | 0.007087 | 0.015967 | 22.11663 | 0.466563 | 6375 |
| prim_5_5@97 | 2.489369 | 0.042263 | 82.12197 | 2.566349 | 0.011394 | 0.044993 | 21.85919 | 0.440572 | 6400 |
| prim_5_5@98 | 2.422188 | 0.054228 | 87.89755 | 2.673264 | 0.01302 | 0.038923 | 23.51808 | 0.487461 | 6425 |
| prim_5_5@99 | 2.512352 | 0.145579 | 82.43486 | 3.050316 | 0.009241 | 0.028949 | 21.5245 | 0.235816 | 6450 |
| prim_5_5@100 | 2.515056 | 0.161574 | 85.67306 | 1.803282 | 0.005917 | 0.00097 | 22.04468 | 0.513293 | 6475 |
| prim_5_6@1 | 2.456539 | 0.059537 | 83.80081 | 0.893153 | 0.00618 | 0.005374 | 22.38401 | 0.396557 | 6500 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_6@2 | 2.383066 | 0.072656 | 90.19818 | 2.025799 | 0.006898 | 0.013663 | 22.23863 | 0.327806 | 6525 |
| prim_5_6@3 | 2.395032 | 0.043473 | 85.42607 | 2.496288 | 0.005486 | 0.001163 | 21.15086 | 0.378122 | 6550 |
| prim_5_6@4 | 2.467504 | 0.118407 | 83.2892 | 2.102741 | 0.005441 | 0.000729 | 23.09958 | 0.398041 | 6575 |
| prim_5_6@5 | 2.511347 | 0.062005 | 82.29482 | 1.731277 | 0.008046 | 0.021957 | 22.49493 | 0.402368 | 6600 |
| prim_5_6@6 | 2.52959 | 0.067361 | 82.50755 | 1.715904 | 0.005141 | 0.003944 | 22.04446 | 0.561851 | 6625 |
| prim_5_6@7 | 2.537804 | 0.107001 | 87.35658 | 1.914445 | 0.005199 | 0.000638 | 22.89929 | 0.321396 | 6650 |
| prim_5_6@8 | 2.501262 | 0.05128 | 89.49906 | 2.854188 | 0.005089 | 0.000921 | 23.49223 | 0.336173 | 6675 |
| prim_5_6@10 | 2.408654 | 0.06636 | 82.0611 | 2.216593 | 0.005641 | 0.000777 | 21.80452 | 0.538506 | 6700 |
| prim_5_6@11 | 2.400337 | 0.038469 | 76.95046 | 2.22901 | 0.008167 | 0.013342 | 19.25388 | 0.256861 | 6725 |
| prim_5_6@12 | 2.365972 | 0.052004 | 77.07232 | 2.608476 | 0.011837 | 0.028987 | 20.43903 | 0.243848 | 6750 |
| prim_5_6@13 | 2.431734 | 0.041711 | 79.2728 | 1.326286 | 0.008219 | 0.017504 | 22.52137 | 0.465271 | 6775 |
| prim_5_6@14 | 2.459651 | 0.051387 | 81.15034 | 2.075458 | 0.008846 | 0.022198 | 22.05341 | 0.48176 | 6800 |
| prim_5_6@15 | 2.464389 | 0.050898 | 79.20061 | 2.935157 | 0.005617 | 0.00099 | 21.23996 | 0.117443 | 6825 |
| prim_5_6@16 | 2.46748 | 0.048511 | 78.93426 | 2.798666 | 0.010756 | 0.020469 | 20.25881 | 0.211047 | 6850 |
| prim_5_6@17 | 2.448071 | 0.069058 | 83.39336 | 2.675107 | 0.005758 | 0.002295 | 22.96219 | 0.354136 | 6875 |
| prim_5_6@18 | 2.484958 | 0.049971 | 78.35385 | 1.582658 | 0.00636 | 0.007112 | 21.14922 | 0.484622 | 6900 |
| prim_5_6@19 | 2.443988 | 0.055014 | 79.40606 | 1.794733 | 0.012594 | 0.026806 | 22.49979 | 0.746215 | 6925 |
| prim_5_7@1 | 2.33552 | 0.111603 | 73.10203 | 1.213462 | 0.006417 | 0.001617 | 19.69027 | 0.540536 | 6950 |
| prim_5_7@2 | 2.302708 | 0.048452 | 77.86372 | 1.508608 | 0.008764 | 0.021713 | 21.52413 | 0.345935 | 6975 |
| prim_5_7@3 | 2.42107 | 0.059043 | 70.63916 | 1.761648 | 0.005905 | 0.001194 | 19.21737 | 0.315564 | 7000 |
| prim_5_7@6 | 2.582932 | 0.051303 | 81.38266 | 2.412991 | 0.007393 | 0.019518 | 24.15253 | 0.50458 | 7150 |
| prim_5_7@7 | 2.570659 | 0.087338 | 80.26526 | 1.949109 | 0.007662 | 0.019136 | 24.47033 | 0.411948 | 7175 |
| prim_5_7@8 | 2.599424 | 0.082123 | 81.89813 | 3.298242 | 0.008031 | 0.021138 | 25.04639 | 0.669309 | 7200 |
| prim_5_7@9 | 2.602358 | 0.06381 | 82.2188 | 1.678749 | 0.009859 | 0.03172 | 23.22426 | 0.467835 | 7225 |
| prim_5_7@10 | 2.51122 | 0.061473 | 87.05327 | 3.298598 | 0.005148 | 0.001367 | 24.52464 | 0.530582 | 7250 |
| prim_5_7@11 | 2.488068 | 0.062934 | 89.68939 | 3.526416 | 0.005208 | 0.001024 | 25.07099 | 0.364784 | 7275 |

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance µm |
|---|---|---|---|---|---|---|---|---|---|
| prim_5_7@12 | 2.518807 | 0.050077 | 80.40267 | 2.448983 | 0.007937 | 0.016614 | 22.79357 | 0.332065 | 7300 |
| prim_5_7@13 | 2.40897 | 0.041186 | 82.90464 | 1.373865 | 0.005513 | 0.000645 | 22.46314 | 0.509081 | 7325 |
| prim_5_7@14 | 2.433665 | 0.067228 | 78.91807 | 0.970562 | 0.01149 | 0.022281 | 20.98896 | 0.517719 | 7350 |
| prim_5_7@15 | 2.495948 | 0.061362 | 75.80384 | 1.700254 | 0.02673 | 0.086856 | 21.61402 | 0.509544 | 7375 |
| prim_5_7@16 | 2.525675 | 0.087712 | 81.28651 | 2.228525 | 0.005905 | 0.001008 | 22.9286 | 0.366211 | 7400 |
| prim_5_7@17 | 2.496743 | 0.072645 | 83.7061 | 2.050726 | 0.008871 | 0.025504 | 23.17747 | 0.39115 | 7425 |
| prim_5_7@18 | 2.467096 | 0.090434 | 86.43277 | 1.856534 | 0.005737 | 0.001117 | 24.1525 | 0.483811 | 7450 |
| prim_5_7@19 | 2.5643 | 0.076352 | 81.51517 | 2.315535 | 0.009258 | 0.030855 | 22.82964 | 0.278902 | 7475 |
| prim_5_7@20 | 2.608993 | 0.052091 | 83.12709 | 1.37346 | 0.010373 | 0.037547 | 23.32474 | 0.75039 | 7500 |
| prim_5_7@21 | 2.585384 | 0.058406 | 86.97906 | 2.115006 | 0.007481 | 0.018893 | 25.45252 | 0.323889 | 7525 |
| prim_5_7@22 | 2.597951 | 0.054268 | 84.17343 | 2.683665 | 0.007848 | 0.009612 | 24.31384 | 0.338852 | 7550 |
| prim_5_7@23 | 2.604936 | 0.153575 | 83.93691 | 1.696142 | 0.004794 | 0.001496 | 24.99292 | 0.597273 | 7575 |
| prim_5_7@24 | 2.557973 | 0.063384 | 84.86489 | 2.823045 | 0.005523 | 0.001235 | 23.70035 | 0.449436 | 7600 |
| prim_5_7@25 | 2.457733 | 0.077204 | 80.65567 | 1.731195 | 0.009303 | 0.026438 | 21.51289 | 0.497865 | 7625 |
| prim_5_7@26 | 2.357378 | 0.063733 | 80.46665 | 1.833009 | 0.006074 | 0.002215 | 20.63853 | 0.541998 | 7650 |
| prim_5_7@27 | 2.424741 | 0.088122 | 78.12587 | 2.866338 | 0.006315 | 0.001177 | 20.9068 | 0.631065 | 7675 |
| prim_5_7@28 | 2.409092 | 0.089119 | 73.65123 | 2.663877 | 0.008421 | 0.016875 | 19.30971 | 0.418899 | 7750 |
| prim_5_7@29 | 2.443374 | 0.055828 | 83.27994 | 2.824822 | 0.005237 | 0.001032 | 25.01176 | 0.446591 | 7775 |
| prim_5_7@30 | 2.485007 | 0.063662 | 83.75201 | 2.437896 | 0.00834 | 0.021363 | 23.34142 | 0.516529 | 7800 |
| prim_5_7@31 | 2.478823 | 0.067347 | 85.89452 | 2.62012 | 0.008714 | 0.022372 | 22.58573 | 0.420808 | 7825 |
| prim_5_7@32 | 2.511868 | 0.106444 | 81.63414 | 1.670567 | 0.005793 | 0.001028 | 21.27756 | 0.332352 | 7850 |

*S.campylecus* (232 transect 1) SIMS data:

**Rows highlighted in grey are SIMS analyses corresponding to remineralized regions in the coral skeleton:**

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 1 | 8.335522 | 0.07111 | 3.221186 | 0.097052 | 0.010547 | 0.000554 | 42.624 | 0.000554 | 0.266943 | 0.244487 |
| 232 2 | 8.021379 | 0.063018 | 2.452932 | 0.038964 | 0.007676 | 0.000487 | 36.759 | 0.000487 | 0.583807 | 0.267589 |
| 232 3 | 8.301606 | 0.086872 | 3.091297 | 0.06344 | 0.008515 | 0.000592 | 42.039 | 0.000592 | 0.758937 | 0.307632 |
| 232 4 | 8.496026 | 0.073014 | 3.210438 | 0.117078 | 0.008906 | 0.000650 | 41.546 | 0.000650 | 0.602253 | 0.343055 |
| 232 5 | 8.560907 | 0.072707 | 3.277721 | 0.183371 | 0.014908 | 0.004148 | 41.276 | 0.004148 | 0.545178 | 0.381558 |
| 232 6 | 8.359632 | 0.080936 | 3.177579 | 0.03229 | 0.008192 | 0.000613 | 41.045 | 0.000613 | 0.392094 | 0.424682 |
| 232 7 | 8.214982 | 0.625754 | 3.087836 | 0.065284 | 0.008079 | 0.004493 | 40.571 | 0.004493 | 0.850441 | 0.450864 |
| 232 8 | 8.228412 | 0.071911 | 3.294163 | 0.030236 | 0.008505 | 0.000657 | 42.837 | 0.000657 | 0.49945 | 0.495528 |
| 232 9 | 8.455439 | 0.06408 | 2.960538 | 0.049235 | 0.009028 | 0.000445 | 41.285 | 0.000445 | 0.8112 | 0.537111 |
| 232 10 | 8.360824 | 0.095612 | 2.951479 | 0.036162 | 0.007858 | 0.000317 | 40.672 | 0.000317 | 0.577741 | 0.578694 |
| 232 11 | 8.439433 | 0.099965 | 2.763394 | 0.040497 | 0.007971 | 0.000372 | 39.124 | 0.000372 | 0.470883 | 0.617197 |
| 232 12 | 8.381370 | 0.111579 | 2.946744 | 0.034371 | 0.008696 | 0.000485 | 40.557 | 0.000485 | 0.549874 | 0.648 |
| 232 13 | 8.434916 | 0.078033 | 2.987307 | 0.026769 | 0.007934 | 0.000313 | 39.616 | 0.000313 | 0.396022 | 0.677262 |
| 232 14 | 8.572302 | 0.079607 | 2.937983 | 0.02227 | 0.008405 | 0.000686 | 39.896 | 0.000686 | 0.518991 | 0.698824 |
| 232 15 | 8.377386 | 0.144907 | 2.673246 | 0.058142 | 0.008461 | 0.000460 | 39.316 | 0.000460 | 1.602281 | 0.735787 |
| 232 16 | 8.334933 | 0.121301 | 2.950152 | 0.025547 | 0.008522 | 0.000631 | 41.444 | 0.000631 | 0.695401 | 0.77121 |
| 232 17 | 8.587762 | 0.124107 | 3.024986 | 0.035895 | 0.009657 | 0.000550 | 41.921 | 0.000550 | 0.523695 | 0.810483 |
| 232 18 | 8.575420 | 0.078818 | 2.974965 | 0.033095 | 0.009571 | 0.000519 | 41.922 | 0.000519 | 0.472687 | 0.845906 |
| 232 19 | 8.540107 | 0.068235 | 3.002538 | 0.055091 | 0.008980 | 0.000428 | 42.017 | 0.000428 | 0.700186 | 0.879789 |
| 232 20 | 8.397652 | 0.121989 | 3.236145 | 0.029574 | 0.008462 | 0.000413 | 42.345 | 0.000413 | 1.027382 | 0.914442 |
| 232 21 | 8.370696 | 0.111087 | 3.042484 | 0.034897 | 0.008188 | 0.000389 | 42.040 | 0.000389 | 0.652226 | 0.952945 |
| 232 22 | 8.122499 | 0.106233 | 3.100924 | 0.050501 | 0.007959 | 0.000396 | 41.546 | 0.000396 | 0.814481 | 0.986828 |
| 232 23 | 8.251648 | 0.080198 | 2.527486 | 0.027259 | 0.008030 | 0.000514 | 37.258 | 0.000514 | 0.366056 | 1.025331 |

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 24 | 8.244557 | 0.120811 | 2.213672 | 0.046308 | 0.007328 | 0.000394 | 36.370 | 0.000394 | 0.344388 | 1.062294 |
| 232 25 | 8.891591 | 0.075235 | 2.309754 | 0.033235 | 0.008599 | 0.000332 | 36.753 | 0.000332 | 0.310447 | 1.099257 |
| 232 26 | 8.344565 | 0.071448 | 2.466471 | 0.020726 | 0.008108 | 0.000294 | 39.369 | 0.000294 | 0.435014 | 1.13391 |
| 232 27 | 8.237313 | 0.098415 | 2.858342 | 0.119278 | 0.008465 | 0.000308 | 41.156 | 0.000308 | 0.720849 | 1.173183 |
| 232 28 | 8.566004 | 0.109168 | 2.903543 | 0.02624 | 0.009316 | 0.000401 | 41.378 | 0.000401 | 0.382722 | 1.207066 |
| 232 29 | 8.429160 | 0.365326 | 2.495311 | 0.068861 | 0.008633 | 0.001627 | 39.445 | 0.001627 | 2.154826 | 1.24403 |
| 232 30 | 8.466278 | 0.066319 | 2.667905 | 0.041661 | 0.008361 | 0.000441 | 40.250 | 0.000441 | 0.371066 | 1.2833 |
| 232 31 | 8.301428 | 0.10382 | 2.966444 | 0.034421 | 0.007708 | 0.000529 | 41.256 | 0.000529 | 0.4914 | 1.32489 |
| 232 32 | 8.306151 | 0.069307 | 3.036077 | 0.044399 | 0.007944 | 0.000623 | 41.220 | 0.000623 | 0.355629 | 1.35723 |
| 232 33 | 8.527908 | 0.123927 | 2.897967 | 0.022299 | 0.008539 | 0.000433 | 40.565 | 0.000433 | 0.419353 | 1.24403 |
| 232 34 | 8.467176 | 0.075705 | 2.745915 | 0.027715 | 0.007940 | 0.000411 | 39.953 | 0.000411 | 0.388399 | 1.2833 |
| 232 35 | 8.483846 | 0.096336 | 2.660817 | 0.043955 | 0.008318 | 0.000503 | 39.273 | 0.000503 | 0.517867 | 1.47813 |
| 232 36 | 8.118640 | 0.059374 | 1.748039 | 0.015368 | 0.006519 | 0.000525 | 33.153 | 0.000525 | 0.344082 | 1.52048 |
| 232 37 | 8.666135 | 0.093145 | 3.356748 | 0.253221 | 0.010629 | 0.000195 | 42.608 | 0.000195 | 0.595962 | 1.55667 |
| 232 38 | 8.597675 | 0.059184 | 3.130391 | 0.043259 | 0.007692 | 0.000308 | 39.847 | 0.000308 | 0.544245 | 1.59518 |
| 232 39 | 8.396189 | 0.130939 | 2.834301 | 0.020763 | 0.007446 | 0.000467 | 38.277 | 0.000467 | 0.627031 | 1.63368 |
| 232 40 | 8.661685 | 0.100451 | 3.235027 | 0.311032 | 0.007984 | 0.000312 | 38.281 | 0.000312 | 0.547895 | 1.68142 |
| 232 41 | 8.489035 | 0.09122 | 2.549337 | 0.065761 | 0.007620 | 0.000406 | 37.199 | 0.000406 | 0.504909 | 1.71839 |
| 232 42 | 8.205245 | 0.725844 | 2.812822 | 0.15527 | 0.007549 | 0.002943 | 38.565 | 0.002943 | 2.104533 | 1.75766 |
| 232 43 | 8.400171 | 0.115654 | 2.717075 | 0.043531 | 0.008673 | 0.000381 | 38.872 | 0.000381 | 0.672364 | 1.80078 |
| 232 44 | 8.460270 | 0.097373 | 3.785904 | 0.19223 | 0.009120 | 0.000625 | 37.954 | 0.000625 | 0.639919 | 1.84314 |
| 232 45 | 8.422945 | 0.096684 | 2.706881 | 0.026742 | 0.008803 | 0.000720 | 39.789 | 0.000720 | 0.608882 | 1.88241 |
| 232 46 | 8.348253 | 0.058311 | 2.947595 | 0.060709 | 0.008158 | 0.000628 | 40.519 | 0.000628 | 0.297128 | 1.92322 |
| 232 47 | 8.192201 | 0.122152 | 3.037612 | 0.028137 | 0.007948 | 0.000663 | 41.188 | 0.000663 | 0.905181 | 1.96712 |
| 232 48 | 8.238541 | 0.114998 | 3.063693 | 0.03325 | 0.007854 | 0.000325 | 41.689 | 0.000325 | 0.503022 | 2.01178 |
| 232 49 | 8.352765 | 0.114353 | 2.563144 | 0.32835 | 0.008312 | 0.000959 | 37.986 | 0.000959 | 0.486889 | 2.05953 |

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 50 | 8.252335 | 0.111935 | 2.892313 | 0.070272 | 0.007483 | 0.000651 | 40.396 | 0.000651 | 0.511271 | 2.09649 |
| 232 51 | 8.490948 | 0.111309 | 3.135351 | 0.047855 | 0.008894 | 0.000331 | 40.757 | 0.000331 | 0.576766 | 2.13499 |
| 232 53 | 8.390957 | 0.087195 | 3.011804 | 0.030714 | 0.008836 | 0.000594 | 41.513 | 0.000594 | 0.51889 | 2.1758 |
| 232 54 | 8.249865 | 0.079176 | 3.229715 | 0.033738 | 0.009362 | 0.000629 | 43.515 | 0.000629 | 0.707163 | 2.21046 |
| 232 55 | 8.148506 | 0.289462 | 3.086817 | 0.048936 | 0.008758 | 0.000633 | 42.381 | 0.000633 | 1.142926 | 2.23202 |
| 232 56 | 8.736219 | 0.157856 | 2.870696 | 0.035289 | 0.009186 | 0.000592 | 40.138 | 0.000592 | 0.799243 | 2.26436 |
| 232 57 | 8.680603 | 0.151376 | 2.939963 | 0.030885 | 0.008487 | 0.000744 | 40.402 | 0.000744 | 1.178069 | 2.30286 |
| 232 58 | 8.029362 | 0.282118 | 3.501314 | 0.370435 | 0.009411 | 0.004046 | 42.700 | 0.004046 | 3.009526 | 2.34368 |
| 232 59 | 8.141195 | 0.090345 | 3.313233 | 0.044232 | 0.007658 | 0.000548 | 42.660 | 0.000548 | 0.785924 | 2.36909 |
| 232 60 | 8.481102 | 0.437675 | 2.941883 | 0.108008 | 0.008275 | 0.001040 | 41.252 | 0.001040 | 1.540688 | 2.41683 |
| 232 61 | 8.284436 | 0.099374 | 3.207475 | 0.059888 | 0.008672 | 0.000417 | 42.328 | 0.000417 | 0.992766 | 2.45765 |
| 232 62 | 8.140915 | 0.209862 | 2.936243 | 0.688576 | 0.007759 | 0.003343 | 40.693 | 0.003343 | 4.201519 | 2.49923 |
| 232 63 | 8.628727 | 0.124797 | 2.701473 | 0.092689 | 0.010486 | 0.001254 | 40.060 | 0.001254 | 0.244753 | 2.53927 |
| 232 64 | 8.701196 | 0.072279 | 2.671708 | 0.026541 | 0.008527 | 0.000390 | 39.250 | 0.000390 | 0.500235 | 2.57855 |
| 232 65 | 9.004592 | 0.071027 | 2.687340 | 0.026589 | 0.009349 | 0.000522 | 39.611 | 0.000522 | 0.443814 | 2.61705 |
| 232 66 | 8.347334 | 0.139863 | 2.716097 | 0.022824 | 0.008239 | 0.000642 | 39.659 | 0.000642 | 0.715008 | 2.64554 |
| 232 67 | 8.397931 | 0.094537 | 2.707266 | 0.027967 | 0.007900 | 0.000630 | 40.181 | 0.000630 | 0.557019 | 2.68559 |
| 232 68 | 8.191939 | 0.067331 | 2.932445 | 0.02992 | 0.007189 | 0.000543 | 41.655 | 0.000543 | 0.468815 | 2.72024 |
| 232 69 | 8.480993 | 0.074248 | 3.035330 | 0.020712 | 0.007832 | 0.000576 | 41.175 | 0.000576 | 0.407635 | 2.75566 |
| 232 70 | 8.619019 | 0.164185 | 2.933083 | 0.025106 | 0.008269 | 0.000397 | 40.392 | 0.000397 | 0.708776 | 2.78877 |
| 232 71 | 8.478348 | 0.244223 | 2.820537 | 0.035768 | 0.008928 | 0.000602 | 39.935 | 0.000602 | 1.360655 | 2.83036 |
| 232 72 | 8.450425 | 0.258756 | 2.809342 | 0.203437 | 0.009122 | 0.001831 | 41.183 | 0.001831 | 1.954511 | 2.87733 |
| 232 73 | 8.343528 | 0.093083 | 2.821788 | 0.087158 | 0.009003 | 0.000822 | 41.522 | 0.000822 | 1.105144 | 2.90274 |
| 232 74 | 7.259481 | 1.975436 | 3.343112 | 0.350016 | 0.007712 | 0.007712 | 39.148 | 0.007712 | 9.662672 | 2.9451 |
| 232 75 | 8.368051 | 0.149025 | 3.147837 | 0.050547 | 0.008965 | 0.008965 | 40.283 | 0.008965 | 0.649552 | 3.00516 |
| 232 76 | 8.118606 | 0.184898 | 3.201607 | 0.125171 | 0.008315 | 0.008315 | 40.599 | 0.008315 | 0.869503 | 3.05522 |

