**Ecological, oceanographic and temperature controls on
the incorporation of trace elements into *Globigerina
bulloides* and *Globoconella inflata* in the Southwest
Pacific Ocean**

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A thesis submitted in partial fulfilment of the requirements for the degree of Masters of
Science with Honours in Geology, Victoria University of Wellington, August, 2009.

Contents	Page
List of Figures and Tables	iii
Acknowledgements	vii
Abstract	1
1.0 Planktonic foraminifera as paleoceanographic proxies	3
1.1 General Introduction	3
1.2 Trace elements in foraminifera	4
1.2.1 Magnesium (Mg)	6
1.2.2 Manganese (Mn) and Aluminium (Al)	10
1.2.3 Zinc (Zn)	11
1.2.4 Strontium (Sr)	11
1.2.5 Barium (Ba)	12
1.3 Processes controlling elemental concentrations in foraminifera	12
1.3.1 Foraminifera species selected for this study	14
1.3.2 Mechanisms of trace element incorporation into foraminiferal calcite	17
1.3.3 Calcification and test growth	17
1.3.4 Depth range/geographic distribution	19
1.3.5 Vital effects	23
1.3.6 Secondary/diagenetic calcite	24
1.3.7 Gametogenic calcite	24
1.3.8 Nutrients	25
1.3.9 Salinity	25
1.3.10 Carbonate ion effect	26
1.3.11 Calcification rate	28
1.4 Thesis Objectives	29
2.0 Regional Setting	30
2.1 Oceanography	30
2.1.1 General surface water masses off eastern New Zealand	30
2.1.2 General ocean circulation off eastern New Zealand	32
2.2 Seasonality of foraminifera off eastern New Zealand	35
3.0 Sample Data Set	38
4.0 Ecological, oceanographic and temperature controls on the incorporation of trace elements into <i>Globigerina bulloides</i> and <i>Globoconella inflata</i> in the Southwest Pacific Ocean	40
Abstract	41
1.0 Introduction	45
2.0 Background	45
2.1 Oceanography	45
2.2 Foraminifera ecology	48

	Page
3.0 Materials and Methods	49
4.0 Results	53
4.1 <i>Foraminiferal trace element chemistry</i>	53
4.1.1 Sample mean trace element variations	53
4.1.2 Chamber-to-chamber trace element variability	59
4.2 <i>Test weight and size</i>	61
5.0 Discussion	62
5.1 <i>Globigerina bulloides: Mg/Ca-T relationships</i>	63
5.2 <i>Globoconella inflata: Mg/Ca-T relationships</i>	66
5.3 <i>Comparison of solution and laser ablation trace element analysis methods for foraminiferal paleothermometry</i>	67
5.4 <i>Variability of Zn/Ca, Mn/Ca and Ba/Ca in Southwest Pacific water masses</i>	69
5.5 <i>Test normalised weight-temperature calibration</i>	71
6.0 Conclusions	72
Acknowledgements	72
References	73
 5.0 Synthesis and Conclusions	 86
5.1 Synthesis	86
5.1.1 <i>Comparison of solution- and laser-ablation based analytical techniques for determining foraminifera geochemistry</i>	86
5.1.2 <i>The comparability of solution and LA-ICP-MS technique based Mg/Ca-temperature calibrations</i>	88
5.1.3 <i>Selection of habitat depth for G. bulloides in Mg/Ca-temperature calibrations</i>	95
5.1.4 <i>Comparison of Zn/Ca, Mn/Ca, Al/Ca and Ba/Ca results with previous data for planktonic foraminifera</i>	96
5.1.5 <i>Ecological interpretation of G. inflata weight data</i>	98
5.2 Conclusions	102
5.3 Suggestions for future studies	105
 6.0 References	 107
 Appendix 1.0 - Analytical Methods	 A1
A1.1 Sample preparation	A1
A1.2 Trace element analytical methods	A4
A1.2.1 <i>Solution technique</i>	A4
A1.2.2 <i>LA-ICP-MS technique</i>	A5
A1.3 LA-ICP-MS data reduction	A9
 Appendix 2.0 – Summary of chamber mean trace element/Ca for all sites	 A13

	Page
Appendix 3.0 – Summary of chemical, weight and size data for foraminifera	
A3.1 <i>G. bulloides</i>	A14
P71	A15
P81	A38
S793	A47
P69	A67
S938	A82
R623	A96
Q220	A118
D178	A130
F111	A150
B32	A180
A3.2 <i>G. inflata</i>	A205
P71	A206
S793	A229
P69	A253
S938	A269
R623	A287
Q220	A305
F111	A313
D178	A331
B32	A357

	List of Figures and Tables	Page
Figures		
Figure 1.	Electron microprobe image of <i>Globigerina bulloides</i> and <i>Globoconella inflata</i> .	15
Figure 2.	A schematic diagram illustrating the calcite lamination scheme for <i>G. inflata</i> .	18
Figure 3.	Saturation depth for calcite estimated from water column chemistry.	27
Figure 4.	Generalized modern surface ocean currents and bathymetric features surrounding New Zealand.	31
Figure 5.	Hydrographic profiles from eastern New Zealand water masses including Subtropical Water, Subtropical Water, and Subantarctic Water.	32
Figure 6.	Transport stream function for the Wairarapa Eddy with relevant core-top sites.	34
Figure 7.	Foraminifera species-specific shell fluxes from Chatham Rise and Campbell Plateau regions.	36
Figure 8.	Scanning electron microprobe images of the <i>Globigerina bulloides</i> and <i>Globoconella inflata</i> .	43
Figure 9.	Generalised modern surface ocean currents and bathymetric features surrounding New Zealand.	44
Figure 10.	Typical and atypical time-resolved depth profiles from a 180 s laser ablation analysis of the final chamber (<i>f</i>) of two <i>G. bulloides</i> individuals.	52
Figure 11.	Schematic illustration explaining the terminology used for different trace element datasets for foraminifera.	53
Figure 12.	Comparison of sample mean trace element/Ca ratios for <i>G. bulloides</i> and <i>G. inflata</i> from all core-top sites.	55
Figure 13.	Sample mean Mg/Ca versus temperature for <i>G. bulloides</i> and <i>G. inflata</i> compared to previously published results.	58
Figure 14.	Plots of observed water column temperature versus measured chamber and sample mean Mg/Ca ratios in <i>G. bulloides</i> and <i>G. inflata</i> .	58

Figure		Page
Figure 15.	Sample mean Sr/Ca versus temperature for <i>G. inflata</i> and <i>G. bulloides</i> .	59
Figure 16.	<i>G. bulloides</i> individual from site S793 analysed 15 times.	60
Figure 17.	Sample mean foraminifera weights and normalised weights plotted against observed temperatures and mean Mg/Ca for <i>G. bulloides</i> and <i>G. inflata</i> .	62
Figure 18.	Time-resolved trace element/Ca ratio plots of selected LA-ICP-MS analyses illustrating highly ‘contaminated’ ablation profiles.	68
Figure 19.	Comparison of the relationships between different environmental and foraminiferal (weight normalised to size) parameters.	72
Figure 20.	Comparison of foraminifera Mg/Ca thermometry calibrations for the planktonic foraminiferal species <i>Globigerina bulloides</i> and <i>Globigerinoides ruber</i> as determined by LA-ICP-MS and solution methods.	91
Figure 21.	Comparison of the <i>G. bulloides</i> Mg/Ca-temperature calibrations of Cléroux et al. (2008) and McConnell and Thunell (2005) with those from this study.	94
Figure 22.	Comparison of the relationships between <i>G. inflata</i> weight and normalized weight with different environmental parameters.	100
Figure 23.	SEM images of representative <i>G. inflata</i> from sites P69 (STW) and B32 (SAW) showing how the morphological characteristics and textures of the chambers differ between these water masses.	100
Figure 24.	New Zealand chlorophyll- <i>a</i> levels from March 1998 (spring), and October 1998 (autumn).	101