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 77 | 8.087438 | 0.276112 | 3.480198 | 0.074815 | 0.007892 | 0.007892 | 41.911 | 0.007892 | 0.652875 | 3.10912 |
| 232 78 | 8.503356 | 0.129704 | 2.939066 | 0.053538 | 0.009084 | 0.009084 | 38.688 | 0.009084 | 0.503375 | 3.15763 |
| 232 79 | 8.237517 | 0.232067 | 3.216521 | 0.107076 | 0.009300 | 0.0093 | 41.577 | 0.0093 | 2.147929 | 3.20846 |
| 232 80 | 8.319673 | 0.160872 | 2.473388 | 0.02546 | 0.042159 | 0.042159 | 35.878 | 0.042159 | 0.506105 | 3.25543 |
| 232 81 | 8.389832 | 0.173104 | 2.872177 | 0.045984 | 0.007782 | 0.007782 | 38.101 | 0.007782 | 0.85276 | 3.30241 |
| 232 82 | 8.617122 | 0.129426 | 2.859544 | 0.079492 | 0.008354 | 0.008354 | 37.450 | 0.008354 | 0.596841 | 3.35246 |
| 232 83 | 8.507738 | 0.161029 | 3.047930 | 0.033372 | 0.009369 | 0.009369 | 39.511 | 0.009369 | 0.771054 | 3.39866 |
| 232 84 | 8.526700 | 0.135832 | 3.108509 | 0.069727 | 0.009421 | 0.009421 | 40.945 | 0.009421 | 0.577228 | 3.44179 |
| 232 85 | 8.495350 | 0.191437 | 2.951025 | 0.080223 | 0.009078 | 0.009078 | 39.890 | 0.009078 | 0.771139 | 3.48645 |
| 232 86 | 8.396178 | 0.188399 | 2.909487 | 0.046951 | 0.008435 | 0.008435 | 39.088 | 0.008435 | 1.130032 | 3.53728 |
| 232 87 | 8.575179 | 0.159175 | 3.072815 | 0.030795 | 0.008890 | 0.00889 | 40.346 | 0.00889 | 0.787156 | 3.57963 |
| 232 88 | 8.715956 | 0.156823 | 2.958722 | 0.03752 | 0.009577 | 0.009577 | 39.953 | 0.009577 | 0.850234 | 3.62891 |
| 232 89 | 8.550081 | 0.190269 | 2.916873 | 0.041817 | 0.008742 | 0.008742 | 38.741 | 0.008742 | 0.799828 | 3.6705 |
| 232 90 | 8.818390 | 0.18479 | 2.718471 | 0.035152 | 0.009904 | 0.009904 | 38.223 | 0.009904 | 0.816119 | 3.71824 |
| 232 91 | 8.562182 | 0.138954 | 3.008998 | 0.019941 | 0.009556 | 0.009556 | 40.569 | 0.009556 | 0.766209 | 3.74827 |
| 232 92 | 8.329921 | 0.16278 | 3.204382 | 0.071409 | 0.008716 | 0.008716 | 42.244 | 0.008716 | 0.887831 | 3.79602 |
| 232 93 | 8.502446 | 0.169555 | 3.094763 | 0.033097 | 0.008906 | 0.008906 | 40.811 | 0.008906 | 0.811611 | 3.84607 |
| 232 94 | 8.249668 | 0.104898 | 3.151922 | 0.031362 | 0.008338 | 0.008338 | 41.233 | 0.008338 | 0.66579 | 3.88996 |
| 232 95 | 8.269508 | 0.149486 | 3.435237 | 0.023743 | 0.009001 | 0.009001 | 43.621 | 0.009001 | 1.160998 | 3.93386 |
| 232 96 | 8.630193 | 0.100021 | 3.060686 | 0.043982 | 0.009933 | 0.009933 | 41.244 | 0.009933 | 0.524364 | 3.97467 |
| 232 97 | 8.583648 | 0.044654 | 3.194233 | 0.028859 | 0.010073 | 0.010073 | 41.752 | 0.010073 | 0.594609 | 4.01317 |
| 232 98 | 8.514222 | 0.144874 | 2.861413 | 0.107841 | 0.009023 | 0.009023 | 38.568 | 0.009023 | 0.67359 | 4.05245 |
| 232 99 | 8.622385 | 0.225503 | 3.164514 | 0.058278 | 0.011417 | 0.011417 | 41.297 | 0.011417 | 0.447656 | 4.10096 |
| 232 100 | 8.458907 | 0.074761 | 3.054822 | 0.042817 | 0.009073 | 0.009073 | 41.402 | 0.009073 | 0.307171 | 4.14871 |
| 232 101 | 8.649241 | 0.185991 | 2.940949 | 0.1178 | 0.009313 | 0.009313 | 39.525 | 0.009313 | 1.030724 | 4.19953 |
| 232 102 | 8.833550 | 0.178559 | 3.287907 | 0.280603 | 0.009418 | 0.009418 | 40.035 | 0.009418 | 0.626653 | 4.23033 |

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 103 | 8.409051 | 0.08364 | 2.988936 | 0.030928 | 0.008737 | 0.008737 | 41.154 | 0.008737 | 0.811085 | 4.27731 |
| 232 104 | 8.399508 | 0.092512 | 3.169848 | 0.028568 | 0.009417 | 0.009417 | 42.077 | 0.009417 | 1.059934 | 4.3212 |
| 232 105 | 8.721751 | 0.104662 | 2.938410 | 0.041679 | 0.010999 | 0.010999 | 39.767 | 0.010999 | 0.761412 | 4.37587 |
| 232 106 | 8.527214 | 0.182388 | 2.979196 | 0.036784 | 0.008608 | 0.008608 | 40.233 | 0.008608 | 1.106137 | 4.41515 |
| 232 107 | 8.432652 | 0.095543 | 3.131984 | 0.037959 | 0.008297 | 0.008297 | 41.732 | 0.008297 | 0.739998 | 4.44287 |
| 232 108 | 8.766948 | 0.135778 | 2.953049 | 0.037298 | 0.009201 | 0.009201 | 40.236 | 0.009201 | 0.519187 | 4.47521 |
| 232 109 | 8.610788 | 0.244526 | 2.789220 | 1.424327 | 0.009214 | 0.009214 | 37.168 | 0.009214 | 0.81724 | 4.5245 |
| 232 110 | 8.417758 | 0.14619 | 2.163854 | 0.042293 | 0.009260 | 0.00926 | 35.532 | 0.00926 | 0.494865 | 4.563 |
| 232 111 | 8.433846 | 0.06961 | 2.938636 | 0.03319 | 0.009292 | 0.009292 | 42.164 | 0.009292 | 0.49784 | 4.6015 |
| 232 112 | 8.304953 | 0.122681 | 3.205776 | 0.041596 | 0.009272 | 0.009272 | 42.609 | 0.009272 | 1.019763 | 4.63693 |
| 232 113 | 8.383056 | 0.189336 | 3.263550 | 0.038264 | 0.008749 | 0.008749 | 41.801 | 0.008749 | 1.025259 | 4.67466 |
| 232 114 | 8.527034 | 0.200262 | 3.111075 | 0.036232 | 0.009426 | 0.009426 | 41.356 | 0.009426 | 0.754137 | 4.71778 |
| 232 115 | 8.496942 | 0.157441 | 3.238468 | 0.039598 | 0.009558 | 0.009558 | 42.399 | 0.009558 | 0.934858 | 4.75783 |
| 232 116 | 7.998858 | 0.064469 | 3.782837 | 0.033325 | 0.008180 | 0.00818 | 38.571 | 0.00818 | 0.566659 | 4.79094 |
| 232 117 | 7.971216 | 0.316355 | 3.853869 | 0.069327 | 0.010136 | 0.010136 | 39.561 | 0.010136 | 1.529038 | 4.83252 |
| 232 118 | 8.016756 | 0.376672 | 3.434500 | 0.044371 | 0.008849 | 0.008849 | 37.424 | 0.008849 | 1.533502 | 4.86794 |
| 232 119 | 8.164202 | 0.333589 | 3.479169 | 0.265221 | 0.009508 | 0.009508 | 37.573 | 0.009508 | 1.515296 | 4.90722 |
| 232 120 | 8.182415 | 0.295193 | 3.568449 | 0.083478 | 0.010194 | 0.010194 | 39.317 | 0.010194 | 1.224529 | 4.94418 |
| 232 121 | 8.093531 | 0.337225 | 3.647641 | 0.079089 | 0.010418 | 0.010418 | 40.070 | 0.010418 | 1.635372 | 4.98499 |
| 232 122 | 8.028426 | 0.251929 | 3.482583 | 0.140473 | 0.008818 | 0.008818 | 37.975 | 0.008818 | 1.060652 | 5.02966 |
| 232 123 | 8.118053 | 0.298123 | 3.374157 | 0.09536 | 0.009059 | 0.009059 | 38.172 | 0.009059 | 1.406092 | 5.06662 |
| 232 124 | 8.265742 | 0.297468 | 3.513003 | 0.105558 | 0.010490 | 0.01049 | 39.654 | 0.01049 | 1.672786 | 5.11051 |
| 232 125 | 8.295405 | 0.306735 | 3.065011 | 0.046979 | 0.010262 | 0.010262 | 37.733 | 0.010262 | 1.619451 | 5.15056 |
| 232 126 | 8.150139 | 0.342534 | 3.496063 | 0.05074 | 0.009839 | 0.009839 | 39.527 | 0.009839 | 1.726258 | 5.19522 |
| 232 127 | 8.096040 | 0.290057 | 3.677897 | 0.085537 | 0.010347 | 0.010347 | 40.532 | 0.010347 | 1.655591 | 5.23372 |
| 232 128 | 8.026449 | 0.291793 | 3.831467 | 0.122717 | 0.010298 | 0.010298 | 41.424 | 0.010298 | 1.679742 | 5.27685 |

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 129 | 8.105417 | 0.285145 | 3.697075 | 0.055705 | 0.012890 | 0.01289 | 40.960 | 0.01289 | 1.953996 | 5.31997 |
| 232 130 | 8.065678 | 0.209984 | 3.586401 | 0.085066 | 0.010656 | 0.010656 | 40.414 | 0.010656 | 1.414346 | 5.36386 |
| 232 131 | 8.137685 | 0.105769 | 3.386254 | 0.131405 | 0.007794 | 0.007794 | 40.619 | 0.007794 | 0.643317 | 5.39929 |
| 232 132 | 8.186529 | 0.275301 | 3.498709 | 0.095777 | 0.009699 | 0.009699 | 40.686 | 0.009699 | 1.36479 | 5.43856 |
| 232 133 | 8.250188 | 0.27342 | 3.125551 | 0.110409 | 0.010397 | 0.010397 | 39.046 | 0.010397 | 0.854855 | 5.47167 |
| 232 134 | 8.180795 | 0.334759 | 2.998190 | 0.086566 | 0.009266 | 0.009266 | 38.123 | 0.009266 | 1.520677 | 5.51403 |
| 232 135 | 8.257824 | 0.218883 | 2.681125 | 0.193629 | 0.009835 | 0.009835 | 37.073 | 0.009835 | 0.765068 | 5.55638 |
| 232 136 | 8.210306 | 0.198575 | 3.046089 | 0.082646 | 0.009502 | 0.009502 | 40.087 | 0.009502 | 1.050959 | 5.5918 |
| 232 137 | 8.290170 | 0.185217 | 3.203206 | 0.464471 | 0.009417 | 0.009417 | 39.672 | 0.009417 | 0.469643 | 5.63108 |
| 232 138 | 8.345091 | 0.191512 | 2.526090 | 0.098478 | 0.008971 | 0.008971 | 37.273 | 0.008971 | 0.530571 | 5.67189 |
| 232 139 | 8.267515 | 0.162073 | 2.632417 | 0.088437 | 0.008767 | 0.000949 | 38.032 | 0.000949 | 1.045818 | 5.71116 |
| 232 140 | 7.961333 | 0.36505 | 2.082662 | 0.032297 | 0.008055 | 0.000919 | 33.858 | 0.000919 | 1.210192 | 5.74274 |
| 232 141 | 8.279458 | 0.039902 | 2.690980 | 0.017236 | 0.009011 | 0.000402 | 38.419 | 0.000402 | 0.490639 | 5.7874 |
| 232 142 | 8.703649 | 0.260181 | 2.700153 | 0.056791 | 0.010118 | 0.000886 | 37.637 | 0.000886 | 0.671818 | 5.82975 |
| 232 143 | 8.484644 | 0.176087 | 3.054954 | 0.037936 | 0.009929 | 0.0013 | 40.917 | 0.0013 | 0.846801 | 5.86364 |
| 232 144 | 8.199779 | 0.305526 | 3.210113 | 0.161546 | 0.009313 | 0.001253 | 40.827 | 0.001253 | 1.084982 | 5.89829 |
| 232 145 | 8.487895 | 0.159215 | 2.596176 | 0.07965 | 0.009243 | 0.000778 | 37.101 | 0.000778 | 0.586281 | 5.93756 |
| 232 146 | 8.192449 | 0.166028 | 2.957549 | 0.046926 | 0.009170 | 0.000951 | 39.673 | 0.000951 | 0.668348 | 5.96913 |
| 232 147 | 8.260818 | 0.208308 | 2.967736 | 0.073145 | 0.009225 | 0.000755 | 39.996 | 0.000755 | 0.897636 | 6.00764 |
| 232 148 | 8.309137 | 0.246841 | 2.949225 | 0.061182 | 0.009343 | 0.001002 | 39.813 | 0.001002 | 0.804318 | 6.0446 |
| 232 149 | 8.265000 | 0.289288 | 3.024351 | 0.13166 | 0.009383 | 0.001055 | 39.478 | 0.001055 | 1.06595 | 6.08387 |
| 232 150 | 8.169186 | 0.239619 | 2.896286 | 0.095463 | 0.008822 | 0.001267 | 38.792 | 0.001267 | 1.273999 | 6.12623 |
| 232 151 | 8.445863 | 0.276256 | 3.013131 | 0.320923 | 0.008951 | 0.00183 | 38.862 | 0.00183 | 0.666933 | 6.17012 |
| 232 153 | 8.163134 | 0.473724 | 2.780201 | 0.796748 | 0.008500 | 0.001913 | 37.604 | 0.001913 | 1.016672 | 6.22017 |
| 232 154 | 8.066610 | 0.09655 | 2.429072 | 0.026336 | 0.007083 | 0.000275 | 35.586 | 0.000275 | 0.680904 | 6.26022 |
| 232 155 | 8.133826 | 0.105696 | 2.385551 | 0.042596 | 0.007400 | 0.00079 | 35.982 | 0.00079 | 0.782572 | 6.29256 |

| file name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD Ba | 23Na/42Ca mmol/mol | 2SD Ba | 2SD Na | distance mm |
|---|---|---|---|---|---|---|---|---|---|---|
| 232 156 | 7.941652 | 0.187321 | 2.842019 | 0.050791 | 0.007538 | 0.001063 | 38.596 | 0.001063 | 1.069538 | 6.3172 |
| 232 157 | 7.993822 | 0.272806 | 3.206713 | 0.056461 | 0.008680 | 0.000675 | 41.219 | 0.000675 | 1.49729 | 6.35186 |
| 232 158 | 7.868929 | 0.158724 | 3.332091 | 0.05871 | 0.008648 | 0.00113 | 42.091 | 0.00113 | 0.838779 | 6.38343 |
| 232 159 | 8.130483 | 0.081107 | 3.173783 | 0.152259 | 0.008375 | 0.000654 | 41.024 | 0.000654 | 0.454152 | 6.41654 |
| 232 160 | 8.155319 | 0.185487 | 3.189049 | 0.042486 | 0.008996 | 0.000898 | 40.536 | 0.000898 | 0.672248 | 6.44888 |
| 232 161 | 7.913035 | 0.262506 | 3.222671 | 0.19266 | 0.008570 | 0.001415 | 39.887 | 0.001415 | 1.339459 | 6.48739 |
| 232 162 | 8.046613 | 0.207256 | 3.026843 | 0.31578 | 0.008096 | 0.000876 | 38.922 | 0.000876 | 1.128062 | 6.51203 |
| 232 163 | 7.825480 | 0.179259 | 3.277140 | 0.066719 | 0.007822 | 0.000966 | 41.938 | 0.000966 | 0.959963 | 6.54976 |
| 232 164 | 7.943275 | 0.168637 | **2.443398** | 0.04859 | **0.006735** | 0.000675 | **36.979** | 0.000675 | 0.831795 | 6.5898 |
| **232 165** | **7.867730** | 0.214351 | **2.432870** | 0.147714 | **0.007731** | 0.001304 | **35.679** | 0.001304 | 0.887298 | 6.61984 |
| **232 166** | **7.632586** | 0.192755 | **3.083535** | 0.159212 | **0.007588** | 0.000768 | **40.626** | 0.000768 | 1.059207 | 6.65449 |
| **232 167** | **8.153225** | 0.148039 | **2.450641** | 0.540961 | **0.007418** | 0.000522 | **35.879** | 0.000522 | 0.839088 | 6.68606 |
| **232 168** | **7.768784** | 0.131476 | **3.288198** | 0.057762 | **0.007430** | 0.000618 | **42.164** | 0.000618 | 0.88227 | 6.7107 |
| **232 169** | **7.894467** | 0.100419 | **2.901055** | 0.044787 | **0.008369** | 0.000566 | **39.708** | 0.000566 | 0.466133 | 6.75383 |
| **232 170** | **7.830969** | 0.424024 | **2.862780** | 0.469905 | **0.009611** | 0.002638 | **37.305** | 0.002638 | 2.000066 | 6.7931 |
| **232 171** | **7.572414** | 0.300006 | **2.952790** | 0.490094 | **0.007844** | 0.002006 | **38.528** | 0.002006 | 1.144151 | 6.82467 |
| **232 172** | 7.526520 | 0.235453 | 2.551180 | 0.08452 | 0.008346 | 0.000917 | 37.672 | 0.000917 | 0.801862 | 6.84855 |
| **232 173** | 7.678048 | 0.319428 | 2.922301 | 0.444674 | 0.009313 | 0.002399 | 37.843 | 0.002399 | 1.589708 | 6.90399 |
| **232 174** | 7.967397 | 0.258691 | 3.030338 | 0.105707 | 0.009415 | 0.001105 | 40.142 | 0.001105 | 1.228566 | 6.94557 |
| **232 176** | 7.797760 | 0.281637 | 2.938085 | 0.259371 | 0.008555 | 0.000738 | 39.313 | 0.000738 | 1.157671 | 6.98716 |
| **232 177** | 8.080129 | 0.300609 | 9.884770 | 1.710855 | 0.052515 | 0.005421 | 39.422 | 0.005421 | 1.531264 | 6.99255 |
| **232 178** | 7.984201 | 0.316514 | 3.584686 | 0.172267 | 0.009641 | 0.002808 | 42.641 | 0.002808 | 1.910575 | 7.01565 |
| **232 181** | 7.420415 | 0.306207 | 3.110250 | 0.18728 | 0.008175 | 0.00108 | 40.545 | 0.00108 | 0.987395 | 7.05261 |
| **232 182** | 8.400099 | 0.254622 | 3.527684 | 0.18827 | 0.010879 | 0.001661 | 41.587 | 0.001661 | 1.135266 | 7.08418 |
| **232 183** | 8.222623 | 0.147334 | 3.217160 | 0.137388 | 0.009785 | 0.001463 | 41.189 | 0.001463 | 0.801447 | 7.1173 |
| **232 184** | 8.426417 | 0.322831 | 3.075725 | 0.135534 | 0.010020 | 0.001225 | 39.389 | 0.001225 | 1.508304 | 7.1558 |

*S.campylecus* (232 transect 2) SIMS data

**Rows highlighted in grey are SIMS analyses corresponding to remineralized regions in the coral skeleton:**

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_232_b@1 | 7.988339 | 0.086547 | 2.285679 | 0.053818 | 0.009495 | 0.000847 | 37.30332 | 0.387921 | 0.288513 |
| coral_232_b@2 | 7.89841 | 0.225481 | 2.601403 | 0.046107 | 0.011872 | 0.002276 | 38.8939 | 0.49089 | 0.305408 |
| coral_232_b@3 | 8.099336 | 0.17087 | 2.674077 | 0.340673 | 0.010836 | 0.001615 | 38.8962 | 0.337106 | 0.33075 |
| coral_232_b@4 | 8.205664 | 0.030009 | 2.721724 | 0.159391 | 0.011713 | 0.001776 | 40.70072 | 0.625094 | 0.354684 |
| coral_232_b@5 | 8.212811 | 0.152356 | 2.715142 | 0.037162 | 0.012263 | 0.001666 | 39.68983 | 0.377699 | 0.374394 |
| coral_232_b@6 | 8.146848 | 0.169794 | 2.780297 | 0.054662 | 0.012417 | 0.002984 | 40.42435 | 0.398393 | 0.401144 |
| coral_232_b@7 | 8.307743 | 0.098042 | 2.505152 | 0.236391 | 0.010844 | 0.002653 | 38.18255 | 0.249883 | 0.43071 |
| coral_232_b@8 | 8.141986 | 0.074959 | 2.656685 | 0.028167 | 0.010459 | 0.001739 | 39.92583 | 0.3668 | 0.454644 |
| coral_232_b@9 | 7.99351 | 0.203793 | 2.702657 | 0.040864 | 0.011254 | 0.001903 | 39.19002 | 0.496607 | 0.481394 |
| coral_232_b@10 | 8.116547 | 0.264603 | 2.831095 | 0.022756 | 0.01142 | 0.001713 | 41.2598 | 0.499529 | 0.516591 |
| coral_232_b@11 | 8.08781 | 0.121573 | 2.877081 | 0.036324 | 0.011157 | 0.002087 | 42.05524 | 0.361817 | 0.539117 |
| coral_232_b@12 | 6.932384 | 0.167036 | 5.684478 | 4.839996 | 0.030641 | 0.012791 | 38.24495 | 3.695373 | 0.571499 |
| coral_232_b@13 | 8.377236 | 0.130858 | 2.531876 | 0.127369 | 0.013091 | 0.002233 | 39.03999 | 0.637556 | 0.591209 |
| coral_232_b@14 | 8.315681 | 0.132892 | 2.885165 | 0.342942 | 0.010753 | 0.001326 | 39.63609 | 0.253859 | 0.622183 |
| coral_232_b@15 | 8.218407 | 0.109796 | 2.351467 | 0.047342 | 0.010977 | 0.001309 | 38.34543 | 0.405584 | 0.636262 |
| coral_232_b@16 | 8.139413 | 0.113894 | 2.477995 | 0.028389 | 0.010799 | 0.001849 | 39.0378 | 0.394072 | 0.665827 |
| coral_232_b@17 | 8.184395 | 0.110251 | 2.564853 | 0.035635 | 0.011315 | 0.0009 | 39.6904 | 0.510765 | 0.68413 |
| coral_232_b@18 | 8.158349 | 0.059738 | 2.69486 | 0.312131 | 0.010662 | 0.002217 | 38.77354 | 0.293281 | 0.712288 |
| coral_232_b1@1 | 7.914976 | 0.193669 | 2.649221 | 0.067398 | 0.010712 | 0.002101 | 29.01523 | 1.147441 | 0.734814 |
| coral_232_b1@2 | 8.332772 | 0.158524 | 2.573674 | 0.023857 | 0.011518 | 0.002438 | 30.06662 | 2.295985 | 0.754525 |
| coral_232_b1@3 | 8.295363 | 0.050015 | 2.590258 | 0.017565 | 0.011648 | 0.003817 | 31.99196 | 0.156927 | 0.78409 |
| coral_232_b1@4 | 8.346815 | 0.132574 | 2.471337 | 0.013631 | 0.01052 | 0.003131 | 30.76175 | 0.182447 | 0.81084 |
| coral_232_b1@5 | 8.237685 | 0.131326 | 1.917192 | 0.042179 | 0.010495 | 0.002202 | 27.21512 | 0.188444 | 0.831958 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_232_b1@6 | 8.4057 | 0.188295 | 2.394411 | 0.084708 | 0.013508 | 0.002539 | 29.99568 | 0.210228 | 0.862932 |
| coral_232_b1@7 | 8.458758 | 0.140554 | 2.453892 | 0.031361 | 0.013138 | 0.002634 | 31.36287 | 0.226239 | 0.889682 |
| coral_232_b1@8 | 8.278197 | 0.18572 | 2.172232 | 0.038043 | 0.011616 | 0.001937 | 29.7076 | 0.277547 | 0.915024 |
| coral_232_b1@9 | 8.262263 | 0.150558 | 1.919335 | 0.01939 | 0.018288 | 0.004705 | 27.35049 | 0.330947 | 0.936142 |
| coral_232_b1@10 | 8.397472 | 0.092821 | 2.775399 | 0.445122 | 0.048123 | 0.012082 | 30.69572 | 0.173211 | 0.962892 |
| coral_232_b1@11 | 8.41617 | 0.056182 | 2.522441 | 0.017744 | 0.01134 | 0.003078 | 32.69818 | 0.186017 | 0.992458 |
| coral_232_b1@12 | 8.305366 | 0.094573 | 2.595979 | 0.034964 | 0.012348 | 0.001992 | 33.28571 | 0.217788 | 1.012168 |
| coral_232_b1@13 | 8.228368 | 0.13713 | 2.19324 | 0.034341 | 0.011903 | 0.002224 | 29.90404 | 0.196769 | 1.033287 |
| coral_232_b1@14 | 8.474819 | 0.142532 | 2.258688 | 0.041068 | 0.012669 | 0.002097 | 30.57793 | 0.272758 | 1.062852 |
| coral_232_b1@15 | 8.21269 | 0.162333 | 2.1785 | 0.046862 | 0.012184 | 0.00284 | 30.11705 | 0.160711 | 1.089602 |
| coral_232_b1@16 | 8.085527 | 0.18345 | 2.401449 | 0.326813 | 0.014009 | 0.004142 | 30.36981 | 1.357581 | 1.119168 |
| coral_232_b1@17 | 8.265172 | 0.100276 | 1.661402 | 0.057069 | 0.011128 | 0.003665 | 27.30544 | 0.315671 | 1.141694 |
| coral_232_b1@18 | 8.51547 | 0.143844 | 1.895099 | 0.039653 | 0.011667 | 0.003687 | 29.51237 | 0.204809 | 1.159997 |
| coral_232_b1@19 | 8.362233 | 0.2148 | 2.372862 | 0.357648 | 0.012465 | 0.003185 | 33.8698 | 1.842961 | 1.189563 |
| coral_232_b1@20 | 8.202433 | 0.178716 | 2.266389 | 0.064084 | 0.014132 | 0.002947 | 33.33603 | 0.317369 | 1.216312 |
| coral_232_b_2@1 | 8.323009 | 0.143463 | 2.399137 | 0.071202 | 0.012972 | 0.005315 | 32.84529 | 0.232931 | 1.243062 |
| coral_232_b_2@2 | 8.393879 | 0.159177 | 2.507128 | 0.0314 | 0.013668 | 0.00257 | 33.10831 | 0.289343 | 1.261365 |
| coral_232_b_2@3 | 8.51424 | 0.189064 | 2.52288 | 0.036155 | 0.013224 | 0.00258 | 32.84864 | 0.216522 | 1.283891 |
| coral_232_b_2@4 | 8.566874 | 0.17818 | 2.511705 | 0.029924 | 0.01223 | 0.002522 | 33.11514 | 0.331399 | 1.310638 |
| coral_232_b_2@5 | 8.418289 | 0.152718 | 2.564907 | 0.071 | 0.011653 | 0.001967 | 32.94642 | 0.279496 | 1.335988 |
| coral_232_b_2@6 | 8.358938 | 0.134721 | 2.994507 | 0.035657 | 0.013819 | 0.004268 | 33.14407 | 0.234874 | 1.359918 |
| coral_232_b_2@7 | 7.992481 | 0.148293 | 3.632379 | 1.079149 | 0.041225 | 0.012562 | 36.71111 | 2.517953 | 1.388078 |
| coral_232_b_2@8 | 8.586928 | 0.129343 | 2.129409 | 0.049665 | 0.012135 | 0.003336 | 30.18231 | 0.220029 | 1.412718 |
| coral_232_b_2@9 | 8.438421 | 0.220473 | 2.299538 | 0.042759 | 0.012905 | 0.00367 | 30.64251 | 0.336516 | 1.438758 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | | | | |
| coral_232_b_2@10 | 8.488906 | 0.164072 | 2.427679 | 0.081593 | 0.013581 | 0.004099 | 32.19985 | 0.492066 | 1.468328 |
| coral_232_b_2@11 | 8.47801 | 0.137473 | 2.44333 | 0.073752 | 0.013827 | 0.002819 | 32.57188 | 0.341918 | 1.488738 |
| coral_232_b_2@12 | 8.567885 | 0.14381 | 2.399038 | 0.0401 | 0.01416 | 0.002542 | 32.80597 | 0.219277 | 1.510558 |
| coral_232_b_2@13 | 8.501225 | 0.088225 | 2.146001 | 0.067516 | 0.012211 | 0.004677 | 31.19364 | 0.235943 | 1.538718 |
| coral_232_b_2@14 | 8.425189 | 0.190677 | 2.026065 | 0.025471 | 0.012538 | 0.002931 | 30.09808 | 0.18724 | 1.568288 |
| coral_232_b_2@15 | 8.792956 | 0.149104 | 2.970891 | 0.030392 | 0.016868 | 0.004513 | 33.40517 | 0.530962 | 1.594328 |
| coral_232_b_2@16 | 8.630708 | 0.14113 | 2.489943 | 0.046643 | 0.01426 | 0.003159 | 32.0591 | 0.190308 | 1.617558 |
| coral_232_b_2@17 | 8.37429 | 0.192925 | 2.491475 | 0.056457 | 0.012921 | 0.002626 | 32.09258 | 0.286847 | 1.644308 |
| coral_232_b_2@18 | 8.435721 | 0.211006 | 2.54728 | 0.073362 | 0.013895 | 0.002801 | 33.73301 | 0.198101 | 1.669658 |
| coral_232_b_2@19 | 8.574159 | 0.242598 | 3.048681 | 0.078075 | 0.013243 | 0.003652 | 40.08826 | 0.199362 | 1.694998 |
| coral_232_b_2@20 | 7.947298 | 0.279317 | 3.642194 | 0.657233 | 0.018578 | 0.006223 | 43.41718 | 0.594232 | 1.727378 |
| coral_232_b_3@1 | 8.160376 | 0.090565 | 2.310671 | 0.035011 | 0.010705 | 0.003521 | 36.05085 | 0.594705 | 1.747788 |
| coral_232_b_3@2 | 7.953985 | 0.134764 | 2.526695 | 0.065145 | 0.013483 | 0.004027 | 37.99209 | 0.441944 | 1.775948 |
| coral_232_b_3@3 | 8.009505 | 0.283589 | 2.568463 | 0.077009 | 0.013664 | 0.003883 | 38.63218 | 0.40742 | 1.794248 |
| coral_232_b_3@4 | 8.144439 | 0.2334 | 2.392373 | 0.077008 | 0.014904 | 0.004456 | 39.03878 | 0.582285 | 1.822408 |
| coral_232_b_3@5 | 8.323855 | 0.215695 | 2.129613 | 0.046006 | 0.013104 | 0.003991 | 37.44124 | 0.401029 | 1.843528 |
| coral_232_b_3@6 | 8.288747 | 0.165186 | 2.259622 | 0.04205 | 0.013535 | 0.003396 | 38.55626 | 0.276897 | 1.866058 |
| coral_232_b4@1 | 7.597506 | 0.068106 | 2.801556 | 0.020166 | 0.009449 | 0.002182 | 35.2741 | 0.490844 | 1.906178 |
| coral_232_b4@2 | 7.772004 | 0.19712 | 2.655051 | 0.028114 | 0.01102 | 0.004806 | 34.96659 | 0.28382 | 1.924478 |
| coral_232_b4@3 | 7.520619 | 0.187835 | 2.168544 | 0.056525 | 0.010484 | 0.002375 | 32.67153 | 0.337751 | 1.958978 |
| coral_232_b4@4 | 7.50667 | 0.324801 | 2.31482 | 0.143732 | 0.011704 | 0.003113 | 32.39702 | 0.362092 | 1.990648 |
| coral_232_b4@5 | 7.409834 | 0.200967 | 3.958074 | 0.703292 | 0.01483 | 0.006053 | 37.79315 | 1.114697 | 2.014588 |
| coral_232_b4@6 | 7.474115 | 0.250322 | 3.656479 | 1.080565 | 0.013221 | 0.005398 | 37.81551 | 0.453474 | 2.043448 |
| coral_232_b4@7 | 7.52814 | 0.218639 | 2.969901 | 0.322385 | 0.010774 | 0.002373 | 38.84369 | 0.632398 | 2.066678 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | | | | |
| coral_232_b4@8 | 7.655616 | 0.280491 | 2.830921 | 0.090721 | 0.009618 | 0.003648 | 38.87132 | 0.220021 | 2.088498 |
| coral_232_b4@9 | 7.890731 | 0.18075 | 2.780284 | 0.045606 | 0.010261 | 0.00193 | 38.815 | 0.23745 | 2.115958 |
| coral_232_b4@10 | 7.94456 | 0.18502 | 3.335075 | 0.153777 | 0.012648 | 0.003765 | 39.33027 | 0.56903 | 2.136368 |
| coral_232_b5@1 | 8.325238 | 0.10576 | 2.83199 | 0.030908 | 0.010792 | 0.001662 | 40.19784 | 0.220869 | 2.161708 |
| coral_232_b5@2 | 7.971122 | 0.195827 | 3.054798 | 1.126622 | 0.017672 | 0.008447 | 38.01053 | 1.912989 | 2.191978 |
| coral_232_b5@3 | 8.297611 | 0.103952 | 2.628725 | 0.056897 | 0.01141 | 0.001643 | 39.56885 | 0.425601 | 2.224358 |
| coral_232_b5@4 | 8.19007 | 0.115224 | 2.640372 | 0.04077 | 0.011314 | 0.002425 | 39.46561 | 0.289871 | 2.239848 |
| coral_232_b5@5 | 8.285696 | 0.220711 | 2.563706 | 0.024632 | 0.012358 | 0.002199 | 38.71424 | 0.267566 | 2.264488 |
| coral_232_b5@8 | 8.02468 | 0.238457 | 3.112548 | 0.415836 | 0.013144 | 0.003389 | 38.46647 | 1.013375 | 2.294048 |
| coral_232_b5@9 | 7.89861 | 0.235744 | 3.060145 | 0.362654 | 0.012105 | 0.005767 | 39.14338 | 0.481938 | 2.312358 |
| coral_232_b5@10 | 7.953174 | 0.187209 | 2.692241 | 0.090124 | 0.01076 | 0.003337 | 40.26085 | 0.627192 | 2.340508 |
| coral_232_b5@11 | 8.081741 | 0.213828 | 2.687842 | 0.206318 | 0.011569 | 0.004965 | 39.84339 | 0.559913 | 2.363738 |
| coral_232_b5@12 | 7.977419 | 0.21847 | 2.860066 | 0.226336 | 0.011904 | 0.001809 | 41.27089 | 0.487752 | 2.387678 |
| coral_232_b5@13 | 8.06743 | 0.16043 | 2.716418 | 0.046401 | 0.011772 | 0.002369 | 41.58413 | 0.743835 | 2.437658 |
| coral_232_b5@14 | 8.075202 | 0.097627 | 2.772602 | 0.02875 | 0.01096 | 0.002498 | 41.19917 | 0.387666 | 2.455958 |
| coral_232_b5@15 | 7.954301 | 0.204236 | 2.64961 | 0.252732 | 0.010581 | 0.003284 | 39.30551 | 0.644795 | 2.485528 |
| coral_232_b5@16 | 7.985768 | 0.186085 | 2.845615 | 0.28848 | 0.016784 | 0.005376 | 41.53724 | 1.226649 | 2.509458 |
| coral_232_b5@17 | 7.922439 | 0.21215 | 2.407984 | 0.099292 | 0.011009 | 0.004042 | 37.60052 | 0.235372 | 2.534098 |
| coral_232_b5@18 | 8.195753 | 0.215567 | 3.668452 | 0.23558 | 0.013025 | 0.003221 | 39.79207 | 0.286147 | 2.549588 |
| coral_232_b5@19 | 8.443448 | 0.168095 | 2.684616 | 0.120658 | 0.014099 | 0.003843 | 40.63549 | 1.176862 | 2.580558 |
| coral_232_b5@20 | 8.708312 | 0.185844 | 2.562944 | 0.079505 | 0.014262 | 0.004005 | 39.49512 | 0.33192 | 2.601678 |
| coral_232_b5@21 | 8.652559 | 0.192214 | 2.428254 | 0.058101 | 0.012912 | 0.003441 | 38.29377 | 0.242077 | 2.630538 |
| coral_232_b5@22 | 8.408457 | 0.160074 | 2.430727 | 0.028969 | 0.011403 | 0.002724 | 39.57055 | 0.411117 | 2.646028 |
| coral_232_b6@1 | 8.446383 | 0.106071 | 2.39709 | 0.078287 | 0.012628 | 0.003237 | 37.46196 | 0.362096 | 2.672068 |

| File name | 88Sr/42Ca | 2SD<br>mmol/mol | 24Mg/42Ca<br>mmol/mol | 2SD<br>mmol/mol | 138Ba/42Ca<br>mmol/mol | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_232_b6@2 | 8.413282 | 0.251964 | 2.106178 | 0.073189 | 0.011388 | 0.002434 | 36.08137 | 0.338839 | 2.703748 |
| coral_232_b6@3 | 8.109111 | 0.142705 | 2.094018 | 0.534437 | 0.010392 | 0.003377 | 32.06465 | 0.379449 | 2.736128 |
| coral_232_b6@4 | 8.360563 | 0.053947 | 2.042511 | 0.059146 | 0.011306 | 0.003009 | 34.8157 | 0.229243 | 2.766398 |
| coral_232_b6@5 | 8.190502 | 0.082231 | 2.240306 | 0.140258 | 0.010726 | 0.002636 | 37.26409 | 0.39591 | 2.788218 |
| coral_232_b6@6 | 7.943733 | 0.43621 | 2.546514 | 0.08957 | 0.011924 | 0.004433 | 40.10802 | 2.632182 | 2.808638 |
| coral_232_b6@7 | 8.191133 | 0.124645 | 2.842366 | 0.101213 | 0.011252 | 0.002548 | 39.34556 | 0.462382 | 2.841718 |
| coral_232_b6@8 | 8.345304 | 0.149066 | 2.430157 | 0.050395 | 0.011444 | 0.002961 | 39.5788 | 0.400081 | 2.868468 |
| coral_232_b6@9 | 8.251317 | 0.106196 | 2.394872 | 0.033384 | 0.012308 | 0.002794 | 39.97939 | 0.429457 | 2.889588 |
| coral_232_b6@10 | 8.200024 | 0.086881 | 2.428442 | 0.033633 | 0.012476 | 0.002155 | 40.35373 | 0.224141 | 2.911408 |
| coral_232_b6@11 | 8.205702 | 0.174816 | 2.384342 | 0.050141 | 0.013213 | 0.00413 | 40.5761 | 0.844133 | 2.937458 |
| coral_232_b6@12 | 8.22017 | 0.150359 | 1.990815 | 0.055586 | 0.010008 | 0.004346 | 36.03403 | 0.270336 | 2.966318 |
| coral_232_b6@13 | 8.390381 | 0.146807 | 2.321642 | 0.058 | 0.011363 | 0.001925 | 40.0771 | 0.371991 | 2.990258 |
| coral_232_b6@14 | 8.464279 | 0.095815 | 2.422738 | 0.047823 | 0.011603 | 0.001585 | 39.82581 | 0.248658 | 3.013488 |
| coral_232_b6@15 | 8.3858 | 0.068007 | 2.446514 | 0.06334 | 0.010603 | 0.001685 | 40.07358 | 0.268546 | 3.035308 |
| coral_232_b6@16 | 8.336238 | 0.040111 | 2.570916 | 0.306427 | 0.012116 | 0.003576 | 39.36265 | 0.872925 | 3.066278 |
| coral_232_b6@17 | 8.381756 | 0.146958 | 2.098965 | 0.020803 | 0.012374 | 0.003087 | 38.38661 | 0.4919 | 3.093028 |
| coral_232_b6@18 | 8.211837 | 0.203183 | 2.400427 | 0.033607 | 0.011213 | 0.002139 | 40.47304 | 0.443874 | 3.121188 |
| coral_232_b6@19 | 8.331092 | 0.098992 | 2.456876 | 0.042984 | 0.011932 | 0.004768 | 39.73022 | 0.211662 | 3.135968 |
| coral_232_b6@20 | 8.397928 | 0.142509 | 2.455497 | 0.080405 | 0.011343 | 0.002011 | 39.35662 | 0.174386 | 3.165538 |
| coral_232_b6@21 | 8.381545 | 0.12562 | 3.292975 | 0.325322 | 0.01342 | 0.004753 | 42.27262 | 1.045233 | 3.189468 |
| coral_232_b6@22 | 7.639295 | 0.289709 | 4.819936 | 1.555943 | 0.017741 | 0.008815 | 41.78765 | 3.60217 | 3.215518 |
| coral_232_b6@23 | 7.827027 | 0.102897 | 3.484014 | 1.577539 | 0.017003 | 0.005248 | 36.70289 | 3.783787 | 3.244378 |
| coral_232_b6@24 | 8.367238 | 0.100274 | 2.650847 | 0.130383 | 0.012831 | 0.003073 | 39.56098 | 0.325212 | 3.268308 |
| coral_232_b6@25 | 8.457395 | 0.146913 | 2.605023 | 0.240949 | 0.011031 | 0.002334 | 38.51955 | 0.281928 | 3.290838 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_232_b6@26 | 8.413352 | 0.128886 | 2.438738 | 0.047928 | 0.011056 | 0.003483 | 39.3054 | 0.245667 | 3.314768 |
| coral_232_b6@27 | 8.539954 | 0.085203 | 2.90805 | 0.427063 | 0.011611 | 0.002442 | 38.59043 | 1.117098 | 3.345748 |
| coral_232_b6@28 | 8.353896 | 0.149085 | 2.465889 | 0.037537 | 0.011849 | 0.001572 | 39.29746 | 0.35917 | 3.366158 |
| coral_232_b6@29 | 8.313998 | 0.134603 | 2.737734 | 0.049314 | 0.013686 | 0.003415 | 41.03647 | 0.490471 | 3.392908 |
| coral_232_b6@30 | 8.376415 | 0.149141 | 2.686369 | 0.071927 | 0.015138 | 0.004924 | 41.33873 | 0.441384 | 3.414728 |
| coral_232_b6@31 | 8.315966 | 0.13914 | 2.691834 | 0.134864 | 0.014032 | 0.003714 | 42.6367 | 0.909456 | 3.442888 |
| coral_232_b6@32 | 8.315298 | 0.101662 | 2.587747 | 0.051182 | 0.012833 | 0.004705 | 41.85774 | 0.316614 | 3.468938 |
| coral_232_b7@1 | 8.428985 | 0.096932 | 2.44455 | 0.046367 | 0.011568 | 0.00346 | 40.51341 | 0.655829 | 3.507658 |
| coral_232_b7@2 | 8.598849 | 0.140146 | 2.409707 | 0.034706 | 0.011888 | 0.004831 | 39.46213 | 0.375133 | 3.537218 |
| coral_232_b7@3 | 8.718996 | 0.137534 | 2.452119 | 0.05867 | 0.012341 | 0.003941 | 39.461 | 0.172795 | 3.556228 |
| coral_232_b7@4 | 8.674554 | 0.083851 | 2.291833 | 0.033292 | 0.01134 | 0.001666 | 38.9585 | 0.198716 | 3.582978 |
| coral_232_b7@5 | 8.509385 | 0.123664 | 2.249511 | 0.103238 | 0.01079 | 0.002728 | 37.93659 | 0.651112 | 3.605498 |
| coral_232_b7@6 | 8.538858 | 0.099595 | 2.47443 | 0.054459 | 0.011516 | 0.003067 | 39.47268 | 0.603664 | 3.628728 |
| coral_232_b7@7 | 8.57226 | 0.15184 | 2.728842 | 0.210665 | 0.012486 | 0.00363 | 40.44799 | 0.477099 | 3.651258 |
| coral_232_b7@8 | 8.682661 | 0.204291 | 2.903102 | 0.527046 | 0.013916 | 0.004562 | 41.1224 | 0.403452 | 3.675898 |
| coral_232_b7@9 | 8.732195 | 0.133257 | 2.479549 | 0.058376 | 0.012615 | 0.003324 | 39.89347 | 0.353027 | 3.704058 |
| coral_232_b7@10 | 8.631839 | 0.058841 | 2.432897 | 0.031469 | 0.011649 | 0.002176 | 39.15565 | 0.21109 | 3.732208 |
| coral_232_b7@11 | 8.600085 | 0.134931 | 2.371326 | 0.033967 | 0.011739 | 0.003139 | 39.02573 | 0.296035 | 3.756148 |
| coral_232_b7@12 | 8.532403 | 0.126894 | 2.435588 | 0.036731 | 0.012347 | 0.00381 | 39.55526 | 0.32648 | 3.773748 |
| coral_232_b7@13 | 8.411558 | 0.217513 | 3.30915 | 2.162791 | 0.015269 | 0.006121 | 38.66672 | 2.020169 | 3.805418 |
| coral_232_b8@1 | 8.021002 | 0.178564 | 2.341161 | 0.101712 | 0.011005 | 0.00161 | 34.34369 | 0.394629 | 3.824428 |
| coral_232_b8@2 | 8.272901 | 0.244627 | 2.566038 | 0.093954 | 0.012492 | 0.003706 | 36.47066 | 0.834641 | 3.843438 |
| coral_232_b8@3 | 8.399554 | 0.124736 | 2.567429 | 0.068331 | 0.012458 | 0.001834 | 38.09406 | 0.225741 | 3.871598 |
| coral_232_b8@4 | 8.210662 | 0.094806 | 2.620015 | 0.040654 | 0.012028 | 0.001486 | 38.81375 | 0.4791 | 3.894828 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | | | | |
| coral_232_b8@5 | 8.087648 | 0.216933 | 2.769176 | 0.05234 | 0.012514 | 0.001993 | 39.39788 | 0.382796 | 3.921578 |
| coral_232_b8@6 | 8.217533 | 0.281818 | 2.722017 | 0.061402 | 0.013297 | 0.00268 | 39.43256 | 0.320825 | 3.946208 |
| coral_232_b8@7 | 8.35365 | 0.215213 | 2.669324 | 0.053302 | 0.012318 | 0.002713 | 39.46763 | 0.226949 | 3.973668 |
| coral_232_b8@8 | 8.244495 | 0.187077 | 2.771302 | 0.112981 | 0.013035 | 0.002321 | 39.25994 | 0.284016 | 4.024348 |
| coral_232_b8@9 | 8.127354 | 0.244581 | 2.721178 | 0.083348 | 0.012807 | 0.002248 | 39.08844 | 0.287978 | 4.044058 |
| coral_232_b8@10 | 8.206167 | 0.325115 | 2.708334 | 0.070373 | 0.012734 | 0.003258 | 39.60617 | 0.455903 | 4.074328 |
| coral_232_b8@11 | 8.343343 | 0.215056 | 2.568364 | 0.052793 | 0.01165 | 0.001525 | 39.58124 | 0.569131 | 4.094748 |
| coral_232_b8@12 | 8.376907 | 0.136503 | 2.528039 | 0.04427 | 0.012081 | 0.002037 | 39.44146 | 0.392264 | 4.116568 |
| coral_232_b8@13 | 8.159351 | 0.339987 | 2.477601 | 0.067335 | 0.01386 | 0.001223 | 38.20588 | 0.337481 | 4.141208 |
| coral_232_b8@14 | 8.156889 | 0.298362 | 2.682002 | 0.134416 | 0.012515 | 0.002719 | 39.90919 | 0.602364 | 4.162318 |
| coral_232_b8@15 | 8.413037 | 0.233554 | 2.754419 | 0.078915 | 0.012558 | 0.002538 | 40.86682 | 0.890975 | 4.191888 |
| coral_232_b8@16 | 8.543118 | 0.136413 | 3.282465 | 0.159242 | 0.016394 | 0.002577 | 40.32163 | 0.325349 | 4.222858 |
| coral_232_b8@17 | 8.464413 | 0.18409 | 3.486956 | 0.763778 | 0.016163 | 0.002701 | 40.01423 | 0.49682 | 4.241168 |
| coral_232_b8@18 | 8.268463 | 0.305285 | 2.718431 | 0.470532 | 0.024768 | 0.00202 | 37.80507 | 0.554109 | 4.272838 |
| coral_232_b8@19 | 8.248787 | 0.208165 | 2.771597 | 0.407836 | 0.014473 | 0.003437 | 38.86108 | 0.698052 | 4.302408 |
| coral_232_b8@20 | 8.38961 | 0.152163 | 2.507489 | 0.154386 | 0.012975 | 0.003258 | 38.07012 | 0.386202 | 4.320708 |
| coral_232_b8@21 | 8.260006 | 0.216951 | 2.502491 | 0.047844 | 0.012031 | 0.001854 | 38.57171 | 0.37423 | 4.342528 |
| coral_232_b8@22 | 8.21767 | 0.248453 | 2.732964 | 0.190963 | 0.0134 | 0.00274 | 40.11479 | 0.468237 | 4.367168 |
| coral_232_b8@23 | 8.444024 | 0.234068 | 2.723888 | 0.068497 | 0.012902 | 0.001921 | 41.44641 | 0.247816 | 4.389698 |
| coral_232_b8@24 | 8.450226 | 0.149759 | 2.923135 | 0.03591 | 0.013067 | 0.001133 | 40.86727 | 0.569733 | 4.418558 |
| coral_232_b8@25 | 8.340797 | 0.193289 | 2.723259 | 0.069783 | 0.01357 | 0.002148 | 40.14875 | 0.252978 | 4.441788 |
| coral_232_b8@26 | 8.155023 | 0.321895 | 2.688202 | 0.059522 | 0.014612 | 0.001808 | 39.70921 | 0.378885 | 4.467838 |
| coral_232_b8@27 | 8.274353 | 0.222536 | 2.514117 | 0.071637 | 0.011066 | 0.002114 | 38.78554 | 0.314979 | 4.490358 |
| coral_232_b8@28 | 8.318942 | 0.110282 | 2.485156 | 0.039199 | 0.010299 | 0.001161 | 38.41935 | 0.212121 | 4.510068 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_232_b8@29 | 8.239607 | 0.252237 | 2.585104 | 0.028243 | 0.011718 | 0.002382 | 38.81738 | 0.411607 | 4.526258 |
| coral_232_b8@30 | 8.18999 | 0.336053 | 2.59899 | 0.042217 | 0.012607 | 0.003146 | 38.71397 | 0.476786 | 4.556528 |
| coral_232_b8@31 | 8.281007 | 0.235681 | 2.628686 | 0.043133 | 0.01288 | 0.002947 | 39.84383 | 1.151715 | 4.579758 |
| coral_232_b9@1 | 8.295501 | 0.118923 | 2.660588 | 0.072208 | 0.010388 | 0.000672 | 38.1716 | 0.381445 | 4.608628 |
| coral_232_b9@2 | 8.113916 | 0.189446 | 2.656165 | 0.041145 | 0.012352 | 0.001671 | 40.28482 | 0.925618 | 4.633258 |
| coral_232_b9@3 | 8.148326 | 0.160585 | 2.606119 | 0.05357 | 0.012133 | 0.001265 | 39.68581 | 0.616228 | 4.662128 |
| coral_232_b9@4 | 8.30399 | 0.112404 | 3.067217 | 0.767724 | 0.012654 | 0.002657 | 39.88096 | 0.817908 | 4.686758 |
| coral_232_b9@5 | 8.101933 | 0.832819 | 2.679747 | 0.924945 | 0.012922 | 0.013307 | 42.5386 | 22.35479 | 4.715628 |
| coral_232_b9@6 | 8.198014 | 0.329862 | 2.757599 | 0.118515 | 0.013357 | 0.00209 | 40.53205 | 0.640702 | 4.745188 |
| coral_232_b9@7 | 8.295707 | 0.200839 | 2.734154 | 0.074137 | 0.012864 | 0.002691 | 41.12992 | 0.508896 | 4.762788 |
| coral_232_b9@8 | 8.385372 | 0.149894 | 2.403754 | 0.110441 | 0.011824 | 0.002296 | 38.38858 | 0.414353 | 4.793058 |
| coral_232_b9@9 | 8.310656 | 0.100221 | 2.21834 | 0.048996 | 0.010722 | 0.001368 | 37.37518 | 0.541424 | 4.809248 |
| coral_232_b9@10 | 8.360047 | 0.250113 | 2.441431 | 0.049577 | 0.010864 | 0.001534 | 38.66036 | 0.508582 | 4.839518 |
| coral_232_b9@11 | 8.283665 | 0.183997 | 2.363576 | 0.13716 | 0.011585 | 0.001655 | 38.00031 | 0.403392 | 4.861338 |
| coral_232_b9@12 | 8.404441 | 0.139061 | 2.565797 | 0.223431 | 0.013542 | 0.002957 | 39.45769 | 0.52795 | 4.886678 |
| coral_232_b9@13 | 8.291925 | 0.166842 | 2.582109 | 0.041711 | 0.011963 | 0.001194 | 40.11621 | 0.699308 | 4.911318 |
| coral_232_b9@14 | 8.233731 | 0.329458 | 2.694484 | 0.0444 | 0.01266 | 0.002385 | 40.48635 | 0.269106 | 4.937368 |
| coral_232_b9@15 | 8.336266 | 0.239393 | 2.579109 | 0.070955 | 0.012206 | 0.001944 | 39.35367 | 0.591225 | 4.962708 |
| coral_232_b9@16 | 8.198206 | 0.194785 | 2.367133 | 0.035905 | 0.011294 | 0.001934 | 38.67299 | 0.856479 | 4.985938 |
| coral_232_b9@17 | 8.312409 | 0.145744 | 2.660003 | 0.036656 | 0.011077 | 0.001796 | 40.29049 | 0.47444 | 5.011988 |
| coral_232_b9@18 | 8.296674 | 0.098805 | 2.7331 | 0.041995 | 0.011818 | 0.001951 | 41.06065 | 0.451333 | 5.030288 |
| coral_232_b9@19 | 8.167685 | 0.281414 | 2.981528 | 0.109297 | 0.014205 | 0.002933 | 43.17104 | 0.538673 | 5.058448 |
| coral_232_b9@20 | 8.218084 | 0.230837 | 2.506479 | 0.128102 | 0.011178 | 0.001297 | 38.99471 | 0.724743 | 5.085198 |
| coral_232_b10@1 | 8.249293 | 0.186181 | 2.507909 | 0.055879 | 0.010509 | 0.001976 | 39.19154 | 0.439349 | 5.138698 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_232_b10@2 | 8.011246 | 0.198446 | 3.379905 | 1.884346 | 0.011252 | 0.00272 | 39.272 | 0.840268 | 5.161928 |
| coral_232_b10@3 | 8.528785 | 0.213794 | 2.460377 | 0.038356 | 0.012467 | 0.002371 | 38.08419 | 0.40781 | 5.187268 |
| coral_232_b10@4 | 8.251193 | 0.266456 | 2.473237 | 0.031198 | 0.011596 | 0.001511 | 38.7057 | 0.30481 | 5.214018 |
| coral_232_b10@5 | 8.354962 | 0.173007 | 2.124082 | 0.026253 | 0.010274 | 0.001826 | 36.59575 | 0.477168 | 5.239358 |
| coral_232_b10@6 | 8.302401 | 0.236185 | 2.165839 | 0.101533 | 0.011616 | 0.001751 | 36.00384 | 0.390112 | 5.264698 |
| coral_232_b10@7 | 8.274144 | 0.29314 | 2.352399 | 0.154419 | 0.012215 | 0.002643 | 36.83371 | 0.460362 | 5.287928 |
| coral_232_b10@8 | 8.496514 | 0.179041 | 2.504929 | 0.099789 | 0.013162 | 0.002769 | 38.56025 | 0.471902 | 5.311158 |
| coral_232_b10@9 | 8.383013 | 0.156838 | 2.617566 | 0.034633 | 0.012085 | 0.001797 | 39.7386 | 0.25961 | 5.338618 |
| coral_232_b10@10 | 8.300748 | 0.208157 | 2.621954 | 0.046563 | 0.011956 | 0.002943 | 40.00327 | 0.341826 | 5.367478 |
| coral_232_b10@11 | 8.243478 | 0.215542 | 2.560095 | 0.047205 | 0.011976 | 0.001691 | 40.04205 | 0.573907 | 5.387888 |
| coral_232_b10@12 | 8.356775 | 0.205651 | 2.583432 | 0.047685 | 0.012548 | 0.002354 | 39.88075 | 0.491264 | 5.423088 |
| coral_232_b11@1 | 8.136939 | 0.170274 | 2.784282 | 0.064101 | 0.012011 | 0.001102 | 38.97171 | 0.633854 | 5.462508 |
| coral_232_b11@2 | 7.810772 | 0.302883 | 2.360652 | 0.409156 | 0.01387 | 0.002377 | 34.15676 | 0.559044 | 5.473768 |
| coral_232_b11@3 | 8.226702 | 0.100638 | 2.567498 | 0.030673 | 0.010804 | 0.001674 | 37.90699 | 0.371359 | 5.488558 |
| coral_232_b11@4 | 8.181959 | 0.141697 | 2.699303 | 0.045609 | 0.011644 | 0.002421 | 39.40168 | 0.673479 | 5.514598 |
| coral_232_b11@5 | 8.218872 | 0.169032 | 2.4211 | 0.04456 | 0.012178 | 0.002047 | 37.66743 | 0.320657 | 5.542758 |
| coral_232_b11@6 | 8.113805 | 0.290545 | 2.159382 | 1.374721 | 0.013083 | 0.0055 | 32.15236 | 0.860525 | 5.570918 |
| coral_232_b11@7 | 8.269708 | 0.078973 | 2.077867 | 0.062231 | 0.01073 | 0.002054 | 35.96744 | 0.30659 | 5.589928 |
| coral_232_b11@8 | 8.499596 | 0.117997 | 2.262443 | 0.058614 | 0.011209 | 0.001604 | 37.35862 | 0.40733 | 5.618078 |
| coral_232_b11@9 | 8.399675 | 0.105603 | 2.530626 | 0.078773 | 0.011108 | 0.00113 | 38.44451 | 0.472357 | 5.643428 |
| coral_232_b11@10 | 8.378643 | 0.149094 | 2.679063 | 0.203399 | 0.011736 | 0.002996 | 39.05075 | 0.498094 | 5.668768 |
| coral_232_b11@11 | 7.675434 | 0.258746 | 3.8927 | 0.659671 | 0.024556 | 0.011188 | 29.28008 | 0.563436 | 5.691998 |
| coral_232_b11@12 | 8.124579 | 0.2125 | 2.07927 | 0.277146 | 0.011163 | 0.002536 | 31.46461 | 0.67137 | 5.713818 |
| coral_232_b11@13 | 8.378783 | 0.157405 | 2.540527 | 0.081249 | 0.011287 | 0.001344 | 39.41118 | 0.444028 | 5.746908 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | | | | |
| coral_232_b11@14 | 8.294648 | 0.158182 | 2.314833 | 0.036424 | 0.011414 | 0.001205 | 38.22003 | 0.624184 | 5.768728 |
| coral_232_b11@15 | 8.54877 | 0.123509 | 2.305292 | 0.05775 | 0.011518 | 0.001469 | 38.59694 | 0.513166 | 5.791248 |
| coral_232_b11@16 | 8.437711 | 0.165053 | 2.511119 | 0.051475 | 0.010923 | 0.001409 | 38.90902 | 0.371626 | 5.813778 |
| coral_232_b11@17 | 8.525512 | 0.139328 | 2.339656 | 0.073856 | 0.011953 | 0.001454 | 38.80527 | 0.697422 | 5.837708 |
| coral_232_b11@18 | 8.517313 | 0.2568 | 2.529593 | 0.059928 | 0.012152 | 0.000963 | 40.02433 | 0.659368 | 5.860238 |
| coral_232_b11@19 | 8.482284 | 0.152191 | 2.677004 | 0.068811 | 0.011958 | 0.000773 | 41.18494 | 0.642332 | 5.887688 |
| coral_232_b11@20 | 8.471679 | 0.081381 | 2.657028 | 0.085115 | 0.012646 | 0.001013 | 41.18638 | 0.691629 | 5.908808 |
| coral_232_b11@21 | 8.536367 | 0.204413 | 2.351768 | 0.074681 | 0.012017 | 0.000834 | 39.06653 | 0.98098 | 5.933448 |
| coral_232_b11@22 | 8.577267 | 0.16214 | 2.043306 | 0.059968 | 0.010899 | 0.001408 | 36.3448 | 0.858042 | 5.952458 |
| coral_232_b11@23 | 8.59528 | 0.177103 | 1.963846 | 0.041536 | 0.010598 | 0.000995 | 35.75108 | 0.624642 | 5.984838 |
| coral_232_b11@24 | 8.373697 | 0.162077 | 2.242597 | 0.057615 | 0.01128 | 0.001073 | 38.11388 | 0.649737 | 6.006658 |
| coral_232_b11@25 | 8.25019 | 0.218181 | 2.362956 | 0.054818 | 0.011727 | 0.002057 | 39.67324 | 0.343745 | 6.030588 |
| coral_232_b11@26 | 8.260202 | 0.230528 | 2.050748 | 0.06425 | 0.011144 | 0.001022 | 35.71778 | 0.612782 | 6.053828 |
| coral_232_b11@27 | 8.357666 | 0.210994 | 2.32715 | 0.073948 | 0.012216 | 0.001538 | 38.16172 | 0.974362 | 6.074938 |
| coral_232_b11@28 | 8.413189 | 0.270704 | 2.116483 | 0.049637 | 0.011191 | 0.001619 | 37.13559 | 1.195056 | 6.105918 |
| coral_232_b11@29 | 7.142323 | 0.195232 | 10.78437 | 3.476296 | 0.046495 | 0.012939 | 41.28221 | 7.347513 | 6.124918 |
| coral_232_b11@30 | 8.596361 | 0.250214 | 2.085792 | 0.080622 | 0.013073 | 0.001622 | 34.95565 | 1.107102 | 6.150968 |
| coral_232_b11@31 | 8.328971 | 0.195731 | 2.575312 | 0.094348 | 0.012043 | 0.001917 | 40.6913 | 1.383905 | 6.179828 |
| coral_232_b11@32 | 8.303635 | 0.134622 | 2.3009 | 0.117369 | 0.011658 | 0.001543 | 38.92919 | 0.984115 | 6.198838 |
| coral_232_b11@33 | 8.38543 | 0.188762 | 2.162493 | 0.108255 | 0.01212 | 0.002907 | 37.29069 | 1.077901 | 6.225588 |
| coral_232_b12@1 | 8.337777 | 0.125651 | 2.701163 | 0.08053 | 0.012755 | 0.001794 | 40.34133 | 0.354991 | 6.266418 |
| coral_232_b12@2 | 7.601809 | 0.313013 | 3.059165 | 2.956381 | 0.015303 | 0.009272 | 21.00041 | 3.482962 | 6.302318 |
| coral_232_b12@3 | 7.318643 | 0.110736 | 2.075696 | 1.741627 | 0.013632 | 0.008888 | 19.65909 | 1.834371 | 6.325548 |
| coral_232_b12@4 | 8.44001 | 0.087678 | 1.802547 | 0.171719 | 0.011883 | 0.001678 | 33.12629 | 0.956458 | 6.348068 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance from the edge in mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | | | | |
| coral_232_b12@5 | 8.279782 | 0.088049 | 2.484793 | 0.040644 | 0.012108 | 0.001604 | 40.60765 | 0.188397 | 6.373418 |
| coral_232_b12@6 | 8.295774 | 0.122433 | 2.500079 | 0.023659 | 0.01192 | 0.001376 | 40.96348 | 0.597414 | 6.401568 |
| coral_232_b12@7 | 8.024671 | 0.108568 | 2.737201 | 0.033575 | 0.010782 | 0.002557 | 40.1286 | 0.359803 | 6.431838 |
| coral_232_b12@8 | 7.678442 | 0.111218 | 2.576921 | 0.085306 | 0.010031 | 0.001578 | 38.49602 | 0.306368 | 6.470558 |
| coral_232_b12@9 | 8.052962 | 0.155644 | 2.428745 | 0.059881 | 0.009771 | 0.000684 | 38.34944 | 0.821422 | 6.499418 |
| coral_232_b12@10 | 8.016066 | 0.091101 | 2.49716 | 0.046326 | 0.011206 | 0.001375 | 38.77472 | 0.45614 | 6.531098 |
| coral_232_b12@11 | 8.113619 | 0.122338 | 2.080065 | 0.028875 | 0.009879 | 0.001717 | 36.5023 | 0.302786 | 6.547988 |
| coral_232_b12@12 | 7.998981 | 0.077631 | 1.744147 | 0.021802 | 0.009291 | 0.000826 | 34.36347 | 0.239261 | 6.573338 |
| coral_232_b12@13 | 8.364572 | 0.117332 | 1.893225 | 0.060874 | 0.009795 | 0.001037 | 36.3385 | 0.158844 | 6.597268 |
| coral_232_b12@14 | 7.977948 | 0.255801 | 2.378883 | 0.563008 | 0.014818 | 0.004539 | 35.84638 | 1.544105 | 6.630358 |
| coral_232_b12@15 | 8.319183 | 0.109034 | 1.924343 | 0.11977 | 0.0101 | 0.000972 | 34.20233 | 0.325577 | 6.679628 |