Figure		Page
<i>Appendices</i>		
Figure A1.	Plain-light photograph of a polished silicate glass standard NIST 610 with several, mounted core-top samples of foraminifera.	A2
Figure A2.	Schematic illustration of laser ablation sample chamber.	A2
Figure A3.	Comparison between trace element/Ca values for the synthetic carbonate standard measured by LA-ICP-MS and ICP-OES.	A8
Figure A4.	Schematic flow diagram showing the process used to generate and process trace element (TE)/Ca data for foraminifera.	A10
Figure A5.	Example of a foraminiferal trace element profile through the test wall of <i>G. inflata</i> generated from a single LA-ICP-MS analysis.	A11
Figure A6.	Example of a bivariate plot of all Al/Ca and Sr/Ca analysis from <i>G. bulloides</i> station P71.	A11
Table		
Table 1.	Summary of ocean residence times for elements analysed in this study.	7
Table 2.	Estimated magnitude of secondary effects which impact upon Mg/Ca values in <i>G. bulloides</i> calcite.	14
Table 3.	Ecological preferences and characteristics for <i>G. bulloides</i> and <i>G. inflata</i> .	15
Table 4.	Mg/Ca-temperature calibrations from published literature for <i>G. bulloides</i> and <i>G. inflata</i> .	16
Table 5.	Calcification depth ranges for planktonic foraminifera species selected for this study.	22
Table 6.	Core-top locations, radiocarbon ages, sedimentation rates and associated surface ocean temperatures for the sites examined in this study.	39

Table		Page
Table 7.	Details of core-top locations, radiocarbon ages, sedimentation rates and relevant surface ocean temperatures for the sites examined in this study.	46
Table 8.	Summary of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) instrumental and analytical conditions.	51
Table 9.	Summary of the size, weight and trace element chemistry for <i>G. bulloides</i> and <i>G. inflata</i> from 10 core-top sites in the Southwest Pacific Ocean, east of New Zealand.	56
Table 10.	Published Mg/Ca-temperature calibrations for <i>G. bulloides</i> and <i>G. ruber</i> .	93
Table 11.	Depth ranges for <i>G. bulloides</i> determined by $\delta^{18}\text{O}$ - core-top or sediment trap measurements and stratified plankton tow abundances.	95
Table 12.	Ranges in trace element/Ca values for planktonic foraminifera for the elements Al, Mn, Zn and Ba in foraminiferal calcite.	97
<i>Appendices</i>		
Table A1.	Weight measurements for a <i>G. bulloides</i> individual repeatedly weighed.	A3
Table A2.	Summary of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) instrumental and analytical conditions.	A3
Table A3.	Repeated ablation of chambers from an individual <i>G. bulloides</i> from site S793.	A7
Table A4.	Measured trace element/Ca values for the trial carbonate standard using LA-ICP-MS and ICP-OES.	A8
Appendix 2.0	Summary of the chamber mean trace element/Ca values by site.	A13

Acknowledgements

Firstly, thank you for the time, patients and effort invested in this thesis from my supervisors; Joel Baker, Lionel Carter and Gavin Dunbar. Through the many developments of this research project your support and encouragement has been invaluable.

Without the constant support and belief in my research endeavours by Aidan this project would have stalled before it even began. Thank you a hundred times over. The patience of Mica and Eddie has also been vital; To my children who learnt what ‘laser ablation’, ‘foraminifera picking’ and ‘research thesis’ meant far too soon, I can now start to work off the debt of stories, park visits and board games that you deserve.

Thank you also to the New Zealand Federation of Graduate Women, Izard and Edith Wheal scholarships for financial support during this research.