*S.campylecus:* Sample 235

**Rows highlighted in grey are SIMS analyses corresponding to remineralized regions in the coral skeleton:**

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b1@1 | 8.296893 | 0.119031 | 2.642948 | 0.017811 | 0.008743 | 0.000439 | 37.94632 | 0.263579 | 13.46718 |
| coral_235_b1@2 | 8.284825 | 0.247833 | 2.612451 | 0.019937 | 0.008821 | 0.000722 | 39.88279 | 0.563162 | 13.42988 |
| coral_235_b1@3 | 8.355323 | 0.221993 | 2.772742 | 0.029089 | 0.009312 | 0.000996 | 40.03198 | 0.609576 | 13.40968 |
| coral_235_b1@4 | 8.35843 | 0.184509 | 2.676385 | 0.016587 | 0.008928 | 0.000904 | 41.16055 | 0.52146 | 13.37248 |
| coral_235_b1@5 | 8.418696 | 0.166483 | 2.661249 | 0.044756 | 0.009528 | 0.000662 | 42.19653 | 1.275397 | 13.35688 |
| coral_235_b1@6 | 8.533307 | 0.157165 | 2.131594 | 0.026476 | 0.008996 | 0.000766 | 38.12363 | 0.746605 | 13.31808 |
| coral_235_b1@7 | 8.55825 | 0.138225 | 2.588406 | 0.0261 | 0.010629 | 0.000444 | 41.87152 | 0.554376 | 13.29328 |
| coral_235_b1@8 | 8.582362 | 0.198804 | 2.44232 | 0.023674 | 0.009381 | 0.000761 | 40.3965 | 0.371738 | 13.27148 |
| coral_235_b1@9 | 8.529653 | 0.181257 | 2.557924 | 0.019606 | 0.009693 | 0.00052 | 41.68721 | 0.633904 | 13.23578 |
| coral_235_b1@10 | 8.513889 | 0.152667 | 2.542509 | 0.025906 | 0.010111 | 0.000555 | 42.10068 | 0.833841 | 13.20938 |
| coral_235_b1@11 | 8.649052 | 0.08394 | 2.348561 | 0.019171 | 0.010495 | 0.000796 | 41.03608 | 0.693966 | 13.18918 |
| coral_235_b1@12 | 8.596453 | 0.167291 | 2.55123 | 0.016516 | 0.010408 | 0.000875 | 42.38503 | 0.328743 | 13.15658 |
| coral_235_b1@13 | 8.779786 | 0.154433 | 2.209702 | 0.016945 | 0.01011 | 0.000805 | 39.61207 | 0.402931 | 13.13478 |
| coral_235_b1@14 | 8.644425 | 0.091146 | 2.680715 | 0.022619 | 0.010676 | 0.000898 | 42.56281 | 0.548241 | 13.11308 |
| coral_235_b1@15 | 8.732397 | 0.099365 | 2.639889 | 0.01786 | 0.011248 | 0.000975 | 43.26022 | 0.460002 | 13.08508 |
| coral_235_b1@16 | 8.654149 | 0.12044 | 1.894577 | 0.016855 | 0.009133 | 0.00064 | 37.34634 | 0.427587 | 13.06178 |
| coral_235_b1@17 | 8.754929 | 0.131545 | 2.19895 | 0.018114 | 0.010088 | 0.000639 | 39.51378 | 0.59076 | 13.04008 |
| coral_235_b1@18 | 8.636061 | 0.130795 | 1.803925 | 0.018441 | 0.009298 | 0.000441 | 36.10511 | 1.020964 | 13.01208 |
| coral_235_b1@19 | 8.791207 | 0.122246 | 1.589089 | 0.0189 | 0.008683 | 0.001063 | 35.1806 | 0.402012 | 12.98418 |
| coral_235_b1@20 | 8.55379 | 0.173411 | 2.507912 | 0.037759 | 0.01043 | 0.000885 | 43.43464 | 1.099077 | 12.95468 |
| coral_235_b2@1 | 8.143549 | 0.280205 | 2.518666 | 0.047739 | 0.009319 | 0.001383 | 41.09918 | 2.084981 | 12.91888 |
| coral_235_b2@2 | 8.497459 | 0.295028 | 2.674946 | 0.026448 | 0.009599 | 0.000861 | 42.09939 | 0.318024 | 12.88168 |