I would like to thank Lisa Northcote, Helen Neill and Helen Bostock from the National Institute of Water and Atmosphere for advice on foraminifera in New Zealand waters, providing the core-top samples and plankton tow data, and maintaining an open door policy for e-mail enquires and office visits. Thank you to Christine Prior from GNS Science, Rafter Radiocarbon Laboratory, for core-top carbon dates. Martin Crundwell from GNS Science provided the basic training for a foraminifera novice, offering knowledge and advice. John Patterson and Kylie Christiansen provided technical assistance for which I am forever grateful. Working with Annette Bolton on developing ideas and concepts for foraminiferal geochemistry has lead to endless conversations discussing the finer details of foraminifera morphology, ecology, phenotypes and geochemistry. Annette provided a kindred soul during the hours of pondering foraminifera, reassuringly logical and inventive, offering a range of possible new directions and challenges.

Thank you to the many people I have shared an office with during this time, Katie Peters, Netty, John Creech, Julia Bull, Jess Orsman, Kylie– you were all saints, even if you were not researching foraminifera you inevitably endured the trials and tribulations of conducting ‘bug’ research in some way. I very much appreciated the pizza dinners, yoga missions, cups of tea/coffee, occasional cake, child entertainment, an ear to listen and helpful advice at the most appropriate times. Thank you also to the many other friends who have become involved with this research in some way, your support at the many stages of this project, regardless of how brief, was gratefully accepted and appreciated.

Thank you to my wider family also: Eddie, Sue and Bridget, Carol, Rodney and Hamish for childcare, dinners, friendly phone calls and most importantly, nodding knowingly when the intricate details of geochemical techniques for analysing foraminifera were being enthusiastically explained.

Abstract

Trace element ratios (Mg/Ca, Al/Ca, Mn/Ca, Zn/Ca, Sr/Ca, Ba/Ca) measured by laser ablation inductively coupled plasma mass spectrometry plus and test weight and size data are presented for two planktonic foraminiferal species, *Globigerina bulloides* and *Globoconella inflata*. These data will be used to investigate the potential of Mg/Ca ocean thermometry and other trace element proxies of past ocean chemistry using these species. Foraminifera were sampled from core-top sediments from 10 sites in the Southwest Pacific Ocean, east of New Zealand, spanning latitudes of ~33° to 54° S and temperatures of 6-19 °C at 75-300 m water depth.

Mg/Ca in *G. bulloides* correlates strongly with observed water temperatures at 200 m depth and yields a new calibration of $\text{Mg/Ca} = 0.941 \exp^{0.0693 \cdot T}$ ($r^2 = 0.95$). When *G. bulloides* Mg/Ca data from this study are combined with previously published data for this species, a calibration of $\text{Mg/Ca} = 0.998 \exp^{0.066 \cdot T}$ ($r^2 = 0.97$) is defined. Significant variability of Mg/Ca values (20-30%) was found for the four largest chambers of *G. bulloides* with the final chamber consistently recording the lowest Mg/Ca values. This is interpreted to reflect changes in the depth habitat towards the end of the life cycle of *G. bulloides*. Levels of Al and the micronutrients Mn and Zn in *G. bulloides* were found to differ significantly between Subtropical and Subantarctic Water masses, suggesting these elements can potentially be used as water mass tracers.

No clear relationship between Mg/Ca and temperature was observed for *G.*

inflata. This is interpreted, in part, to reflect the ecological niche that *G. inflata* occupies at the base of the thermocline, coupled with the impact of heavy secondary calcite which lowers Mg/Ca values.

A correlation between size normalized test weight, water temperature and seawater carbonate ion concentration is observed for *G. bulloides* suggesting a modern calibration that could be potentially applied for paleoceanographic reconstructions of ocean water temperature and carbonate ion concentrations. No correlation between temperature or carbonate ion was found with size normalized *G. inflata* test weights. However, a bimodal population of *G. inflata* test weights indicates a possible link between high levels of chlorophyll-*a* in surface waters and light *G. inflata* tests.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) and solution-based techniques for measuring Mg/Ca in *G. bulloides* yield compatible results. However, this is possible only when minimal dissolution of test calcite has occurred during the reductive and dilute acid leaching stages of cleaning prior to solution analysis, or, if only the older three visible chambers are used for LA-ICP-MS analysis. LA-ICP-MS analysis is an effective method for measuring trace element/Ca values in foraminifera, especially for small sample sizes, and enables the test to be used for further geochemical analysis (e.g. boron or carbon/oxygen stable isotope analysis).

Chapter 1.0 Planktonic foraminifera as paleoceanographic proxies

1.1 General Introduction

Understanding the causes of past (and potential future) changes in Earth's oceans and climate requires detailed knowledge of the timing and magnitude of ocean/climate variations (Trenberth et al., 1994; Petit et al., 1999; Lear et al., 2000). The development of chemical and isotopic proxies for changing oceanographic conditions (e.g. temperature), commonly measured on carbonate microfossils such as foraminifera, have contributed significantly towards this goal (e.g. Mashiotta et al., 1999; Rosenthal et al., 1999; Anand et al., 2003; Anand and Elderfield, 2005; Sadekov et al., 2008). Mg/Ca of foraminifera calcite provides a means of quantifying past sea surface temperatures. However, the accuracy of such temperature reconstructions using Mg/Ca paleothermometry is dependent upon the accurate calibration of the Mg/Ca-temperature relationship for specific foraminifera species from specific oceanic regions.

A key objective of this thesis is to investigate the Mg/Ca-temperature relationship of two species of planktonic foraminifera *Globigerina bulloides* and *Globoconella inflata* to generate an effective Mg/Ca-temperature calibration for the Southwest Pacific Ocean. Mg/Ca and trace element ratios (Al/Ca, Mn/Ca, Zn/Ca, Sr/Ca, Ba/Ca) for samples from 10 cores, will be determined using novel laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) techniques. These data will be used to (a) provide a Mg/Ca temperature calibration for the New Zealand region and (b) identify water masses and ecological condition as recorded in the foraminifera tests.

1.2 Trace elements in foraminifera

Prior to the development of geochemical paleoclimate proxies, researchers relied on information derived from microfossil assemblages, weathered clay mineral assemblages and sea level changes recorded by coral terraces to reconstruct paleoceanographic conditions. In isolation, these records are of limited use as they are often incomplete and ambiguous (Lear et al., 2000).

One key source of ocean paleotemperature data is oxygen isotope ($\delta^{18}\text{O}$) records of foraminiferal calcite (e.g. Erez and Honjo, 1981; Deuser and Ross, 1989; Bemis et al., 1998; Mortyn and Charles, 2003). This is based on the thermodynamic isotopic fractionation of ^{16}O and ^{18}O during precipitation (Urey, 1947). The thermodynamic relationship between ocean temperature and oxygen isotope composition was first described by Epstein et al. (1953) and regular cyclic variations in the oxygen isotopic composition of planktonic foraminifera were documented by Emiliani (1955). Today it is the most commonly used proxy to reconstruct the paleo marine environment (King and Howard, 2003; Moses et al., 2006; McConnell et al., 2009). However, oxygen isotopes in foraminifera record the effects of temperature, salinity and ice volume (Lea et al., 1999; Billups and Schrag, 2002). Trace elements incorporated into foraminiferal test calcite offer an alternative source of ocean paleoenvironmental information if the elements are proved to be incorporated into test calcite in equilibrium with the surrounding seawater (Lea, 2003). The Mg/Ca ratio derived from foraminifera test calcite is currently the most promising ocean paleotemperature proxy (e.g. Elderfield and Ganssen, 2000; Anand et al., 2003; Clroux et al., 2008), with composite temperature records created from

foraminiferal Mg/Ca calcite ratios extending back to the early Cenozoic (e.g. Lear et al., 2000; Hollis et al., 2009).