| File name | 88Sr/42Ca | 2SD<br>mmol/mol | 24Mg/42Ca<br>mmol/mol | 2SD<br>mmol/mol | 138Ba/42Ca<br>mmol/mol | 2SD<br>mm | 23Na/42Ca | 2SD | distance<br>mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b2@3 | 8.691983 | 0.183245 | 2.588777 | 0.03134 | 0.009267 | 0.000998 | 41.35153 | 0.442274 | 12.85838 |
| coral_235_b2@4 | 8.707689 | 0.182114 | 2.556551 | 0.024955 | 0.009458 | 0.000829 | 41.51058 | 0.272785 | 12.83198 |
| coral_235_b2@5 | 8.699248 | 0.234663 | 2.561165 | 0.023477 | 0.009877 | 0.000853 | 42.19505 | 0.657193 | 12.80558 |
| coral_235_b2@6 | 8.594733 | 0.374309 | 2.606794 | 0.037863 | 0.009759 | 0.000729 | 42.7975 | 0.683407 | 12.77448 |
| coral_235_b2@7 | 8.625549 | 0.251413 | 2.322545 | 0.032527 | 0.009424 | 0.000832 | 41.06691 | 0.369718 | 12.74648 |
| coral_235_b2@8 | 8.629888 | 0.257062 | 2.107388 | 0.022152 | 0.009302 | 0.000418 | 39.59598 | 0.625738 | 12.71548 |
| coral_235_b2@9 | 8.413703 | 0.215672 | 2.324138 | 0.026573 | 0.009497 | 0.000715 | 41.51671 | 0.601826 | 12.68908 |
| coral_235_b2@10 | 8.570313 | 0.19815 | 2.536651 | 0.023264 | 0.009264 | 0.001211 | 42.17275 | 0.474198 | 12.66418 |
| coral_235_b2@11 | 8.701733 | 0.189948 | 2.579105 | 0.027192 | 0.009237 | 0.001476 | 42.92482 | 0.550986 | 12.64248 |
| coral_235_b2@12 | 8.674382 | 0.223855 | 2.350731 | 0.013469 | 0.009326 | 0.000871 | 41.75659 | 0.519738 | 12.61448 |
| coral_235_b2@13 | 8.660421 | 0.227471 | 2.565688 | 0.026479 | 0.009452 | 0.000686 | 43.32691 | 0.370784 | 12.59118 |
| coral_235_b2@14 | 8.677889 | 0.226988 | 2.732611 | 0.044133 | 0.009928 | 0.000886 | 44.59867 | 0.733346 | 12.56948 |
| coral_235_b2@15 | 8.613208 | 0.251622 | 2.736289 | 0.022998 | 0.01075 | 0.001389 | 45.45992 | 0.716124 | 12.53838 |
| coral_235_b2@16 | 8.69057 | 0.169545 | 2.734563 | 0.027654 | 0.011143 | 0.001156 | 45.87681 | 0.7037 | 12.51818 |
| coral_235_b2@17 | 8.699412 | 0.230534 | 2.775257 | 0.037469 | 0.011213 | 0.000959 | 46.8369 | 0.843703 | 12.49178 |
| coral_235_b2@18 | 8.640518 | 0.188146 | 2.76492 | 0.037069 | 0.011149 | 0.000437 | 46.78571 | 0.487426 | 12.47008 |
| coral_235_b2@19 | 8.500324 | 0.293199 | 2.737982 | 0.019629 | 0.010694 | 0.000778 | 47.9567 | 0.854328 | 12.43588 |
| coral_235_b2@20 | 8.661073 | 0.212895 | 2.551999 | 0.019353 | 0.01129 | 0.000852 | 46.70201 | 0.996052 | 12.41418 |
| coral_235_b2@21 | 8.736858 | 0.207895 | 2.527579 | 0.03203 | 0.011118 | 0.000618 | 45.3257 | 0.725562 | 12.39088 |
| coral_235_b2@22 | 8.654196 | 0.240525 | 2.553493 | 0.062996 | 0.009649 | 0.000977 | 43.56142 | 0.46825 | 12.36758 |
| coral_235_b3@1 | 7.693758 | 0.362619 | 1.581202 | 0.083264 | 0.00913 | 0.001247 | 32.20578 | 1.339683 | 12.33488 |
| coral_235_b3@2 | 7.79832 | 0.400323 | 1.419619 | 0.236762 | 0.014801 | 0.003629 | 31.60017 | 1.72784 | 12.29608 |
| coral_235_b3@3 | 8.17762 | 0.315706 | 2.763131 | 0.065341 | 0.009547 | 0.000819 | 43.93816 | 1.686305 | 12.25728 |
| coral_235_b3@4 | 8.265736 | 0.345896 | 2.589316 | 0.058154 | 0.009117 | 0.000785 | 43.51896 | 1.374448 | 12.22158 |
| coral_235_b3@5 | 8.382852 | 0.305361 | 2.849601 | 0.034768 | 0.009829 | 0.000606 | 46.81392 | 2.548697 | 12.17958 |
| coral_235_b3@6 | 8.323572 | 0.338809 | 2.872847 | 0.045586 | 0.0095 | 0.001239 | 47.31255 | 2.217267 | 12.13768 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | mm |
| coral_235_b3@7 | 8.421399 | 0.309262 | 2.763755 | 0.019287 | 0.009894 | 0.001226 | 45.59016 | 1.069867 | 12.11438 |
| coral_235_b3@8 | 8.289132 | 0.23287 | 2.438179 | 0.029436 | 0.008949 | 0.001317 | 41.79846 | 0.704453 | 12.08018 |
| coral_235_b3@9 | 8.39428 | 0.225288 | 2.542748 | 0.028994 | 0.009329 | 0.000929 | 42.14591 | 0.313554 | 12.05688 |
| coral_235_b3@10 | 8.429139 | 0.208379 | 2.650228 | 0.048457 | 0.00963 | 0.000892 | 44.39849 | 0.989164 | 12.03978 |
| coral_235_b3@11 | 8.457825 | 0.217126 | 2.614433 | 0.061353 | 0.009494 | 0.00089 | 45.26057 | 1.367559 | 12.01498 |
| coral_235_b3@12 | 8.31341 | 0.237842 | 2.132212 | 0.037866 | 0.008586 | 0.000931 | 40.85804 | 0.74727 | 11.98388 |
| coral_235_b3@13 | 8.357078 | 0.124929 | 2.428927 | 0.056017 | 0.009858 | 0.00102 | 43.83616 | 1.347898 | 11.96218 |
| coral_235_b3@14 | 8.401905 | 0.218637 | 2.394852 | 0.050298 | 0.009888 | 0.001105 | 44.32818 | 1.183115 | 11.92488 |
| coral_235_b3@15 | 8.446402 | 0.175965 | 2.237733 | 0.039673 | 0.009196 | 0.001062 | 43.53845 | 1.122357 | 11.90318 |
| coral_235_b3@16 | 8.446195 | 0.165588 | 2.280412 | 0.024951 | 0.008911 | 0.000915 | 44.68632 | 2.072965 | 11.87828 |
| coral_235_b3@17 | 8.234508 | 0.221466 | 2.005241 | 0.070314 | 0.008339 | 0.000838 | 41.33521 | 1.641611 | 11.85498 |
| coral_235_b3@18 | 7.906614 | 0.22122 | 2.451603 | 0.055816 | 0.008458 | 0.000716 | 45.74823 | 1.801458 | 11.82238 |
| coral_235_b3@19 | 7.921406 | 0.191429 | 2.046861 | 0.022984 | 0.007761 | 0.000745 | 39.8598 | 1.110141 | 11.79748 |
| coral_235_b3@20 | 8.212982 | 0.214037 | 0.847882 | 0.021079 | 0.005773 | 0.000382 | 26.06561 | 0.430677 | 11.77738 |
| coral_235_b4@1 | 8.259717 | 0.128159 | 0.917655 | 0.011909 | 0.005754 | 0.000836 | 25.79242 | 0.315079 | 11.72758 |
| coral_235_b4@2 | 8.249618 | 0.259293 | 2.192004 | 0.013608 | 0.008327 | 0.001107 | 43.11879 | 0.686062 | 11.70898 |
| coral_235_b4@3 | 8.290847 | 0.237203 | 2.278676 | 0.047305 | 0.008672 | 0.001126 | 42.7693 | 0.521524 | 11.68568 |
| coral_235_b4@4 | 8.190892 | 0.203352 | 2.438196 | 0.032876 | 0.008626 | 0.000543 | 45.10906 | 0.483197 | 11.65928 |
| coral_235_b4@5 | 7.884795 | 0.189233 | 2.677499 | 0.044392 | 0.008493 | 0.00091 | 46.84694 | 0.714951 | 11.63758 |
| coral_235_b4@6 | 7.994105 | 0.21236 | 2.804812 | 0.02736 | 0.008599 | 0.001091 | 46.34231 | 0.432927 | 11.60648 |
| coral_235_b4@7 | 8.478757 | 0.195003 | 2.14302 | 0.035348 | 0.009085 | 0.000925 | 41.89145 | 0.448882 | 11.57698 |
| coral_235_b4@8 | 8.66199 | 0.203347 | 1.731344 | 0.020539 | 0.008551 | 0.000985 | 37.58543 | 0.237883 | 11.55368 |
| coral_235_b4@9 | 8.462715 | 0.224173 | 1.42431 | 0.033444 | 0.007636 | 0.000903 | 31.88134 | 0.313546 | 11.53188 |
| coral_235_b4@10 | 7.887885 | 0.168113 | 1.040287 | 0.021424 | 0.006227 | 0.001019 | 26.52966 | 0.313573 | 11.51178 |
| coral_235_b4@11 | 7.380134 | 0.14516 | 0.643991 | 0.011338 | 0.004745 | 0.000666 | 22.11089 | 0.336972 | 11.48848 |
| coral_235_b4@12 | 7.600356 | 0.114778 | 0.527005 | 0.010299 | 0.004875 | 0.000589 | 21.94197 | 0.950797 | 11.46048 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | mm |
| coral_235_b5@1 | 7.883535 | 0.378633 | 2.721365 | 0.067757 | 0.008876 | 0.001039 | 39.99651 | 0.28359 | 11.40458 |
| coral_235_b5@2 | 8.257652 | 0.323995 | 2.338681 | 0.062235 | 0.009009 | 0.001232 | 39.36117 | 0.61157 | 11.36268 |
| coral_235_b5@3 | 8.313042 | 0.357742 | 2.481674 | 0.035586 | 0.009212 | 0.001268 | 41.40292 | 0.542824 | 11.32998 |
| coral_235_b5@4 | 8.34247 | 0.261847 | 2.465847 | 0.038142 | 0.009283 | 0.000637 | 42.08782 | 0.582103 | 11.30518 |
| coral_235_b5@5 | 8.337301 | 0.230594 | 2.452613 | 0.03414 | 0.009076 | 0.000913 | 42.26182 | 0.349138 | 11.27408 |
| coral_235_b5@6 | 8.281639 | 0.259094 | 2.540111 | 0.048677 | 0.008759 | 0.001142 | 43.52002 | 0.39833 | 11.25548 |
| coral_235_b5@7 | 8.345399 | 0.31726 | 2.517212 | 0.060739 | 0.009372 | 0.001128 | 43.86939 | 0.423132 | 11.23058 |
| coral_235_b5@8 | 8.274404 | 0.224669 | 2.813511 | 0.063873 | 0.009707 | 0.001224 | 46.33775 | 0.792371 | 11.18708 |
| coral_235_b5@9 | 8.316118 | 0.239238 | 2.743062 | 0.044229 | 0.009822 | 0.000695 | 45.1252 | 0.590881 | 11.17008 |
| coral_235_b5@10 | 8.477452 | 0.235435 | 3.152021 | 0.390324 | 0.010792 | 0.001009 | 44.04877 | 0.416785 | 11.14518 |
| coral_235_b6@1 | 7.800902 | 0.425056 | 2.960779 | 0.057614 | 0.008281 | 0.001815 | 43.66984 | 0.991542 | 11.09708 |
| coral_235_b6@2 | 7.984929 | 0.466336 | 2.916859 | 0.0688 | 0.008315 | 0.000687 | 44.30741 | 1.00013 | 11.05978 |
| coral_235_b6@3 | 7.897404 | 0.415659 | 2.355886 | 0.04836 | 0.009017 | 0.001841 | 39.99339 | 0.493741 | 11.03488 |
| coral_235_b6@4 | 7.550794 | 0.502454 | 1.832746 | 0.041831 | 0.00706 | 0.001348 | 35.72391 | 0.197671 | 10.95108 |
| coral_235_b6@6 | 8.253468 | 0.438545 | 2.64879 | 0.080261 | 0.009661 | 0.000827 | 44.1481 | 0.840189 | 10.91838 |
| coral_235_b6@7 | 8.358657 | 0.353454 | 2.483582 | 0.030481 | 0.009604 | 0.001013 | 42.36239 | 0.306297 | 10.87808 |
| coral_235_b6@8 | 7.517941 | 0.38833 | 2.180218 | 0.080975 | 0.007871 | 0.000915 | 36.74269 | 0.559643 | 10.85628 |
| coral_235_b6@9 | 8.206649 | 0.473132 | 2.581741 | 0.070377 | 0.009735 | 0.001056 | 46.69767 | 0.493811 | 10.78798 |
| coral_235_b6@10 | 8.104423 | 0.420135 | 2.325525 | 0.076265 | 0.009292 | 0.001602 | 42.9114 | 0.241298 | 10.73978 |
| coral_235_b6@11 | 8.134773 | 0.251566 | 2.556275 | 0.068633 | 0.009196 | 0.000948 | 46.27858 | 0.465186 | 10.71958 |
| coral_235_b6@12 | 8.008756 | 0.376461 | 2.54542 | 0.051004 | 0.008956 | 0.000937 | 46.86487 | 0.385192 | 10.69628 |
| coral_235_b6@13 | 8.133618 | 0.29937 | 2.380312 | 0.018615 | 0.008916 | 0.001244 | 44.89848 | 0.478288 | 10.67298 |
| coral_235_b6@14 | 8.172654 | 0.280572 | 2.286939 | 0.017922 | 0.008661 | 0.000467 | 43.54435 | 0.368425 | 10.64198 |
| coral_235_b6@15 | 8.146129 | 0.302988 | 2.425879 | 0.0576 | 0.008966 | 0.00088 | 44.8617 | 0.428827 | 10.62018 |
| coral_235_b6@16 | 8.140534 | 0.379872 | 2.531963 | 0.084235 | 0.009002 | 0.001034 | 45.86058 | 0.745555 | 10.60308 |
| coral_235_b6@17 | 8.364071 | 0.34393 | 2.513031 | 0.055319 | 0.009136 | 0.000998 | 44.66614 | 0.293236 | 10.57048 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD mm | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b6@18 | 8.60095 | 0.352799 | 2.436258 | 0.05038 | 0.009524 | 0.001239 | 43.87403 | 0.414957 | 10.54258 |
| coral_235_b6@19 | 8.560247 | 0.235604 | 2.275795 | 0.055555 | 0.008645 | 0.001227 | 42.50652 | 0.418325 | 10.50998 |
| coral_235_b6@20 | 8.496664 | 0.324373 | 2.462613 | 0.054735 | 0.009007 | 0.00103 | 43.7648 | 0.383628 | 10.47888 |
| coral_235_b7@1 | 8.057733 | 0.481866 | 2.693048 | 0.10905 | 0.008214 | 0.001691 | 45.44178 | 0.847336 | 10.44468 |
| coral_235_b7@2 | 8.394783 | 0.416289 | 2.481983 | 0.099423 | 0.009644 | 0.001001 | 42.60649 | 0.289602 | 10.40738 |
| coral_235_b7@3 | 8.451991 | 0.453502 | 2.587403 | 0.118231 | 0.011006 | 0.001022 | 45.02767 | 0.689246 | 10.33288 |
| coral_235_b7@4 | 8.363767 | 0.447079 | 2.60581 | 0.072742 | 0.00954 | 0.00167 | 44.67572 | 0.306835 | 10.29558 |
| coral_235_b7@5 | 8.316353 | 0.370359 | 2.777273 | 0.058272 | 0.010345 | 0.000885 | 46.22086 | 0.448851 | 10.27228 |
| coral_235_b7@6 | 8.439871 | 0.294288 | 2.617467 | 0.067323 | 0.010964 | 0.001411 | 45.64426 | 0.445795 | 10.24748 |
| coral_235_b7@7 | 8.282645 | 0.356665 | 2.254311 | 0.089421 | 0.011565 | 0.001225 | 41.86235 | 1.108328 | 10.22108 |
| coral_235_b7@8 | 8.192351 | 0.345439 | 1.970334 | 0.24567 | 0.011724 | 0.004012 | 36.43229 | 2.39093 | 10.19464 |
| coral_235_b7@9 | 8.002363 | 0.40957 | 2.342345 | 0.199637 | 0.012172 | 0.003512 | 40.87489 | 2.788803 | 10.17445 |
| coral_235_b7@10 | 8.557293 | 0.334269 | 2.493019 | 0.087022 | 0.012207 | 0.001975 | 45.58915 | 0.957507 | 10.13717 |
| coral_235_b7@11 | 8.415673 | 0.308667 | 2.60365 | 0.104418 | 0.01173 | 0.001354 | 46.44628 | 1.276529 | 10.10766 |
| coral_235_b8@1 | 8.007779 | 0.410111 | 3.028647 | 0.088022 | 0.01103 | 0.000631 | 44.71545 | 0.704213 | 10.0797 |
| coral_235_b8@2 | 8.245687 | 0.372264 | 2.754742 | 0.170448 | 0.011948 | 0.001518 | 44.28372 | 1.266378 | 10.02068 |
| coral_235_b8@3 | 8.428914 | 0.34397 | 2.683114 | 0.088978 | 0.009781 | 0.001178 | 43.35335 | 0.72403 | 9.995835 |
| coral_235_b8@4 | 8.460116 | 0.317957 | 2.761154 | 0.062946 | 0.00972 | 0.001312 | 44.15908 | 0.2997 | 9.959335 |
| coral_235_b8@5 | 8.327763 | 0.366475 | 2.852939 | 0.040212 | 0.009217 | 0.001595 | 45.69996 | 0.512036 | 9.933715 |
| coral_235_b8@6 | 8.357823 | 0.46318 | 2.742707 | 0.086285 | 0.009987 | 0.001031 | 45.40061 | 0.610006 | 9.910415 |
| coral_235_b8@7 | 8.350184 | 0.340796 | 2.674055 | 0.066942 | 0.009925 | 0.000629 | 45.53919 | 0.42857 | 9.887895 |
| coral_235_b8@8 | 8.432315 | 0.23838 | 2.61037 | 0.036674 | 0.010015 | 0.000671 | 45.74751 | 0.339632 | 9.860715 |
| coral_235_b8@9 | 8.541397 | 0.250951 | 2.528931 | 0.048237 | 0.010087 | 0.001264 | 45.29761 | 0.527469 | 9.839745 |
| coral_235_b8@10 | 8.635304 | 0.258069 | 2.489639 | 0.048927 | 0.010874 | 0.001014 | 45.45435 | 0.297623 | 9.810235 |
| coral_235_b8@11 | 8.747805 | 0.234794 | 2.464602 | 0.026651 | 0.011183 | 0.00113 | 44.81125 | 0.324495 | 9.794705 |
| coral_235_b8@12 | 8.681548 | 0.204313 | 2.278244 | 0.038729 | 0.010067 | 0.001167 | 42.51918 | 0.563046 | 9.770625 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | |
| coral_235_b8@13 | 8.656287 | 0.244493 | 1.814921 | 0.024711 | 0.008708 | 0.001088 | 37.78816 | 0.471787 | 9.741115 |
| coral_235_b8@14 | 8.477231 | 0.262214 | 1.746945 | 0.027338 | 0.008385 | 0.000633 | 37.18046 | 0.248204 | 9.713155 |
| coral_235_b8@15 | 8.561727 | 0.307679 | 2.504041 | 0.059461 | 0.010006 | 0.000785 | 44.90606 | 0.422287 | 9.690635 |
| coral_235_b8@16 | 8.572443 | 0.318022 | 2.478409 | 0.055023 | 0.009698 | 0.000749 | 44.21791 | 0.556861 | 9.659575 |
| coral_235_b8@17 | 8.419016 | 0.271527 | 2.357064 | 0.046091 | 0.008913 | 0.001263 | 44.08863 | 0.422118 | 9.630835 |
| coral_235_b8@18 | 8.569174 | 0.320509 | 2.131886 | 0.032683 | 0.008751 | 0.001094 | 42.34686 | 0.33163 | 9.603665 |
| coral_235_b8@19 | 8.612147 | 0.337591 | 2.126641 | 0.057284 | 0.008944 | 0.001452 | 42.09698 | 0.350189 | 9.585795 |
| coral_235_b8@20 | 8.495862 | 0.236395 | 2.328695 | 0.035425 | 0.009268 | 0.000806 | 44.28386 | 0.302676 | 9.561725 |
| coral_235_b8@21 | 8.29923 | 0.356892 | 2.488389 | 0.030845 | 0.009892 | 0.000854 | 45.43024 | 0.427216 | 9.533765 |
| coral_235_b8@22 | 8.542829 | 0.32461 | 2.494356 | 0.049216 | 0.010013 | 0.001399 | 44.79688 | 0.449673 | 9.503485 |
| coral_235_b9@1 | 8.844547 | 0.065426 | 2.50991 | 0.018395 | 0.010919 | 0.001176 | 43.5381 | 0.395601 | 9.482515 |
| coral_235_b9@2 | 8.751311 | 0.102205 | 2.70222 | 0.045015 | 0.010968 | 0.001195 | 45.5482 | 0.523297 | 9.473975 |
| coral_235_b9@3 | 8.86298 | 0.112065 | 2.695502 | 0.028022 | 0.012031 | 0.000996 | 46.01964 | 0.300313 | 9.456885 |
| coral_235_b9@4 | 8.630968 | 0.206375 | 2.724269 | 0.044095 | 0.010805 | 0.000845 | 46.36204 | 0.307594 | 9.431255 |
| coral_235_b9@5 | 8.53814 | 0.251828 | 2.671985 | 0.034779 | 0.0096 | 0.001006 | 46.20272 | 0.504005 | 9.407955 |
| coral_235_b9@6 | 8.918555 | 0.208351 | 2.502753 | 0.037664 | 0.009987 | 0.001107 | 44.04777 | 0.37387 | 9.378445 |
| coral_235_b9@7 | 9.11768 | 0.186537 | 2.460899 | 0.037525 | 0.010265 | 0.001051 | 43.57461 | 0.197509 | 9.349715 |
| coral_235_b9@9 | 9.110208 | 0.148018 | 2.524729 | 0.026552 | 0.010433 | 0.001538 | 44.04193 | 0.41628 | 9.326415 |
| coral_235_b9@10 | 8.965097 | 0.288311 | 2.521526 | 0.031989 | 0.009915 | 0.000935 | 43.7245 | 0.431891 | 9.296905 |
| coral_235_b10@1 | 8.93661 | 0.305302 | 2.541988 | 0.039081 | 0.011733 | 0.001061 | 45.78053 | 0.424972 | 9.268955 |
| coral_235_b10@2 | 8.896916 | 0.174184 | 2.623172 | 0.029079 | 0.011574 | 0.00095 | 46.90397 | 0.428194 | 9.219245 |
| coral_235_b10@3 | 8.849542 | 0.1525 | 2.562288 | 0.032531 | 0.011216 | 0.001128 | 46.05021 | 0.436372 | 9.191295 |
| coral_235_b10@4 | 8.789412 | 0.194029 | 2.552412 | 0.015284 | 0.010621 | 0.001064 | 45.3177 | 0.404789 | 9.177315 |
| coral_235_b10@5 | 8.769297 | 0.217085 | 2.425248 | 0.023595 | 0.009426 | 0.001446 | 44.63057 | 0.426084 | 9.149355 |
| coral_235_b10@6 | 8.76373 | 0.22007 | 2.514908 | 0.021714 | 0.009946 | 0.000789 | 45.55594 | 0.467573 | 9.115185 |
| coral_235_b10@7 | 8.91931 | 0.207083 | 2.551836 | 0.047596 | 0.009931 | 0.000962 | 45.70077 | 0.625145 | 9.091885 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| | | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | |
| coral_235_b10@8 | 8.858804 | 0.264355 | 2.346362 | 0.033935 | 0.009575 | 0.004635 | 43.76145 | 0.351887 | 9.079465 |
| coral_235_b10@9 | 9.075516 | 0.324022 | 2.384561 | 0.031191 | 0.010803 | 0.000982 | 45.19115 | 0.424483 | 9.051505 |
| coral_235_b10@10 | 8.916317 | 0.270116 | 2.124285 | 0.070715 | 0.010831 | 0.001198 | 41.11989 | 0.690091 | 8.990935 |
| coral_235_b10@11 | 8.9478 | 0.289846 | 2.588839 | 0.033067 | 0.011637 | 0.000682 | 47.35791 | 0.255543 | 8.959865 |
| coral_235_b10@12 | 8.777409 | 0.242291 | 2.508406 | 0.032733 | 0.010976 | 0.00118 | 45.67277 | 0.291802 | 8.936575 |
| coral_235_b10@13 | 8.834646 | 0.226472 | 2.460847 | 0.018893 | 0.010148 | 0.00068 | 44.92348 | 0.422258 | 8.903955 |
| coral_235_b10@14 | 8.678671 | 0.402297 | 2.585525 | 0.030969 | 0.010085 | 0.000828 | 46.02401 | 0.630218 | 8.880655 |
| coral_235_b10@15 | 8.742816 | 0.288318 | 2.37023 | 0.033073 | 0.009429 | 0.001115 | 43.72838 | 0.414222 | 8.855805 |
| coral_235_b10@16 | 8.787319 | 0.167489 | 2.359906 | 0.04739 | 0.009362 | 0.001455 | 43.45331 | 0.469638 | 8.829405 |
| coral_235_b10@17 | 8.869445 | 0.293459 | 2.395137 | 0.036636 | 0.010772 | 0.000612 | 43.98794 | 0.548167 | 8.795235 |
| coral_235_b10@18 | 8.787395 | 0.205825 | 2.591751 | 0.025234 | 0.011547 | 0.000483 | 46.36341 | 0.299224 | 8.764165 |
| coral_235_b10@19 | 8.647705 | 0.402455 | 1.882627 | 0.051116 | 0.008952 | 0.001483 | 38.72462 | 0.393999 | 8.739315 |
| coral_235_b10@20 | 8.722127 | 0.279674 | 2.293442 | 0.0649 | 0.009253 | 0.000942 | 43.27921 | 0.31376 | 8.692725 |
| coral_235_b10@21 | 8.868627 | 0.257766 | 1.547353 | 0.048562 | 0.008428 | 0.00098 | 36.02058 | 0.261522 | 8.666315 |
| coral_235_b10@22 | 9.108086 | 0.202212 | 1.929226 | 0.026813 | 0.009575 | 0.001341 | 40.41063 | 0.336098 | 8.644575 |
| coral_235_b10@23 | 8.712031 | 0.306885 | 2.592142 | 0.047683 | 0.009808 | 0.007216 | 46.41969 | 0.405218 | 8.610405 |
| coral_235_b10@24 | 8.70143 | 0.12603 | 2.576413 | 0.040348 | 0.008934 | 0.000722 | 46.69526 | 0.499326 | 8.587105 |
| coral_235_b10@25 | 8.928307 | 0.32091 | 1.654296 | 0.025121 | 0.008779 | 0.001518 | 37.52534 | 0.22068 | 8.559145 |
| coral_235_b10@26 | 8.641531 | 0.217415 | 1.295644 | 0.067614 | 0.008231 | 0.000711 | 29.92872 | 0.486104 | 8.529635 |
| coral_235_b10@27 | 8.860769 | 0.200165 | 2.004469 | 0.019564 | 0.009957 | 0.001173 | 40.85113 | 0.443828 | 8.504785 |
| coral_235_b10@28 | 8.831485 | 0.23162 | 2.406569 | 0.040234 | 0.010175 | 0.001177 | 45.33201 | 0.307588 | 8.481485 |
| coral_235_b10@29 | 8.831551 | 0.204865 | 2.543692 | 0.022074 | 0.011058 | 0.000699 | 46.83819 | 0.629184 | 8.456635 |
| coral_235_b10@30 | 8.878046 | 0.167162 | 2.54163 | 0.021896 | 0.011028 | 0.001541 | 46.34758 | 0.345638 | 8.430235 |
| coral_235_b10@31 | 8.799738 | 0.181991 | 2.481665 | 0.042909 | 0.010551 | 0.000939 | 45.70992 | 0.441852 | 8.400725 |
| coral_235_b10@32 | 8.54489 | 0.188476 | 1.67459 | 0.129906 | 0.008447 | 0.000801 | 35.28771 | 1.53978 | 8.372765 |
| coral_235_b10@33 | 8.11199 | 0.452455 | 1.614581 | 0.190309 | 0.008057 | 0.000931 | 31.49659 | 1.482366 | 8.344805 |

| File name | 88Sr/42Ca | 2SD<br>mmol/mol | 24Mg/42Ca<br>mmol/mol | 2SD<br>mmol/mol | 138Ba/42Ca<br>mmol/mol | 2SD<br>mm | 23Na/42Ca | 2SD | Distance<br>mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b10@34 | 8.648201 | 0.20421 | 2.370403 | 0.041546 | 0.009422 | 0.000771 | 44.15407 | 0.360255 | 8.316855 |
| coral_235_b10@35 | 8.828679 | 0.28682 | 2.548687 | 0.033846 | 0.010099 | 0.001104 | 45.34761 | 0.437931 | 8.293555 |
| coral_235_b10@36 | 8.580834 | 0.186879 | 2.528424 | 0.050514 | 0.009244 | 0.000574 | 45.43311 | 0.483876 | 8.267145 |
| coral_235_b10@37 | 8.63511 | 0.241614 | 2.387897 | 0.029601 | 0.009061 | 0.00084 | 44.4098 | 0.694619 | 8.236085 |
| coral_235_b10@38 | 8.861873 | 0.228584 | 2.32267 | 0.028607 | 0.009664 | 0.001124 | 44.16498 | 0.436708 | 8.212785 |
| coral_235_b10@39 | 8.876765 | 0.17232 | 2.498296 | 0.023923 | 0.010062 | 0.001519 | 46.3361 | 0.507421 | 8.186385 |
| coral_235_b10@40 | 8.39899 | 0.103817 | 2.55441 | 0.042299 | 0.00913 | 0.000702 | 45.05543 | 0.468448 | 8.159975 |
| coral_235_b11@1 | 8.501118 | 0.326207 | 2.800133 | 0.051706 | 0.009721 | 0.000686 | 43.63832 | 0.703004 | 8.141345 |
| coral_235_b11@2 | 8.715466 | 0.204139 | 2.683966 | 0.042377 | 0.01073 | 0.000767 | 42.71323 | 0.189784 | 8.119595 |
| coral_235_b11@3 | 8.182195 | 0.181356 | 2.673683 | 0.035253 | 0.009675 | 0.000687 | 43.17347 | 0.466028 | 8.085425 |
| coral_235_b11@4 | 8.461674 | 0.181428 | 2.666331 | 0.03037 | 0.009439 | 0.001081 | 44.21022 | 0.699123 | 8.061355 |
| coral_235_b11@5 | 8.541354 | 0.144962 | 2.079243 | 0.035765 | 0.008639 | 0.000568 | 39.27569 | 0.451983 | 8.030285 |
| coral_235_b11@6 | 8.556892 | 0.149199 | 2.776194 | 0.030539 | 0.009871 | 0.00061 | 45.22738 | 0.376892 | 8.004665 |
| coral_235_b11@7 | 8.484785 | 0.116592 | 2.795626 | 0.030959 | 0.009854 | 0.001094 | 45.50636 | 0.363576 | 7.978255 |
| coral_235_b11@8 | 8.373982 | 0.196025 | 2.784827 | 0.05993 | 0.008954 | 0.00074 | 45.15901 | 0.421444 | 7.954185 |
| coral_235_b11@9 | 8.698216 | 0.158343 | 2.542479 | 0.022673 | 0.009644 | 0.000768 | 43.47211 | 0.379822 | 7.928555 |
| coral_235_b11@10 | 8.836501 | 0.192682 | 2.459721 | 0.055661 | 0.010445 | 0.001055 | 42.60209 | 0.394208 | 7.904485 |
| coral_235_b11@11 | 8.579953 | 0.130692 | 1.812477 | 0.028668 | 0.008782 | 0.000887 | 37.32688 | 0.317079 | 7.878075 |
| coral_235_b11@12 | 8.763291 | 0.242079 | 2.4276 | 0.019259 | 0.010609 | 0.000725 | 43.46603 | 0.390725 | 7.850125 |
| coral_235_b11@13 | 8.606487 | 0.128094 | 2.67149 | 0.031524 | 0.010096 | 0.00058 | 44.88991 | 0.426069 | 7.823715 |
| coral_235_b11@14 | 8.650584 | 0.139069 | 2.453965 | 0.031351 | 0.010172 | 0.001198 | 43.15063 | 0.340731 | 7.800415 |
| coral_235_b11@15 | 8.992783 | 0.183485 | 1.772147 | 0.025937 | 0.00935 | 0.000704 | 38.3579 | 0.295425 | 7.773235 |
| coral_235_b11@16 | 8.737686 | 0.120583 | 2.384145 | 0.019019 | 0.009945 | 0.0008 | 42.49942 | 0.466889 | 7.748385 |
| coral_235_b11@17 | 8.620457 | 0.179568 | 2.72967 | 0.036651 | 0.009674 | 0.001036 | 45.95097 | 0.291649 | 7.724315 |
| coral_235_b11@18 | 8.583911 | 0.169666 | 2.67726 | 0.048313 | 0.009927 | 0.00121 | 44.77037 | 0.681099 | 7.697135 |
| coral_235_b11@19 | 8.592005 | 0.225554 | 2.128482 | 0.03636 | 0.009807 | 0.000678 | 40.61548 | 0.381139 | 7.673055 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b11@20 | 8.960066 | 0.12648 | 2.09869 | 0.056822 | 0.009655 | 0.001005 | 40.56665 | 0.39998 | 7.647435 |
| coral_235_b12@1 | 8.944498 | 0.032725 | 2.382936 | 0.04169 | 0.010257 | 0.001049 | 43.60302 | 0.338713 | 7.612485 |
| coral_235_b12@2 | 8.966806 | 0.142601 | 2.513945 | 0.020686 | 0.011907 | 0.000877 | 45.05554 | 0.534352 | 7.580645 |
| coral_235_b12@3 | 8.809797 | 0.133132 | 2.601185 | 0.037281 | 0.011507 | 0.00127 | 44.80184 | 0.332591 | 7.554235 |
| coral_235_b12@4 | 8.824316 | 0.162283 | 2.563835 | 0.027563 | 0.010518 | 0.000857 | 44.01179 | 0.279778 | 7.534825 |
| coral_235_b12@5 | 9.018988 | 0.09263 | 2.510496 | 0.029453 | 0.010507 | 0.001115 | 44.2004 | 0.370827 | 7.505315 |
| coral_235_b12@6 | 8.851927 | 0.142372 | 2.549053 | 0.040215 | 0.010531 | 0.00139 | 44.143 | 0.485856 | 7.485125 |
| coral_235_b12@7 | 8.881611 | 0.131595 | 2.423012 | 0.035074 | 0.013852 | 0.001852 | 43.5706 | 0.395022 | 7.457165 |
| coral_235_b12@8 | 9.10361 | 0.206322 | 2.275538 | 0.038612 | 0.011108 | 0.000914 | 43.48751 | 0.375602 | 7.426875 |
| coral_235_b12@9 | 8.850355 | 0.180011 | 2.661195 | 0.029197 | 0.011825 | 0.000914 | 46.72901 | 0.424285 | 7.401255 |
| coral_235_b12@10 | 8.405394 | 0.145656 | 2.58702 | 0.036851 | 0.010546 | 0.000806 | 47.07391 | 0.646376 | 7.370965 |
| coral_235_b12@11 | 8.702638 | 0.152829 | 2.452055 | 0.030045 | 0.010296 | 0.001511 | 45.44369 | 0.480082 | 7.345335 |
| coral_235_b12@12 | 8.79345 | 0.174457 | 2.531491 | 0.030132 | 0.010417 | 0.001031 | 45.7814 | 0.480433 | 7.287095 |
| coral_235_b13@1 | 8.656829 | 0.218024 | 2.737161 | 0.098369 | 0.010498 | 0.000501 | 44.54164 | 0.726278 | 7.259135 |
| coral_235_b13@2 | 9.13133 | 0.230401 | 2.463592 | 0.048039 | 0.011135 | 0.001356 | 42.54278 | 0.380839 | 7.197005 |
| coral_235_b13@4 | 8.955451 | 0.201861 | 2.694243 | 0.110595 | 0.011155 | 0.001388 | 45.27829 | 0.490379 | 7.177595 |
| coral_235_b13@3 | 8.648048 | 0.173937 | 1.493192 | 0.029996 | 0.008819 | 0.000539 | 35.46253 | 0.430932 | 7.140315 |
| coral_235_b13@5 | 8.713973 | 0.187021 | 2.612319 | 0.03614 | 0.011235 | 0.00151 | 45.52855 | 0.432501 | 7.108475 |
| coral_235_b13@6 | 8.519367 | 0.099304 | 2.680032 | 0.037503 | 0.010906 | 0.00093 | 46.06061 | 0.434044 | 7.086735 |
| coral_235_b13@7 | 8.871377 | 0.152034 | 2.252245 | 0.031012 | 0.00993 | 0.001742 | 42.35388 | 0.261034 | 7.064985 |
| coral_235_b13@8 | 9.371843 | 0.149465 | 2.078365 | 0.034221 | 0.010242 | 0.001411 | 41.05165 | 0.325418 | 7.039365 |
| coral_235_b13@9 | 8.966547 | 0.09042 | 2.269548 | 0.029139 | 0.010551 | 0.00046 | 42.81887 | 0.408573 | 7.007525 |
| coral_235_b13@10 | 9.082538 | 0.110271 | 2.299274 | 0.029861 | 0.010284 | 0.000494 | 43.2476 | 0.377658 | 6.981115 |
| coral_235_b13@11 | 9.013702 | 0.174433 | 2.349118 | 0.024308 | 0.010972 | 0.000681 | 44.1202 | 0.319747 | 6.950055 |
| coral_235_b13@12 | 8.843353 | 0.168467 | 1.886684 | 0.018562 | 0.009405 | 0.000985 | 40.36026 | 0.304458 | 6.925975 |
| coral_235_b13@13 | 8.794067 | 0.15047 | 1.987291 | 0.030068 | 0.010001 | 0.002797 | 40.71118 | 0.319648 | 6.898795 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b13@14 | 8.877989 | 0.109824 | 2.585731 | 0.030518 | 0.010389 | 0.000943 | 45.46783 | 0.38926 | 6.872395 |
| coral_235_b13@15 | 9.015753 | 0.099878 | 1.585662 | 0.025227 | 0.009554 | 0.000872 | 37.89681 | 0.436712 | 6.852975 |
| coral_235_b13@16 | 8.939786 | 0.156185 | 2.320524 | 0.027608 | 0.010539 | 0.001084 | 43.20767 | 0.546633 | 6.797065 |
| coral_235_b13@17 | 8.855191 | 0.125681 | 1.546974 | 0.037969 | 0.009233 | 0.000591 | 35.25168 | 0.74538 | 6.772985 |
| coral_235_b13@18 | 9.09295 | 0.135397 | 2.539202 | 0.040517 | 0.011212 | 0.00091 | 46.54472 | 0.519453 | 6.745035 |
| coral_235_b13@19 | 9.139352 | 0.192119 | 2.40958 | 0.027659 | 0.012191 | 0.00149 | 46.14063 | 0.80337 | 6.714355 |
| coral_235_b13@20 | 9.136618 | 0.156994 | 2.291639 | 0.022354 | 0.011087 | 0.000979 | 44.95316 | 0.374731 | 6.692615 |
| coral_235_b13@21 | 9.099103 | 0.156321 | 2.085972 | 0.027475 | 0.011209 | 0.001018 | 43.34437 | 0.501147 | 6.673975 |
| coral_235_b13@22 | 9.176828 | 0.118547 | 2.32498 | 0.03442 | 0.012423 | 0.001394 | 45.64472 | 0.673128 | 6.644075 |
| coral_235_b13@23 | 9.149533 | 0.21852 | 2.208725 | 0.022907 | 0.01132 | 0.000828 | 43.97314 | 0.480061 | 6.625055 |
| coral_235_b13@24 | 8.83645 | 0.092659 | 1.21495 | 0.023412 | 0.007752 | 0.000894 | 33.96599 | 0.340667 | 6.609135 |
| coral_235_b13@25 | 9.036131 | 0.153686 | 1.909964 | 0.030081 | 0.009774 | 0.000919 | 40.744 | 0.538821 | 6.585055 |
| coral_235_b14@1 | 8.923172 | 0.101024 | 2.369417 | 0.041908 | 0.010327 | 0.001256 | 42.00955 | 0.23344 | 6.560595 |
| coral_235_b14@2 | 8.659956 | 0.150945 | 2.742362 | 0.031473 | 0.01084 | 0.000774 | 45.62818 | 0.43155 | 6.534965 |
| coral_235_b14@3 | 8.746024 | 0.169037 | 2.733198 | 0.033141 | 0.01052 | 0.000745 | 45.71669 | 0.31554 | 6.507005 |
| coral_235_b14@4 | 8.771452 | 0.171643 | 2.654078 | 0.050328 | 0.009643 | 0.000753 | 46.04179 | 0.559359 | 6.481385 |
| coral_235_b14@5 | 9.079602 | 0.178701 | 2.484089 | 0.061637 | 0.011699 | 0.00058 | 45.12201 | 0.605193 | 6.454585 |
| coral_235_b14@6 | 8.949542 | 0.116343 | 2.526361 | 0.035033 | 0.011127 | 0.001181 | 44.88452 | 0.440654 | 6.424305 |
| coral_235_b14@7 | 8.957531 | 0.131835 | 2.50725 | 0.031223 | 0.011432 | 0.000693 | 44.9055 | 0.375866 | 6.389355 |
| coral_235_b14@8 | 8.938928 | 0.130405 | 2.449038 | 0.024998 | 0.011328 | 0.000661 | 45.55079 | 0.25499 | 6.373825 |
| coral_235_b14@9 | 8.813189 | 0.145269 | 2.329332 | 0.028811 | 0.011253 | 0.00071 | 45.81732 | 0.555461 | 6.348195 |
| coral_235_b14@10 | 8.636265 | 0.129738 | 2.39173 | 0.030835 | 0.010778 | 0.000463 | 46.62169 | 0.423544 | 6.324125 |
| coral_235_b14@11 | 8.650098 | 0.157382 | 2.291563 | 0.023227 | 0.011083 | 0.001195 | 45.53979 | 0.435684 | 6.292285 |
| coral_235_b14@12 | 8.702813 | 0.131763 | 2.120813 | 0.054154 | 0.009791 | 0.001001 | 43.56744 | 0.695058 | 6.264325 |
| coral_235_b14@13 | 8.651119 | 0.184304 | 2.013318 | 0.035779 | 0.008724 | 0.000902 | 41.68009 | 0.537223 | 6.218505 |
| coral_235_b14@14 | 9.087663 | 0.149578 | 2.437794 | 0.016915 | 0.011599 | 0.001266 | 46.32175 | 0.555565 | 6.197535 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b14@15 | 8.937919 | 0.200756 | 2.604847 | 0.045418 | 0.010465 | 0.001019 | 47.03138 | 0.50524 | 6.165695 |
| coral_235_b14@16 | 8.863956 | 0.239671 | 2.468421 | 0.047219 | 0.009965 | 0.001 | 45.96821 | 0.602617 | 6.148615 |
| coral_235_b14@17 | 8.434839 | 0.198325 | 1.435982 | 0.062969 | 0.008243 | 0.000678 | 35.55027 | 0.415396 | 6.115995 |
| coral_235_b14@18 | 8.934247 | 0.115634 | 2.406667 | 0.026025 | 0.010197 | 0.00116 | 45.20621 | 0.702804 | 6.091925 |
| coral_235_b15@1 | 8.825145 | 0.069024 | 2.171617 | 0.031508 | 0.009636 | 0.001344 | 43.35345 | 0.69143 | 6.064745 |
| coral_235_b15@2 | 8.685139 | 0.105172 | 1.471685 | 0.020766 | 0.007793 | 0.000713 | 36.60981 | 0.640281 | 6.049205 |
| coral_235_b15@3 | 9.033975 | 0.119174 | 1.530703 | 0.032129 | 0.00782 | 0.000725 | 37.55254 | 0.445283 | 6.024355 |
| coral_235_b15@4 | 8.899363 | 0.091817 | 2.329771 | 0.038663 | 0.009664 | 0.000807 | 44.73217 | 0.571572 | 5.993295 |
| coral_235_b15@5 | 8.654541 | 0.145452 | 2.508774 | 0.059192 | 0.009541 | 0.00139 | 46.66272 | 0.903919 | 5.963785 |
| coral_235_b15@6 | 8.778536 | 0.110876 | 2.489662 | 0.030081 | 0.01002 | 0.000915 | 45.99537 | 0.227817 | 5.940485 |
| coral_235_b15@7 | 8.649159 | 0.140222 | 2.347815 | 0.031009 | 0.008704 | 0.001098 | 44.63455 | 0.378536 | 5.912525 |
| coral_235_b15@8 | 8.525961 | 0.115327 | 2.38958 | 0.045279 | 0.008362 | 0.001119 | 45.3947 | 0.428174 | 5.889235 |
| coral_235_b15@9 | 8.487209 | 0.267124 | 1.166473 | 0.058663 | 0.008308 | 0.000924 | 32.53998 | 0.788459 | 5.861275 |
| coral_235_b15@10 | 8.940506 | 0.16256 | 1.653793 | 0.028651 | 0.00872 | 0.000887 | 36.9278 | 0.414073 | 5.837975 |
| coral_235_b15@11 | 8.804455 | 0.108529 | 2.451267 | 0.033313 | 0.010365 | 0.000669 | 46.22769 | 0.278649 | 5.763425 |
| coral_235_b15@12 | 8.797767 | 0.103444 | 2.271449 | 0.045628 | 0.009739 | 0.000724 | 44.74384 | 0.745494 | 5.732365 |
| coral_235_b15@13 | 9.157465 | 0.152916 | 2.194693 | 0.02551 | 0.010005 | 0.001269 | 44.0435 | 0.439062 | 5.705955 |
| coral_235_b15@14 | 8.796661 | 0.195971 | 1.814652 | 0.019529 | 0.008756 | 0.00138 | 37.849 | 0.656051 | 5.681105 |
| coral_235_b15@15 | 8.735746 | 0.178815 | 2.450804 | 0.186191 | 0.010285 | 0.000887 | 40.7323 | 1.258689 | 5.656255 |
| coral_235_b15@16 | 9.052785 | 0.120751 | 2.485615 | 0.030918 | 0.010096 | 0.000851 | 45.697 | 0.343825 | 5.586365 |
| coral_235_b15@17 | 9.020971 | 0.110746 | 2.506314 | 0.019539 | 0.010221 | 0.00051 | 45.73902 | 0.294375 | 5.553745 |
| coral_235_b16@1 | 9.002745 | 0.207076 | 2.319298 | 0.040779 | 0.010035 | 0.001081 | 43.52326 | 0.696175 | 5.521125 |
| coral_235_b16@2 | 8.819175 | 0.234453 | 2.650943 | 0.029127 | 0.009842 | 0.001076 | 45.89693 | 0.306973 | 5.497835 |
| coral_235_b16@3 | 8.911035 | 0.172463 | 2.746565 | 0.027304 | 0.009929 | 0.001048 | 46.7864 | 0.344831 | 5.472975 |
| coral_235_b16@4 | 8.922331 | 0.154397 | 2.79652 | 0.044117 | 0.010895 | 0.001041 | 47.02613 | 0.453217 | 5.438805 |
| coral_235_b16@5 | 8.903757 | 0.11487 | 2.683982 | 0.049295 | 0.010859 | 0.000957 | 46.38704 | 0.632523 | 5.417065 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b16@6 | 8.947562 | 0.269635 | 2.690159 | 0.039558 | 0.010834 | 0.001753 | 46.99946 | 0.626316 | 5.398425 |
| coral_235_b16@7 | 8.651922 | 0.130367 | 2.274809 | 0.029805 | 0.009972 | 0.001373 | 42.53398 | 0.411606 | 5.375125 |
| coral_235_b16@8 | 8.801745 | 0.241086 | 1.456737 | 0.023687 | 0.008735 | 0.001019 | 35.45851 | 0.615529 | 5.345615 |
| coral_235_b16@9 | 8.74103 | 0.244856 | 1.75262 | 0.020175 | 0.00878 | 0.000896 | 38.56499 | 0.527331 | 5.309895 |
| coral_235_b16@10 | 8.550983 | 0.174181 | 1.669587 | 0.016678 | 0.00839 | 0.001173 | 37.02273 | 0.519361 | 5.285045 |
| coral_235_b16@11 | 8.581588 | 0.160772 | 1.23277 | 0.017159 | 0.007989 | 0.000537 | 32.41085 | 0.292467 | 5.260195 |
| coral_235_b16@12 | 9.171818 | 0.164424 | 2.26697 | 0.014744 | 0.011033 | 0.000863 | 44.43289 | 0.340162 | 5.161565 |
| coral_235_b16@13 | 9.039622 | 0.178528 | 2.150227 | 0.035141 | 0.010058 | 0.001355 | 43.20483 | 0.358648 | 5.139045 |
| coral_235_b16@14 | 9.085384 | 0.207109 | 2.4984 | 0.033804 | 0.01102 | 0.00104 | 46.65111 | 0.711893 | 5.113415 |
| coral_235_b16@15 | 8.979662 | 0.17782 | 2.575422 | 0.028078 | 0.010743 | 0.001505 | 46.79859 | 0.617141 | 5.087785 |
| coral_235_b16@16 | 8.927791 | 0.156209 | 2.686369 | 0.046148 | 0.011148 | 0.000769 | 47.40524 | 0.327521 | 5.066825 |
| coral_235_b16@17 | 9.005099 | 0.171085 | 2.456985 | 0.028393 | 0.009667 | 0.001574 | 45.28039 | 0.397 | 5.046635 |
| coral_235_b16@18 | 9.263094 | 0.248981 | 2.348484 | 0.021547 | 0.011582 | 0.000917 | 44.40164 | 0.380016 | 5.019445 |
| coral_235_b16@19 | 9.203022 | 0.166737 | 2.293025 | 0.027694 | 0.012015 | 0.001408 | 44.41187 | 0.396909 | 4.989945 |
| coral_235_b16@20 | 8.978044 | 0.168283 | 2.297739 | 0.026483 | 0.010605 | 0.000726 | 43.07536 | 0.389335 | 4.967415 |
| coral_235_b16@21 | 8.868344 | 0.164579 | 2.210556 | 0.036376 | 0.010306 | 0.000863 | 42.29713 | 0.411242 | 4.943345 |
| coral_235_b16@22 | 8.969889 | 0.114058 | 2.363542 | 0.04144 | 0.010412 | 0.001058 | 44.6467 | 0.487572 | 4.913835 |
| coral_235_b16@23 | 9.062987 | 0.131017 | 2.246419 | 0.045771 | 0.010343 | 0.00062 | 43.84545 | 0.33253 | 4.892865 |
| coral_235_b16@24 | 9.208925 | 0.158689 | 2.322131 | 0.035042 | 0.012465 | 0.000806 | 45.12478 | 0.588399 | 4.861805 |
| coral_235_b16@25 | 8.963771 | 0.157947 | 1.710836 | 0.075519 | 0.00981 | 0.001425 | 38.85739 | 0.438228 | 4.802785 |
| coral_235_b16@26 | 9.105688 | 0.100605 | 2.078551 | 0.030124 | 0.011352 | 0.001053 | 41.84375 | 0.354481 | 4.776375 |
| coral_235_b16@27 | 8.922721 | 0.145113 | 2.346735 | 0.053109 | 0.010219 | 0.001314 | 45.19055 | 0.686288 | 4.748415 |
| coral_235_b16@28 | 8.794443 | 0.183075 | 2.460178 | 0.043232 | 0.009755 | 0.000852 | 45.60249 | 0.469626 | 4.731335 |
| coral_235_b_17@1 | 8.371405 | 0.337553 | 2.908443 | 0.052384 | 0.009778 | 0.000617 | 45.07189 | 0.43968 | 4.701825 |
| coral_235_b_17@2 | 8.541777 | 0.227417 | 2.810457 | 0.046158 | 0.010072 | 0.001062 | 45.17164 | 0.424355 | 4.666105 |
| coral_235_b_17@3 | 8.690089 | 0.222861 | 2.768775 | 0.037574 | 0.010301 | 0.00111 | 45.70913 | 0.312905 | 4.638145 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b_17@4 | 8.508649 | 0.289177 | 2.64555 | 0.085347 | 0.010584 | 0.000955 | 46.6253 | 0.892299 | 4.591545 |
| coral_235_b_17@5 | 8.440336 | 0.210467 | 2.640073 | 0.048606 | 0.01043 | 0.001165 | 48.67533 | 1.411567 | 4.566695 |
| coral_235_b_17@6 | 8.543319 | 0.271794 | 2.207934 | 0.031988 | 0.009541 | 0.001114 | 42.85459 | 0.748214 | 4.537965 |
| coral_235_b_17@7 | 8.952393 | 0.205493 | 1.862435 | 0.046262 | 0.009403 | 0.001154 | 39.13113 | 0.426439 | 4.513885 |
| coral_235_b_17@8 | 8.674108 | 0.281969 | 2.489174 | 0.038281 | 0.010874 | 0.000762 | 46.0993 | 0.39531 | 4.492925 |
| coral_235_b_17@9 | 8.605562 | 0.236345 | 2.490703 | 0.050949 | 0.010207 | 0.001 | 45.62537 | 0.459674 | 4.433125 |
| coral_235_b_17@10 | 8.511363 | 0.251477 | 2.607302 | 0.037578 | 0.010567 | 0.001591 | 47.03561 | 0.59202 | 4.384205 |
| coral_235_b_17@11 | 8.804156 | 0.218401 | 2.322641 | 0.036195 | 0.009756 | 0.000966 | 43.7785 | 0.345457 | 4.297995 |
| coral_235_b_17@12 | 8.744417 | 0.355699 | 2.310467 | 0.023175 | 0.009981 | 0.001261 | 44.78524 | 0.420935 | 4.252955 |
| coral_235_b_17@13 | 8.800375 | 0.234962 | 2.304639 | 0.047036 | 0.01071 | 0.001426 | 44.32321 | 0.645123 | 4.231215 |
| coral_235_b_17@14 | 8.813854 | 0.211889 | 2.494689 | 0.030005 | 0.010124 | 0.000928 | 46.03416 | 0.219588 | 4.208685 |
| coral_235_b_17@15 | 8.770705 | 0.125408 | 2.557992 | 0.0619 | 0.010219 | 0.001245 | 46.90994 | 0.721944 | 4.170635 |
| coral_235_b_17@16 | 8.735803 | 0.217283 | 2.461254 | 0.055371 | 0.010004 | 0.001046 | 45.8771 | 0.455589 | 4.148895 |
| coral_235_b_17@17 | 8.74691 | 0.177716 | 2.53483 | 0.032676 | 0.010494 | 0.00065 | 46.67654 | 0.411475 | 4.124045 |
| coral_235_b_17@18 | 8.862897 | 0.173571 | 2.527496 | 0.053107 | 0.010472 | 0.000778 | 46.56214 | 0.335469 | 4.103075 |
| coral_235_b_17@19 | 8.539387 | 0.269148 | 1.928874 | 0.065976 | 0.008952 | 0.001232 | 39.0425 | 0.515494 | 4.037065 |
| coral_235_b_17@20 | 8.115028 | 0.218077 | 1.120606 | 0.037705 | 0.006901 | 0.000803 | 32.27671 | 0.295807 | 4.002115 |
| coral_235_b_17@21 | 8.314451 | 0.168124 | 2.44462 | 0.051655 | 0.009123 | 0.001247 | 46.78948 | 0.734687 | 3.974935 |
| coral_235_b_17@22 | 8.596852 | 0.188115 | 1.304773 | 0.04097 | 0.007745 | 0.001098 | 34.90759 | 0.328484 | 3.943095 |
| coral_235_b_17@23 | 8.324803 | 0.115339 | 3.181155 | 1.275916 | 0.025751 | 0.011563 | 39.93318 | 0.99216 | 3.917465 |
| coral_235_b_17@24 | 8.771253 | 0.170412 | 1.232626 | 0.019173 | 0.007936 | 0.000939 | 34.55793 | 0.351107 | 3.900385 |
| coral_235_b_17@25 | 8.991317 | 0.221173 | 1.871833 | 0.028152 | 0.00936 | 0.000674 | 41.42645 | 0.304018 | 3.895725 |
| coral_235_b_18@1 | 8.598451 | 0.140431 | 2.42715 | 0.035536 | 0.009606 | 0.000988 | 46.00436 | 0.525828 | 3.870095 |
| coral_235_b_18@2 | 8.570769 | 0.192871 | 2.45853 | 0.048238 | 0.009738 | 0.001098 | 47.51331 | 0.587324 | 3.848355 |
| coral_235_b_18@3 | 8.633316 | 0.213483 | 2.440508 | 0.012517 | 0.010508 | 0.001227 | 47.19103 | 0.616932 | 3.814965 |
| coral_235_b_18@4 | 8.888523 | 0.181408 | 1.655764 | 0.024798 | 0.009124 | 0.000594 | 39.02717 | 0.403041 | 3.793215 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b_18@5 | 8.935197 | 0.216097 | 1.512293 | 0.011329 | 0.008763 | 0.000481 | 37.83987 | 0.284131 | 3.745065 |
| coral_235_b19@1 | 8.464973 | 0.102417 | 2.610883 | 0.048199 | 0.009489 | 0.001155 | 42.52521 | 0.546159 | 3.712445 |
| coral_235_b19@2 | 8.515453 | 0.193666 | 2.391659 | 0.046865 | 0.009376 | 0.000775 | 42.22056 | 0.473376 | 3.685265 |
| coral_235_b19@3 | 8.638583 | 0.216489 | 2.248434 | 0.025925 | 0.015658 | 0.001566 | 42.25148 | 0.373023 | 3.660415 |
| coral_235_b19@4 | 8.556524 | 0.19084 | 2.654372 | 0.028558 | 0.010886 | 0.001098 | 46.46743 | 0.650774 | 3.640225 |
| coral_235_b19@5 | 8.571333 | 0.149696 | 2.782178 | 0.052368 | 0.010145 | 0.000934 | 47.00844 | 0.310229 | 3.608385 |
| coral_235_b19@6 | 8.473021 | 0.206114 | 2.791123 | 0.03084 | 0.009988 | 0.000899 | 47.31881 | 0.345257 | 3.584305 |
| coral_235_b19@7 | 8.517037 | 0.206426 | 2.664871 | 0.023524 | 0.009501 | 0.000935 | 46.66708 | 0.343347 | 3.562565 |
| coral_235_b19@8 | 8.864039 | 0.180643 | 2.126245 | 0.041209 | 0.00901 | 0.000684 | 41.19771 | 0.678676 | 3.527615 |
| coral_235_b19@9 | 8.530361 | 0.244326 | 1.872658 | 0.043141 | 0.008962 | 0.001111 | 39.08824 | 0.657042 | 3.506655 |
| coral_235_b19@10 | 8.821838 | 0.177391 | 2.399975 | 0.029397 | 0.009692 | 0.001522 | 45.50472 | 0.347326 | 3.480245 |
| coral_235_b19@11 | 8.666555 | 0.20405 | 2.515593 | 0.039246 | 0.009273 | 0.00122 | 46.04693 | 0.427098 | 3.450735 |
| coral_235_b19@12 | 8.85708 | 0.1637 | 2.327342 | 0.03005 | 0.009259 | 0.000731 | 44.45802 | 0.479707 | 3.424335 |
| coral_235_b19@13 | 8.798386 | 0.224729 | 2.497611 | 0.031974 | 0.009496 | 0.001113 | 46.6804 | 0.495207 | 3.403365 |
| coral_235_b19@14 | 8.865657 | 0.119948 | 2.53178 | 0.031628 | 0.009557 | 0.000822 | 46.54258 | 0.502022 | 3.376965 |
| coral_235_b19@15 | 8.824868 | 0.174736 | 2.619194 | 0.047312 | 0.010116 | 0.001231 | 47.63731 | 0.596807 | 3.355215 |
| coral_235_b19@16 | 8.58568 | 0.211473 | 2.205382 | 0.062894 | 0.00933 | 0.000785 | 42.41503 | 0.737154 | 3.330365 |
| coral_235_b19@17 | 9.095603 | 0.234982 | 1.967431 | 0.033418 | 0.009591 | 0.00077 | 41.94045 | 0.357554 | 3.293085 |
| coral_235_b19@18 | 8.655849 | 0.181874 | 2.625281 | 0.045845 | 0.00947 | 0.000894 | 48.30303 | 1.035586 | 3.270565 |
| coral_235_b19@19 | 8.664634 | 0.189935 | 2.202529 | 0.100362 | 0.010016 | 0.000726 | 43.11249 | 0.752543 | 3.237175 |
| coral_235_b19@20 | 8.973136 | 0.210586 | 2.181498 | 0.037277 | 0.010261 | 0.000498 | 43.56449 | 0.37366 | 3.212325 |
| coral_235_b19@21 | 8.873066 | 0.135195 | 2.508493 | 0.038268 | 0.009657 | 0.000665 | 47.07709 | 0.852673 | 3.185915 |
| coral_235_b19@22 | 8.958573 | 0.139074 | 2.23275 | 0.045762 | 0.010407 | 0.00049 | 45.02812 | 0.572039 | 3.162625 |
| coral_235_b19@23 | 8.896051 | 0.161958 | 2.443156 | 0.049808 | 0.010474 | 0.000812 | 46.82993 | 0.755707 | 3.143985 |
| coral_235_b19@24 | 8.804538 | 0.136328 | 2.112946 | 0.026552 | 0.010236 | 0.000883 | 42.93871 | 0.419552 | 3.120685 |
| coral_235_b19@25 | 8.812007 | 0.294896 | 2.248796 | 0.033162 | 0.009964 | 0.001108 | 44.72423 | 0.405357 | 3.057005 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b19@26 | 8.77609 | 0.197318 | 2.475214 | 0.06551 | 0.010004 | 0.000919 | 46.50232 | 0.694288 | 3.034485 |
| coral_235_b19@27 | 9.06083 | 0.15565 | 2.442872 | 0.092554 | 0.012482 | 0.003255 | 45.83765 | 1.236114 | 3.001095 |
| coral_235_b19@28 | 9.050048 | 0.192546 | 2.160114 | 0.025418 | 0.010104 | 0.001177 | 44.08834 | 0.589044 | 2.973915 |
| coral_235_b19@29 | 8.94857 | 0.200789 | 2.380124 | 0.028069 | 0.009902 | 0.000564 | 46.18502 | 0.360613 | 2.956045 |
| coral_235_b19@30 | 8.924705 | 0.117335 | 2.409944 | 0.059844 | 0.009983 | 0.001178 | 45.67272 | 0.548023 | 2.929645 |
| coral_235_b19@31 | 8.688494 | 0.185971 | 2.206172 | 0.076398 | 0.009446 | 0.001057 | 43.51426 | 0.749287 | 2.901685 |
| coral_235_b19@32 | 9.013446 | 0.133224 | 2.168776 | 0.036734 | 0.009278 | 0.000786 | 43.95524 | 0.173066 | 2.873735 |
| coral_235_b19@33 | 8.87066 | 0.1764 | 2.401271 | 0.024259 | 0.009845 | 0.000832 | 45.9583 | 0.589993 | 2.847325 |
| coral_235_b19@34 | 8.620266 | 0.207825 | 2.607259 | 0.034563 | 0.009965 | 0.000923 | 47.76418 | 0.524213 | 2.825585 |
| coral_235_b19@35 | 8.728208 | 0.172967 | 2.458923 | 0.026468 | 0.009294 | 0.001116 | 45.82853 | 0.406053 | 2.790635 |
| coral_235_b19@36 | 8.278367 | 0.241141 | 1.630705 | 0.034848 | 0.008088 | 0.001265 | 35.6519 | 0.65107 | 2.773555 |
| coral_235_b19@37 | 8.787311 | 0.134731 | 2.200153 | 0.03882 | 0.009359 | 0.000687 | 43.10881 | 0.410679 | 2.748705 |
| coral_235_b19@38 | 8.753545 | 0.119401 | 2.334927 | 0.05358 | 0.009413 | 0.000935 | 44.68468 | 0.386138 | 2.723075 |
| coral_235_b19@39 | 8.830243 | 0.16664 | 2.482709 | 0.027698 | 0.009468 | 0.000892 | 46.95854 | 0.418935 | 2.696665 |
| coral_235_b19@40 | 8.747315 | 0.221047 | 2.667921 | 0.047744 | 0.009701 | 0.000634 | 48.31433 | 0.558244 | 2.664055 |
| coral_235_b20@1 | 7.825801 | 0.399939 | 3.126827 | 0.084032 | 0.008202 | 0.000936 | 45.31496 | 1.125862 | 2.643865 |
| coral_235_b20@2 | 8.127548 | 0.366358 | 3.011049 | 0.047535 | 0.009131 | 0.001051 | 45.09148 | 0.483707 | 2.619785 |
| coral_235_b20@3 | 8.247249 | 0.23968 | 2.792634 | 0.05998 | 0.008231 | 0.00113 | 44.95984 | 0.731245 | 2.589495 |
| coral_235_b20@4 | 8.387736 | 0.353296 | 2.656788 | 0.049894 | 0.00863 | 0.001468 | 52.24886 | 0.717592 | 2.562315 |
| coral_235_b20@5 | 8.526115 | 0.332425 | 2.570819 | 0.058419 | 0.008914 | 0.000661 | 44.47291 | 0.52106 | 2.529705 |
| coral_235_b20@6 | 8.565313 | 0.254563 | 2.643381 | 0.079148 | 0.009027 | 0.001238 | 46.32545 | 0.891358 | 2.503295 |
| coral_235_b20@7 | 8.613047 | 0.255532 | 2.622942 | 0.080389 | 0.009702 | 0.000964 | 47.85536 | 0.953016 | 2.472235 |
| coral_235_b20@8 | 8.898778 | 0.256815 | 2.388663 | 0.064597 | 0.009999 | 0.001275 | 45.19316 | 0.824653 | 2.445835 |
| coral_235_b20@9 | 8.641218 | 0.213727 | 2.633769 | 0.067416 | 0.010003 | 0.0017 | 47.32536 | 1.017659 | 2.423305 |
| coral_235_b20@10 | 8.653768 | 0.217349 | 2.576666 | 0.052628 | 0.01029 | 0.000786 | 46.27574 | 0.779736 | 2.391465 |
| coral_235_b20@11 | 8.705751 | 0.233713 | 2.55111 | 0.060326 | 0.009641 | 0.000803 | 44.97121 | 0.698971 | 2.359625 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b20@12 | 8.831715 | 0.301478 | 2.628217 | 0.041996 | 0.01034 | 0.001002 | 46.5168 | 0.411896 | 2.321575 |
| coral_235_b20@13 | 8.60689 | 0.277001 | 2.331846 | 0.04479 | 0.009591 | 0.000872 | 44.5667 | 0.730994 | 2.299835 |
| coral_235_b20@14 | 8.932146 | 0.215181 | 1.870096 | 0.039477 | 0.008968 | 0.00089 | 40.40817 | 0.585617 | 2.276535 |
| coral_235_b20@15 | 8.828589 | 0.244092 | 1.657785 | 0.02794 | 0.009302 | 0.000876 | 39.43172 | 0.647469 | 2.243915 |
| coral_235_b20@16 | 8.984648 | 0.229143 | 1.45962 | 0.082165 | 0.009637 | 0.001021 | 35.33091 | 1.186395 | 2.173245 |
| coral_235_b21@1 | 8.757479 | 0.163968 | 2.234415 | 0.025342 | 0.009323 | 0.001335 | 43.78294 | 0.417665 | 2.129755 |
| coral_235_b21@2 | 9.424949 | 0.285997 | 1.8753 | 0.033493 | 0.009468 | 0.001255 | 40.05169 | 0.573314 | 2.101805 |
| coral_235_b21@3 | 8.971201 | 0.170516 | 2.002741 | 0.047822 | 0.009853 | 0.000979 | 41.15761 | 0.522344 | 2.081605 |
| coral_235_b22@1 | 8.868609 | 0.133955 | 2.564161 | 0.045834 | 0.010985 | 0.001113 | 46.39082 | 0.398249 | 2.062975 |
| coral_235_b22@2 | 8.915686 | 0.163596 | 2.726967 | 0.032992 | 0.010747 | 0.001051 | 48.07835 | 0.732928 | 2.038125 |
| coral_235_b22@4 | 8.840614 | 0.09593 | 2.585582 | 0.047413 | 0.011005 | 0.000921 | 46.68935 | 0.319775 | 1.979095 |
| coral_235_b22@5 | 8.856054 | 0.263177 | 2.058531 | 0.018286 | 0.009301 | 0.000707 | 41.67143 | 0.720545 | 1.955025 |
| coral_235_b22@6 | 8.913835 | 0.263998 | 2.505739 | 0.042443 | 0.009985 | 0.001341 | 45.79927 | 0.629941 | 1.922405 |
| coral_235_b22@7 | 8.951335 | 0.147827 | 2.61461 | 0.035039 | 0.009668 | 0.000743 | 46.78703 | 0.390904 | 1.902995 |
| coral_235_b22@8 | 8.988743 | 0.255352 | 2.601137 | 0.032287 | 0.009777 | 0.001254 | 45.96644 | 0.861094 | 1.874265 |
| coral_235_b22@9 | 9.329801 | 0.119538 | 2.4696 | 0.027163 | 0.010561 | 0.001622 | 43.56848 | 0.442246 | 1.822225 |
| coral_235_b22@10 | 8.82472 | 0.246433 | 2.567682 | 0.047324 | 0.010155 | 0.00121 | 46.29039 | 0.63166 | 1.789615 |
| coral_235_b_23@1 | 8.713669 | 0.255398 | 2.218293 | 0.066985 | 0.009796 | 0.000954 | 40.7716 | 0.321283 | 1.760105 |
| coral_235_b_23@2 | 8.770861 | 0.207205 | 1.840835 | 0.106522 | 0.009412 | 0.000803 | 37.19989 | 0.446644 | 1.732925 |
| coral_235_b_23@3 | 8.966579 | 0.195478 | 2.004978 | 0.024396 | 0.010281 | 0.001196 | 39.77108 | 0.384501 | 1.706515 |
| coral_235_b_23@4 | 8.578136 | 0.214479 | 2.199206 | 0.033787 | 0.009404 | 0.001229 | 41.51161 | 0.467522 | 1.684775 |
| coral_235_b_23@5 | 8.389376 | 0.205839 | 2.468761 | 0.065779 | 0.009508 | 0.000829 | 44.17822 | 0.549533 | 1.657595 |
| coral_235_b_23@6 | 7.88339 | 0.212644 | 4.393342 | 0.618452 | 0.009681 | 0.001644 | 41.41817 | 0.472909 | 1.628085 |
| coral_235_b_23@7 | 8.335591 | 0.134601 | 2.701748 | 0.031165 | 0.009647 | 0.000692 | 46.77529 | 0.252086 | 1.606335 |
| coral_235_b_23@8 | 8.325319 | 0.189081 | 2.541508 | 0.084916 | 0.00998 | 0.001143 | 45.83132 | 0.429152 | 1.570615 |
| coral_235_b_23@9 | 9.154133 | 0.211569 | 2.154183 | 0.041318 | 0.010662 | 0.000676 | 43.86549 | 0.41291 | 1.422285 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b_23@10 | 8.575532 | 0.16428 | 2.569249 | 0.042067 | 0.011205 | 0.001114 | 44.13203 | 0.203239 | 1.399765 |
| coral_235_b_23@11 | 7.999311 | 0.160308 | 2.423968 | 0.059096 | 0.008597 | 0.00094 | 44.85685 | 0.522618 | 1.374135 |
| coral_235_b_23@12 | 8.274165 | 0.22871 | 2.159894 | 0.045039 | 0.008854 | 0.001203 | 43.61054 | 0.776672 | 1.354725 |
| coral_235_b_23@13 | 8.564513 | 0.194984 | 2.040554 | 0.022204 | 0.009743 | 0.001019 | 42.76436 | 1.373766 | 1.329095 |
| coral_235_b_23@14 | 7.980657 | 0.186817 | 2.521152 | 0.051851 | 0.008686 | 0.001331 | 45.83755 | 0.623594 | 1.307345 |
| coral_235_b_23@15 | 7.968591 | 0.184592 | 2.439132 | 0.032703 | 0.008626 | 0.000724 | 43.40895 | 1.155452 | 1.273175 |
| coral_235_b_23@16 | 9.212053 | 0.218398 | 1.741894 | 0.035145 | 0.010633 | 0.000721 | 39.28183 | 0.998677 | 1.212993 |
| coral_235_b_23@18 | 9.189788 | 0.156567 | 1.56036 | 0.06847 | 0.010382 | 0.000612 | 38.18959 | 0.480003 | 1.189307 |
| coral_235_b_23@19 | 8.749313 | 0.31418 | 6.583167 | 0.820455 | 0.015367 | 0.002196 | 51.54915 | 22.4641 | 1.15669 |
| coral_235_b_23@20 | 9.456446 | 0.208005 | 1.996485 | 0.032966 | 0.011461 | 0.001181 | 40.58333 | 0.712779 | 1.134946 |
| coral_235_b_23@21 | 9.423308 | 0.212268 | 1.584744 | 0.045705 | 0.010152 | 0.001016 | 37.48156 | 0.723214 | 1.114366 |
| coral_235_b_23@22 | 9.035466 | 0.145309 | 1.593892 | 0.032833 | 0.009626 | 0.000696 | 38.12829 | 0.866172 | 1.085633 |
| coral_235_b_23@23 | 9.527312 | 0.32641 | 1.686335 | 0.021247 | 0.011158 | 0.000965 | 39.553 | 0.813486 | 1.060393 |
| coral_235_b_23@24 | 8.594179 | 0.219439 | 2.467528 | 0.07992 | 0.010929 | 0.001302 | 45.13566 | 0.635891 | 1.033213 |
| coral_235_b_23@25 | 8.080956 | 0.153421 | 2.576073 | 0.055186 | 0.00933 | 0.000862 | 48.62603 | 0.827589 | 1.000984 |
| coral_235_b_23@26 | 8.839495 | 0.167045 | 1.708767 | 0.050394 | 0.008928 | 0.000835 | 40.21828 | 0.498973 | 0.978463 |
| coral_235_b_23@27 | 9.534783 | 0.161648 | 1.541077 | 0.017812 | 0.009719 | 0.001286 | 38.50988 | 0.557101 | 0.948564 |
| coral_235_b_23@28 | 9.450983 | 0.15983 | 1.588069 | 0.023884 | 0.010625 | 0.0005 | 39.42747 | 0.678563 | 0.925267 |
| coral_235_b_23@29 | 9.341302 | 0.232351 | 1.551782 | 0.038837 | 0.010497 | 0.001079 | 37.05276 | 0.492952 | 0.901192 |
| coral_235_b_23@30 | 9.302403 | 0.12226 | 1.737346 | 0.03363 | 0.010403 | 0.001219 | 39.97397 | 0.620516 | 0.877506 |
| coral_235_b_23@31 | 8.87391 | 0.16958 | 1.750701 | 0.040078 | 0.009615 | 0.000836 | 40.7499 | 1.291099 | 0.850326 |
| coral_235_b_23@32 | 8.349767 | 0.209248 | 2.089812 | 0.043932 | 0.009474 | 0.001201 | 42.78812 | 0.831643 | 0.845666 |
| coral_235_b_23@33 | 8.063757 | 0.150273 | 2.526733 | 0.082522 | 0.009269 | 0.000581 | 47.44282 | 0.458112 | 0.820815 |
| coral_235_b_23@34 | 8.262408 | 0.198743 | 2.377077 | 0.027527 | 0.008977 | 0.000779 | 47.79547 | 0.520574 | 0.797518 |
| coral_235_b_24@1 | 8.497177 | 0.086875 | 2.314896 | 0.027525 | 0.011671 | 0.004439 | 45.33863 | 0.230717 | 0.764513 |
| coral_235_b_24@2 | 8.259287 | 0.151268 | 2.568369 | 0.05718 | 0.010388 | 0.002307 | 47.39256 | 0.322724 | 0.741215 |