The trace element composition of marine calcium carbonate is primarily used to infer the chemical and physical conditions of the ocean at the time of calcification. Mg/Ca paleothermometry exploits an exponential relationship between the concentration of Mg in foraminiferal test calcite as a function of the ocean temperature at the time of calcification (e.g. Bender et al., 1975; Lea et al., 1999; Anand et al., 2003; McConnell and Thunell, 2005). Mg/Ca offers an independent paleothermometer, which is complimentary to paleothermometry methods based on organic geochemistry such as TEX-86 (e.g. Schouten et al., 2007; Kim et al., 2008) and alkenones (e.g. Prahl et al., 1988; Müller et al., 1998; Bard, 2001). Traditionally Mg/Ca thermometry is undertaken using solution analytical techniques, involving the homogenization of a number of foraminifera (generally > 6 individuals) followed by a rigorous cleaning protocol (e.g. Mashiotta et al., 1999; Elderfield and Ganssen 2000; Rosenthal and Lohmann, 2002; Barker et al., 2003). Using *in situ* geochemical techniques (e.g. laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS)), elemental ratios in calcite can be measured at a high spatial resolution (~25 µm) on chambers grown at different stages throughout an individual foraminifera life cycle. Trace element/Ca ratios measured in this manner can also potentially offer insights into the foraminiferal life cycle, such as migration of planktonic species through the water column, in addition to ocean paleothermometry.

Micropaleontologists and geochemists have long held an interest in using Mg variations in foraminiferal shells for paleoceanographic studies (Clarke and

Wheeler, 1922; Savin and Douglas, 1973; Bender et al., 1975; Delaney et al., 1985). The potential application of Mg as an ocean paleotemperature proxy was first recognized by Clarke and Wheeler (1922), and subsequent research demonstrated that Mg substitution into inorganically precipitated calcite was temperature dependent (e.g. Burton and Walter, 1987; Mucci, 1987; Oomori et al., 1987). Emiliani (1955) highlighted the significance of detrital contamination (contaminants absorbed by the calcite of the foraminiferal test, which contains elevated levels of trace elements, including Mg, Ba, Al and Zn) and its potential impact on magnesium paleothermometry. The trace elements Mg, Al, Mn, Sr, Zn and Ba are utilized in this study of paleocean proxies and are further discussed individually below.

1.2.1 Magnesium (Mg)

The underlying basis of this paleothermometer is the endothermic substitution of Mg for Ca in calcite, a process favoured by high temperatures with an exponential increase in Mg/Ca of ~8 - 10% per °C in foraminiferal calcite (Lea et al., 1999). Inorganic calcite precipitation experiments generally follow this thermodynamic prediction (Mg/Ca increase 3% per °C), except that foraminifera calcite contains 5–10 times less magnesium than is predicted from inorganic thermodynamic calculations (Bender et al. 1975) and the response of organic calcite Mg to temperature is ~3 times more sensitive than the theoretical prediction (Lea et al., 1999).

These observations have two important implications for Mg/Ca paleothermometry. Firstly, the temperature sensitivity of foraminiferal calcite to Mg incorporation means that secondary environmental factors such as salinity

and carbonate ion controls on primary calcite Mg incorporation are less important than temperature. Secondly, it raises the question as to why the response might be so much greater in foraminifera than in the inorganic calcite experiments (e.g. $\text{Mg/Ca} = 1.20\text{exp}^{0.057*T}$, McConnell and Thunell, 2005), suggesting significant influences of secondary (biological) factors on Mg incorporation in foraminifera tests (Erez, 2003; Lea, 2003).