| File name | 88Sr/42Ca | 2SD mmol/mol | 24Mg/42Ca mmol/mol | 2SD mmol/mol | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca | 2SD | Distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_235_b_24@3 | 8.645384 | 0.239538 | 2.391017 | 0.051878 | 0.010982 | 0.000828 | 46.15854 | 0.306263 | 0.710151 |
| coral_235_b_24@4 | 8.744396 | 0.252983 | 2.293231 | 0.060489 | 0.010148 | 0.001049 | 46.39697 | 0.797975 | 0.686077 |
| coral_235_b_24@5 | 8.591762 | 0.275263 | 2.205035 | 0.037263 | 0.009324 | 0.001222 | 47.68581 | 2.64528 | 0.652684 |
| coral_235_b_24@6 | 8.412983 | 0.266303 | 2.383243 | 0.067748 | 0.008914 | 0.001279 | 47.72464 | 3.686225 | 0.625503 |
| coral_235_b_24@7 | 8.273214 | 0.225839 | 2.556104 | 0.111633 | 0.01091 | 0.002172 | 50.41221 | 3.903557 | 0.598322 |
| coral_235_b_24@8 | 8.542067 | 0.228202 | 2.508385 | 0.077882 | 0.011015 | 0.001032 | 47.8434 | 1.569266 | 0.575801 |
| coral_235_b_24@9 | 8.636956 | 0.34527 | 2.183085 | 0.053843 | 0.011395 | 0.000638 | 44.54648 | 1.497597 | 0.550174 |
| coral_235_b_24@10 | 8.751154 | 0.214928 | 2.158153 | 0.11877 | 0.010567 | 0.001045 | 44.51355 | 2.736256 | 0.526099 |
| coral_235_b_24@11 | 8.604881 | 0.255033 | 2.245633 | 0.027263 | 0.010012 | 0.00099 | 43.84504 | 0.602462 | 0.495036 |
| coral_235_b_25@1 | 9.143734 | 0.240015 | 2.0633 | 0.017399 | 0.011145 | 0.001455 | 42.74423 | 0.288211 | 0.469408 |
| coral_235_b_25@2 | 9.896097 | 0.280742 | 1.801409 | 0.032403 | 0.012868 | 0.001557 | 41.74012 | 0.448178 | 0.443781 |
| coral_235_b_25@3 | 8.952643 | 0.205821 | 2.269058 | 0.021708 | 0.010934 | 0.001126 | 44.85188 | 0.580824 | 0.420483 |
| coral_235_b_25@4 | 8.802575 | 0.305736 | 2.402934 | 0.052111 | 0.011214 | 0.000672 | 46.1477 | 0.487379 | 0.397186 |
| coral_235_b_25@5 | 8.890782 | 0.320353 | 2.20595 | 0.062175 | 0.01192 | 0.001819 | 46.3317 | 0.582237 | 0.369228 |
| coral_235_b_25@6 | 8.893978 | 0.099405 | 2.325666 | 0.086815 | 0.01246 | 0.001163 | 47.35121 | 0.895489 | 0.342824 |
| coral_235_b_25@7 | 8.736356 | 0.156533 | 2.147958 | 0.081588 | 0.011945 | 0.001125 | 45.05554 | 0.9084 | 0.31642 |
| coral_235_b_25@8 | 8.910951 | 0.291895 | 2.232456 | 0.019073 | 0.011066 | 0.000962 | 43.26266 | 0.624338 | 0.292346 |
| coral_235_b_25@9 | 8.874642 | 0.183659 | 2.243815 | 0.068158 | 0.010931 | 0.001018 | 42.98789 | 0.549458 | 0.269825 |
| coral_235_b_25@10 | 8.89079 | 0.247186 | 2.245597 | 0.052247 | 0.011346 | 0.000991 | 43.75413 | 0.488164 | 0.239538 |
| coral_235_b_25@11 | 9.124964 | 0.234707 | 1.880693 | 0.037647 | 0.010829 | 0.001094 | 40.53175 | 0.576811 | 0.214 |

*S.campylecus* Sample 241: SIMS data:

**Rows highlighted in grey are SIMS analyses corresponding to remineralized regions in the coral skeleton:**

| File name | 88Sr/42Ca mmol/mol | 2SD | 24Mg/42Ca mmol/mol | 2SD | 138Ba/42Ca mmol/mol | 2SD | 23Na/42Ca mmol/mol | 2SD | distance mm |
|---|---|---|---|---|---|---|---|---|---|
| coral_241_b1@1 | 7.629555 | 0.267782 | 3.927086 | 0.047155 | 0.011762 | 0.001578 | 39.97623 | 0.642323 | 0.059846 |
| coral_241_b1@2 | 7.772511 | 0.292869 | 3.786059 | 0.073307 | 0.011873 | 0.001603 | 40.71981 | 0.605594 | 0.084014 |
| coral_241_b1@3 | 8.07611 | 0.210853 | 3.703824 | 0.106174 | 0.012403 | 0.001308 | 40.03749 | 0.977733 | 0.117537 |
| coral_241_b1@4 | 8.094659 | 0.173416 | 3.427742 | 0.159993 | 0.013623 | 0.001639 | 38.72186 | 1.049434 | 0.154957 |
| coral_241_b1@5 | 8.181718 | 0.223009 | 3.244301 | 0.05408 | 0.013397 | 0.001164 | 37.66081 | 0.713279 | 0.178345 |
| coral_241_b1@6 | 8.201541 | 0.250313 | 3.223705 | 0.097346 | 0.013279 | 0.001715 | 39.39715 | 0.580286 | 0.204851 |
| coral_241_b1@7 | 8.019149 | 0.270852 | 3.39084 | 0.102179 | 0.014312 | 0.001858 | 41.69142 | 0.952592 | 0.232917 |
| coral_241_b1@8 | 8.03491 | 0.188407 | 3.004259 | 0.063599 | 0.013254 | 0.001434 | 39.47596 | 0.777136 | 0.262541 |
| coral_241_b1@9 | 8.017194 | 0.199465 | 3.628226 | 0.11349 | 0.019234 | 0.003383 | 43.3566 | 1.731343 | 0.295284 |
| coral_241_b1@10 | 8.246486 | 0.319548 | 3.080472 | 0.078443 | 0.016655 | 0.003818 | 40.34991 | 0.918287 | 0.32335 |
| coral_241_b1@11 | 8.234672 | 0.173579 | 3.405496 | 0.12843 | 0.017533 | 0.003515 | 41.83382 | 0.961417 | 0.354534 |
| coral_241_b1@12 | 8.144933 | 0.279963 | 3.708115 | 0.109947 | 0.015356 | 0.003151 | 42.27536 | 0.754878 | 0.384938 |
| coral_241_b1@15 | 8.618276 | 0.116306 | 3.268944 | 0.081769 | 0.014321 | 0.001982 | 41.78533 | 0.984737 | 0.417681 |
| coral_241_b1@16 | 8.512753 | 0.100895 | 3.253994 | 0.089318 | 0.013585 | 0.001578 | 41.37562 | 0.500274 | 0.448085 |
| coral_241_b2@1 | 8.503857 | 0.12975 | 3.280266 | 0.052889 | 0.012674 | 0.001301 | 43.18118 | 0.463398 | 0.475371 |
| coral_241_b2@2 | 8.555981 | 0.094909 | 3.348448 | 0.035919 | 0.014112 | 0.001651 | 43.7044 | 0.758243 | 0.49564 |
| coral_241_b2@3 | 8.550095 | 0.089578 | 3.351675 | 0.073779 | 0.014096 | 0.001026 | 44.09077 | 0.73062 | 0.528383 |
| coral_241_b2@4 | 8.778061 | 0.135348 | 3.394525 | 0.066454 | 0.013459 | 0.001433 | 43.96601 | 0.795878 | 0.55411 |
| coral_241_b2@5 | 8.588903 | 0.143594 | 3.498059 | 0.044804 | 0.013718 | 0.001375 | 43.3016 | 0.639817 | 0.580616 |
| coral_241_b2@6 | 8.557485 | 0.079889 | 3.366752 | 0.032529 | 0.011545 | 0.000731 | 41.64082 | 0.222936 | 0.601665 |
| coral_241_b2@7 | 8.717245 | 0.133474 | 3.499214 | 0.058715 | 0.012801 | 0.00089 | 43.37671 | 0.632046 | 0.625833 |
| coral_241_b2@8 | 8.844666 | 0.175335 | 3.453834 | 0.074289 | 0.013816 | 0.001074 | 43.08092 | 1.055 | 0.65078 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance |
|---|---|---|---|---|---|---|---|---|---|
| | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | | mm |
| coral_241_b2@9 | 8.73566 | 0.083832 | 3.310845 | 0.057443 | 0.012765 | 0.001065 | 42.12795 | 0.523538 | 0.682743 |
| coral_241_b2@10 | 8.543818 | 0.122619 | 3.164297 | 0.040365 | 0.012 | 0.001167 | 41.77319 | 0.53203 | 0.70847 |
| coral_241_b2@11 | 8.406187 | 0.206498 | 2.860917 | 0.67825 | 0.018056 | 0.006603 | 37.9239 | 1.418812 | 0.733417 |
| coral_241_b2@13 | 8.316919 | 0.118853 | 5.046068 | 0.828821 | 0.023039 | 0.006797 | 43.41833 | 0.821339 | 0.787989 |
| coral_241_b3@1 | 8.608947 | 0.064631 | 3.461112 | 0.074271 | 0.013156 | 0.000699 | 41.73156 | 0.377758 | 0.815274 |
| coral_241_b3@2 | 8.464816 | 0.07644 | 3.290251 | 0.067126 | 0.011586 | 0.000858 | 40.44933 | 0.45127 | 0.839442 |
| coral_241_b4@1 | 8.338755 | 0.122145 | 3.674618 | 0.028425 | 0.012609 | 0.000533 | 39.48619 | 0.182884 | 0.863609 |
| coral_241_b4@2 | 8.2071 | 0.144724 | 3.282566 | 0.039766 | 0.012098 | 0.001388 | 38.36574 | 0.311173 | 0.889336 |
| coral_241_b4@3 | 8.401841 | 0.030245 | 3.526521 | 0.078155 | 0.012266 | 0.001298 | 39.63677 | 0.216734 | 0.915842 |
| coral_241_b4@4 | 8.369464 | 0.132359 | 3.544077 | 0.078609 | 0.013654 | 0.001766 | 40.06851 | 0.364448 | 0.961838 |
| coral_241_b4@5 | 8.231226 | 0.069234 | 3.600898 | 0.074686 | 0.013258 | 0.001856 | 42.02724 | 0.319314 | 0.9977 |
| coral_241_b4@6 | 8.344972 | 0.132032 | 3.159674 | 0.062798 | 0.012685 | 0.00091 | 40.04126 | 0.249734 | 1.024206 |
| coral_241_b4@7 | 8.405227 | 0.141839 | 3.633411 | 0.04881 | 0.013307 | 0.001878 | 42.49497 | 0.285717 | 1.05461 |
| coral_241_b4@8 | 8.406746 | 0.086878 | 3.675699 | 0.06529 | 0.013188 | 0.000976 | 43.61423 | 0.332956 | 1.075658 |
| coral_241_b4@9 | 8.310234 | 0.111886 | 3.591781 | 0.046777 | 0.011825 | 0.001676 | 41.70733 | 0.439661 | 1.107618 |
| coral_241_b4@10 | 8.400966 | 0.113218 | 3.464005 | 0.064618 | 0.011871 | 0.001755 | 41.25062 | 0.280581 | 1.127108 |
| coral_241_b4@11 | 8.417656 | 0.07685 | 2.977126 | 0.090931 | 0.011856 | 0.000752 | 39.49927 | 0.511402 | 1.152058 |
| coral_241_b4@12 | 8.484934 | 0.036698 | 3.046244 | 0.056803 | 0.011535 | 0.001285 | 39.99645 | 0.381877 | 1.180908 |
| coral_241_b4@13 | 8.748041 | 0.148674 | 3.320605 | 0.025504 | 0.013623 | 0.001087 | 41.95755 | 0.221854 | 1.207408 |
| coral_241_b4@14 | 8.512512 | 0.105303 | 2.918462 | 0.062335 | 0.01253 | 0.00111 | 40.47477 | 0.35079 | 1.264318 |
| coral_241_b4@15 | 8.75826 | 0.069448 | 2.930089 | 0.062847 | 0.013035 | 0.000873 | 40.37621 | 0.310159 | 1.292388 |
| coral_241_b4@16 | 8.391719 | 0.078576 | 3.049038 | 0.034854 | 0.013266 | 0.000884 | 42.32192 | 0.239415 | 1.317338 |
| coral_241_b4@17 | 8.374865 | 0.099452 | 3.089354 | 0.048002 | 0.013245 | 0.000806 | 43.14408 | 0.292148 | 1.350858 |
| coral_241_b4@18 | 8.387215 | 0.071475 | 3.452851 | 0.057441 | 0.012893 | 0.001001 | 43.25688 | 0.269598 | 1.372688 |
| coral_241_b4@19 | 8.484202 | 0.058194 | 3.260856 | 0.034031 | 0.012168 | 0.000583 | 43.56289 | 0.313496 | 1.403868 |
| coral_241_b4@20 | 8.446738 | 0.053618 | 3.266084 | 0.098486 | 0.012268 | 0.000552 | 43.13492 | 0.349712 | 1.428038 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance |
|---|---|---|---|---|---|---|---|---|---|
| | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | | mm |
| coral_241_b5@1 | 8.197871 | 0.27622 | 2.689503 | 0.333085 | 0.013578 | 0.003007 | 38.47402 | 2.434217 | 1.457658 |
| coral_241_b5@2 | 8.259662 | 0.121065 | 3.440526 | 0.101012 | 0.01258 | 0.00075 | 42.69335 | 0.302639 | 1.490408 |
| coral_241_b5@3 | 8.370069 | 0.09051 | 3.519205 | 0.075465 | 0.013442 | 0.001427 | 44.16443 | 0.264788 | 1.515348 |
| coral_241_b5@4 | 8.425179 | 0.05101 | 3.223173 | 0.036576 | 0.012952 | 0.000757 | 43.25898 | 0.27057 | 1.535618 |
| coral_241_b5@5 | 8.417712 | 0.055273 | 3.027476 | 0.054328 | 0.013198 | 0.001426 | 42.31545 | 0.385136 | 1.551988 |
| coral_241_b5@6 | 8.347751 | 0.062059 | 2.940584 | 0.064298 | 0.012422 | 0.001175 | 41.64558 | 0.217195 | 1.581618 |
| coral_241_b5@7 | 8.388512 | 0.059845 | 3.29064 | 0.047533 | 0.013374 | 0.001717 | 44.52536 | 0.207169 | 1.607348 |
| coral_241_b5@8 | 8.363898 | 0.070626 | 3.158985 | 0.050195 | 0.013274 | 0.001218 | 43.93334 | 0.276627 | 1.636188 |
| coral_241_b5@9 | 8.531214 | 0.065597 | 2.830598 | 0.075352 | 0.012992 | 0.000675 | 41.92172 | 0.510766 | 1.665038 |
| coral_241_b5@10 | 8.689156 | 0.152607 | 2.829993 | 0.115385 | 0.013592 | 0.000856 | 41.13801 | 0.501439 | 1.688418 |
| coral_241_b5@11 | 8.011638 | 0.139618 | 2.94176 | 0.151824 | 0.013292 | 0.001454 | 41.69053 | 0.448583 | 1.714148 |
| coral_241_b5@12 | 8.336164 | 0.09242 | 3.52671 | 0.076922 | 0.013109 | 0.001544 | 45.63416 | 0.22845 | 1.744548 |
| coral_241_b5@13 | 8.317839 | 0.129595 | 3.08761 | 0.068537 | 0.012954 | 0.000961 | 40.13647 | 0.598007 | 1.773398 |
| coral_241_b5@14 | 8.458757 | 0.081077 | 3.579973 | 0.082992 | 0.012069 | 0.00227 | 45.20887 | 0.189286 | 1.802238 |
| coral_241_b5@15 | 8.642789 | 0.108449 | 3.406754 | 0.095065 | 0.013571 | 0.000905 | 42.69016 | 0.362009 | 1.852138 |
| coral_241_b5@16 | 8.571775 | 0.117412 | 3.469919 | 0.156305 | 0.013935 | 0.001222 | 44.02457 | 0.530526 | 1.880978 |
| coral_241_b5@17 | 8.501399 | 0.057538 | 3.325908 | 0.042479 | 0.013041 | 0.000661 | 44.14465 | 0.479005 | 1.906708 |
| coral_241_b5@18 | 8.345766 | 0.090216 | 3.345699 | 0.054954 | 0.013345 | 0.001101 | 45.41439 | 0.292394 | 1.941008 |
| coral_241_b5@19 | 8.566047 | 0.056436 | 3.468158 | 0.080009 | 0.015124 | 0.001782 | 45.56258 | 0.45669 | 1.967518 |
| coral_241_b5@20 | 8.476285 | 0.073413 | 3.437297 | 0.055305 | 0.014338 | 0.001446 | 45.94872 | 0.233883 | 1.992468 |
| coral_241_b5@21 | 8.462766 | 0.076763 | 3.351915 | 0.040157 | 0.014308 | 0.000646 | 45.48142 | 0.363963 | 2.024428 |
| coral_241_b5@22 | 8.652146 | 0.171488 | 3.165667 | 0.063391 | 0.013955 | 0.001777 | 45.02057 | 0.400716 | 2.047818 |
| coral_241_b5@23 | 8.526001 | 0.040298 | 3.42712 | 0.096661 | 0.014492 | 0.0013 | 45.3188 | 0.583998 | 2.078998 |
| coral_241_b6@1 | 8.111605 | 0.167378 | 3.505381 | 0.092417 | 0.014082 | 0.001013 | 40.07997 | 0.603144 | 2.105508 |
| coral_241_b6@2 | 8.187176 | 0.287071 | 3.499989 | 0.121049 | 0.013952 | 0.001165 | 40.73965 | 0.309814 | 2.148378 |
| coral_241_b6@3 | 8.008073 | 0.222489 | 3.500347 | 0.173678 | 0.012354 | 0.000756 | 40.45024 | 0.498538 | 2.184248 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance |
|---|---|---|---|---|---|---|---|---|---|
| | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | | mm |
| coral_241_b6@4 | 8.049435 | 0.237603 | 3.300223 | 0.091877 | 0.011566 | 0.000985 | 40.58206 | 0.191896 | 2.214648 |
| coral_241_b6@5 | 8.064419 | 0.189493 | 3.572288 | 0.114693 | 0.013739 | 0.000709 | 41.96797 | 0.41669 | 2.242718 |
| coral_241_b6@6 | 7.558017 | 0.256988 | 5.615741 | 4.077962 | 0.017871 | 0.005753 | 38.96015 | 2.718984 | 2.267658 |
| coral_241_b6@7 | 8.183821 | 0.168547 | 3.374972 | 0.074228 | 0.014001 | 0.001572 | 42.19216 | 0.276185 | 2.296508 |
| coral_241_b6@8 | 8.153159 | 0.113301 | 2.733038 | 0.317591 | 0.044537 | 0.00254 | 36.38671 | 0.307799 | 2.323008 |
| coral_241_b6@9 | 7.886853 | 0.141193 | 2.33074 | 0.166906 | 0.014942 | 0.000866 | 35.28666 | 0.295613 | 2.353418 |
| coral_241_b6@10 | 8.554744 | 0.164372 | 2.960358 | 0.101763 | 0.016471 | 0.002374 | 37.74819 | 0.319626 | 2.384598 |
| coral_241_b6@11 | 8.466035 | 0.187583 | 3.781002 | 0.289015 | 0.016347 | 0.001856 | 37.77979 | 0.46441 | 2.411888 |
| coral_241_b6@12 | 8.309394 | 0.161378 | 4.569647 | 0.825757 | 0.024714 | 0.002872 | 39.79588 | 0.626767 | 2.439948 |
| coral_241_b6@13 | 8.44473 | 0.219692 | 3.256599 | 0.228452 | 0.015391 | 0.001225 | 40.19403 | 0.509269 | 2.468798 |
| coral_241_b6@14 | 8.555012 | 0.212201 | 3.337349 | 0.162636 | 0.015787 | 0.001429 | 42.45162 | 0.358575 | 2.496858 |
| coral_241_b6@15 | 8.565273 | 0.191637 | 3.336105 | 0.06249 | 0.014696 | 0.001301 | 43.003 | 0.359259 | 2.522588 |
| coral_241_b6@16 | 8.608075 | 0.172582 | 3.506133 | 0.065334 | 0.015333 | 0.001086 | 43.12791 | 0.521838 | 2.549878 |
| coral_241_b6@17 | 8.674833 | 0.14434 | 3.560384 | 0.111314 | 0.014869 | 0.00057 | 43.4975 | 0.227474 | 2.576378 |
| coral_241_b6@18 | 8.703462 | 0.196464 | 3.460961 | 0.066546 | 0.014252 | 0.00144 | 43.06006 | 0.468297 | 2.602108 |
| coral_241_b6@19 | 8.71954 | 0.214257 | 3.272898 | 0.391754 | 0.019255 | 0.003188 | 40.47392 | 0.751971 | 2.630168 |
| coral_241_b6@20 | 8.730167 | 0.096932 | 3.284198 | 0.123799 | 0.016313 | 0.001802 | 41.71728 | 0.31257 | 2.658238 |
| coral_241_b7@1 | 8.827025 | 0.090733 | 3.346549 | 0.061809 | 0.014194 | 0.000997 | 42.33463 | 0.494504 | 2.679288 |
| coral_241_b7@2 | 8.725574 | 0.300853 | 3.310492 | 0.122954 | 0.015168 | 0.001651 | 41.54673 | 0.463826 | 2.705798 |
| coral_241_b7@3 | 8.736581 | 0.178981 | 3.154658 | 0.068321 | 0.014637 | 0.001205 | 40.69896 | 0.521071 | 2.743998 |
| coral_241_b7@4 | 8.396589 | 0.143904 | 2.025784 | 0.11244 | 0.014708 | 0.002378 | 32.74219 | 0.136493 | 2.772058 |
| coral_241_b7@5 | 8.677153 | 0.190792 | 2.986191 | 0.069372 | 0.013141 | 0.001386 | 39.72904 | 0.293618 | 2.803238 |
| coral_241_b7@6 | 8.598944 | 0.110591 | 3.339751 | 0.041941 | 0.012223 | 0.000864 | 42.16005 | 0.215571 | 2.832088 |
| coral_241_b7@7 | 8.699021 | 0.158594 | 3.157824 | 0.059408 | 0.012353 | 0.001331 | 40.89488 | 0.343008 | 2.857818 |
| coral_241_b7@8 | 8.688235 | 0.16487 | 3.083199 | 0.091774 | 0.013249 | 0.001707 | 40.26443 | 0.294196 | 2.882758 |
| coral_241_b7@9 | 8.895775 | 0.147107 | 3.127689 | 0.034006 | 0.013474 | 0.001241 | 41.14555 | 0.289788 | 2.911608 |

| File name | 88Sr/42Ca | 2SD | 24Mg/42Ca | 2SD | 138Ba/42Ca | 2SD | 23Na/42Ca | 2SD | distance |
|---|---|---|---|---|---|---|---|---|---|
| | mmol/mol | mmol/mol | mmol/mol | mmol/mol | mm | | | | mm |
| coral_241_b7@10 | 8.702072 | 0.148318 | 3.279367 | 0.152528 | 0.013418 | 0.001183 | 41.87358 | 0.446369 | 2.938888 |
| coral_241_b8@1 | 7.611906 | 0.328649 | 3.702021 | 0.07436 | 0.011382 | 0.000868 | 37.07402 | 0.815545 | 2.963058 |
| coral_241_b8@2 | 7.802792 | 0.250885 | 3.601428 | 0.07296 | 0.011674 | 0.001837 | 37.20322 | 0.589066 | 2.991908 |
| coral_241_b8@3 | 7.896396 | 0.217232 | 3.743105 | 0.038961 | 0.013221 | 0.001607 | 38.90228 | 0.601032 | 3.020748 |
| coral_241_b8@4 | 8.119341 | 0.244885 | 4.198293 | 0.116091 | 0.039016 | 0.012518 | 40.65205 | 0.780948 | 3.050378 |
| coral_241_b8@5 | 8.075207 | 0.209515 | 3.994057 | 0.282183 | 0.046126 | 0.019384 | 40.67987 | 0.891804 | 3.072978 |
| coral_241_b8@6 | 8.026939 | 0.224114 | 3.775409 | 0.161453 | 0.015489 | 0.002781 | 40.5048 | 0.749243 | 3.094808 |
| coral_241_b8@7 | 8.223484 | 0.181355 | 3.701591 | 0.351815 | 0.017373 | 0.002633 | 39.6441 | 0.921228 | 3.137688 |
| coral_241_b8@8 | 7.771432 | 0.234059 | 3.255595 | 0.232439 | 0.016901 | 0.004412 | 35.96521 | 0.696695 | 3.156398 |
| coral_241_b8@9 | 8.105698 | 0.196325 | 3.721584 | 0.091376 | 0.013335 | 0.00209 | 40.56415 | 0.40669 | 3.182128 |
| coral_241_b8@10 | 8.240111 | 0.300327 | 3.392798 | 0.10755 | 0.0151 | 0.003923 | 38.81786 | 0.398748 | 3.201618 |
| coral_241_b8@11 | 8.122369 | 0.226417 | 3.40999 | 0.069473 | 0.014292 | 0.001704 | 39.48105 | 0.384785 | 3.229678 |
| coral_241_b8@12 | 8.288335 | 0.2348 | 3.547518 | 0.047836 | 0.01686 | 0.001196 | 40.72307 | 0.316958 | 3.247608 |
| coral_241_b8@13 | 8.279622 | 0.248657 | 3.110988 | 0.046868 | 0.012591 | 0.001535 | 38.11785 | 0.416565 | 3.281138 |
| coral_241_b8@14 | 8.3466 | 0.160993 | 3.168993 | 0.072414 | 0.013805 | 0.001022 | 39.06595 | 0.629666 | 3.318558 |
| coral_241_b8@15 | 8.279372 | 0.217114 | 3.328181 | 0.068592 | 0.013916 | 0.002259 | 40.16069 | 0.2859 | 3.328688 |
| coral_241_b8@16 | 8.341245 | 0.216459 | 3.328674 | 0.097596 | 0.013009 | 0.001368 | 40.2125 | 0.492532 | 3.342718 |
| coral_241_b8@17 | 8.181007 | 0.245625 | 3.52752 | 0.085195 | 0.014157 | 0.001596 | 42.09193 | 0.507674 | 3.374688 |
| coral_241_b8@18 | 8.277652 | 0.199224 | 3.472928 | 0.097181 | 0.01541 | 0.002118 | 41.96661 | 0.392779 | 3.415228 |
| coral_241_b8@19 | 8.325726 | 0.185616 | 3.068068 | 0.139895 | 0.014493 | 0.00172 | 39.54342 | 0.581024 | 3.474478 |
| coral_241_b8@20 | 8.318578 | 0.165017 | 3.099582 | 0.093483 | 0.014528 | 0.00178 | 41.15314 | 1.055463 | 3.497858 |

Sample 232 transect 1 *S.campylecus*:

**Average values of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca used in figure14 and Figure 17.**

| Sr/Ca mmol/mol Average per band | 1SD | Mg/Ca mmol/mol Average per band | 1SD | Ba/Ca mmol/mol Average per band | 1SD | Na/Ca mmol/mol Average per band | 1SD | Number of analyses | Band number from edge |
|---|---|---|---|---|---|---|---|---|---|
| 8.387944467 | 0.172962907 | 3.182778618 | 0.094943 | 0.011493852 | 0.003415 | 40.92347088 | 0.352841 | 2 | 4 |
| 8.39903064 | 0.047232208 | 3.026014159 | 0.053706 | 0.008733342 | 0.000178 | 41.66743545 | 0.297384 | 9 | 5 |
| 8.393934821 | 0.125934228 | 2.47514481 | 0.110765 | 0.008105817 | 0.000222 | 38.18125111 | 0.906373 | 5 | 7 |
| 8.436742457 | 0.054017384 | 2.820398598 | 0.138491 | 0.008247727 | 0.000352 | 39.42698346 | 0.837315 | 10 | 8 |
| 8.338577501 | 0.055615465 | 2.978226336 | 0.074191 | 0.008331566 | 0.000217 | 40.78861555 | 0.319678 | 5 | 9 |
| 8.372585318 | 0.116978167 | 3.106717945 | 0.093764 | 0.00900669 | 0.000151 | 41.77476781 | 0.5441 | 6 | 10 |
| 8.302244422 | 0.085325938 | 3.099708515 | 0.095235 | 0.008091145 | 0.000256 | 41.73317344 | 0.367961 | 3 | 11 |
| 8.485489858 | 0.100490188 | 2.827438872 | 0.054951 | 0.008133018 | 0.000225 | 40.3269551 | 0.291589 | 8 | 12 |

Sample 232 transect 2 *S.campylecus*:

**Average values of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca used in figure14 and Figure 17.**

| Sr/Ca mmol/mol Average per band | 1 Sd | Mg/Ca mmol/mol Average per band | 1SD | Ba/Ca mmol/mol Average per band | 1SD | Na/Ca mmol/mol Average per band | 1SD | Numer of analyses | Band number from edge |
|---|---|---|---|---|---|---|---|---|---|
| 8.139946408 | 0.064647 | 2.673897438 | 0.067274 | 0.01099416 | 0.000215 | 39.63954929 | 0.647566 | 4 | 3 |
| 8.096988693 | 0.053862 | 2.652802161 | 0.075156 | 0.010929183 | 0.000145 | 37.71444135 | 2.516151 | 4 | 4 |
| 8.344012863 | 0.031662 | 2.416181398 | 0.081348 | 0.011731011 | 0.000318 | 30.87379773 | 0.633851 | 8 | 6 |
| 8.385210617 | 0.048818 | 2.208989191 | 0.094575 | 0.013021304 | 0.000358 | 32.58674122 | 0.634216 | 6 | 7 |
| 8.494889671 | 0.021069 | 2.222769458 | 0.05526 | 0.012557783 | 0.000349 | 30.9180759 | 0.41478 | 5 | 8 |
| 8.248781091 | 0.0874 | 2.396640463 | 0.0874 | 0.013096083 | 0.00043 | 36.11775728 | 1.093406 | 7 | 9 |
| 7.91785921 | 0.19126 | 2.76747976 | 0.19126 | 0.010779139 | 0.000412 | 39.18736873 | 0.191692 | 4 | 10 |
| 8.428139493 | 0.096606 | 2.516523264 | 0.096606 | 0.012556051 | 0.000409 | 39.18662625 | 0.576929 | 6 | 12 |
| 8.230799937 | 0.028828 | 2.49714687 | 0.028828 | 0.011919741 | 0.000397 | 40.06544601 | 0.251502 | 5 | 13 |

Sample 235 *S.campylecus*: **Average values of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca used in figure 2.13**

| Sr/Ca mmol/mol Average per band | 1 Sd | Mg/Ca mmol/mol Average per band | 1SD | Ba/Ca mmol/mol Average per band | 1SD | Na/Ca mmol/mol Average per band | 1SD | Number of analyses | Band number from edge |
|---|---|---|---|---|---|---|---|---|---|
| 8.713847361 | 0.064688 | 2.418738785 | 0.070923 | 0.009362031 | 0.000658 | 45.31495738 | 0.680412 | 2 | 9 |
| 8.876482106 | 0.074115 | 2.416036009 | 0.131829 | 0.009689192 | 0.000323 | 44.35999058 | 1.191457 | 7 | 10 |
| 9.134096832 | 0.128998 | 2.402734354 | 0.054251 | 0.01062474 | 0.000958 | 44.84101923 | 0.439374 | 2 | 11 |
| 8.75505847 | 0.123724 | 2.579977209 | 0.100577 | 0.010543016 | 0.000332 | 45.46356103 | 0.577654 | 7 | 12 |
| 8.641033899 | 0.081257 | 2.542182351 | 0.042895 | 0.010263445 | 0.000164 | 46.60754805 | 0.367022 | 3 | 13 |

Sample 241 *S.campylecus*: **Average values of Na/Ca, Mg/Ca, Sr/Ca and Ba/Ca used in figure14 and Figure 17.**

| Sr/Ca mmol/mol Average per band | 1 Sd | Mg/Ca mmol/mol Average per band | 1SD | Ba/Ca mmol/mol Average per band | 1SD | Na/Ca mmol/mol Average per band | 1SD | Number of analyses | Band number from edge |
|---|---|---|---|---|---|---|---|---|---|
| 7.826058426 | 0.131661 | 3.805656317 | 0.065191 | 0.012012435 | 0.000198 | 40.24451171 | 0.238307 | 3 | 1 |
| 8.311091619 | 0.104875 | 3.365756677 | 0.132145 | 0.015966346 | 0.000707 | 41.56110514 | 0.41851 | 4 | 2 |
| 8.646503145 | 0.051594 | 3.318555359 | 0.076127 | 0.013520094 | 0.000707 | 42.14888705 | 0.671581 | 8 | 3 |
| 8.350545794 | 0.031818 | 3.492916269 | 0.085497 | 0.013034201 | 0.000247 | 40.85375017 | 0.584314 | 5 | 5 |
| 8.451126125 | 0.046126 | 3.146518615 | 0.069621 | 0.012649829 | 0.000198 | 41.54945528 | 0.4772 | 12 | 7 |
| 8.448433378 | 0.055322 | 3.095000775 | 0.113475 | 0.013182726 | 0.000173 | 42.88807364 | 0.603952 | 6 | 8 |