Contamination presents an important issue for the determination of primary calcite trace element/Ca values in foraminifera and needs constant monitoring (Barker et al., 2003, Rosenthal et al., 2004; Sadekov et al., 2008). In addition, the residence times of Mg and Ca in seawater are ~ 13 Ma and ~ 1 Ma respectively (Broecker and Peng, 1982), and on timescales beyond 13 Ma other proxies or modelling for oceanic Mg must be used (e.g. Lowenstein et al., 2001; Dickson, 2004; Berner, 2004) (Table 1). Absolute paleotemperature estimates using this method are thus dependent upon assumptions of how the Mg/Ca ratio of seawater has changed over time. In contrast, relative changes in ocean temperatures inferred from this method are relatively robust for geologically brief timescales (e.g. < 1 Ma) (Peeters et al., 2002; Williams et al., 2005).

Element	Ocean residency time (ca. Ma)	Reference
Mg	13×10^0	Broecker and Peng (1982)
Al	6.2×10^{-4}	Brand et al. (1983); Morel et al. (1991)
Ca	1.0×10^0	Broecker and Peng (1982)
Mn	76×10^{-5}	Savenko (2008)
Zn	5.1×10^{-4}	Brand et al. (1983); Morel et al. (1991)
Sr	5.0×10^0	Broecker and Peng (1982)
Ba	10×10^{-3}	Paytan et al. (2007)

Table 1. Summary of ocean residence times for elements analysed in this study.

The foraminifera analysed in this project are modern, from the top 1-2 cm of marine sediment cores (core-tops) and therefore the residency time of magnesium and calcium in seawater is not important in this study. However, biological responses or secondary/vital effects, which may otherwise influence the temperature dependence of Mg/Ca incorporation in modern foraminifera are the subject of this thesis.

Robust calibration equations are essential to translating Mg/Ca measurements of foraminifera into meaningful estimates of ocean temperature. The exponential dependence of Mg/Ca on temperature is defined by the relationship:

$$\text{Mg/Ca} = B \exp^{(AT)}$$

where T = temperature, and A and B are the exponential and pre-exponent constants, respectively (Anand et al., 2003).

For this equation, temperature can be either determined from $\delta^{18}\text{O}$ calcification temperatures or from direct ocean temperature measurements at specific depths relevant to the foraminifera species being studied. A number of Mg/Ca thermometry calibrations exist for different foraminiferal species, reflecting the complex nature of Mg incorporation into the calcite shells and other significant factors such as diagenesis, dissolution or species extinction (e.g. Mashiotto et al., 1999; Elderfield and Ganssen, 2000; Lea et al., 2000; Anand et al., 2003; McConnell & Thunell, 2005; Ferguson et al., 2008). Different calibrations reflect (in part) the type of analytical methodology used to derive them (e.g. solution ICP-MS of ~5–40 whole foraminifera in a single sample versus LA-ICP-MS which analyses each foraminifera individually from a sample multiple

times) and the cleaning techniques used (e.g. Barker et al., 2003; Eggins et al., 2003; Rosenthal et al., 2004; Sadekov et al., 2008).

Although it may be convenient to assume that groups of foraminifera species, or indeed all populations of a given species, will respond in the same way to environmental controls, there is evidence to suggest that this is not always the case (Murray, 1991; Anand et al., 2003; Eggins et al., 2003; Sadekov et al., 2008). It is therefore important that calibrations of foraminifera are species-specific. Broad intra-species variations (morphotypes) and population adaptations to specific local habitats (ecophenotypes) may have a different biological response to temperature change, which could play a critical role in affecting the accuracy of the Mg/Ca thermometer (Murray, 1991; Steinke et al., 2005; Sadekov et al., 2008).

In addition to correct species identification during sample preparation, the method of sampling foraminifera for Mg/Ca-temperature calibration can impact on the accuracy of the calibration equation. Calibration using samples with variable preservation (e.g. dissolution, diagenetic alteration) and potentially variable age, depending on the local sedimentation rate, can lead to significant differences in the pre-exponential constant (Anand et al., 2003). Planktonic foraminifera from core-tops also require the establishment of a direct link between sea surface temperature (SST) and Mg/Ca ratios, although this is often difficult as the exact SST at the time of the shell growth may not be known (Anand et al., 2003). There are two main methods of deriving ocean temperatures for foraminifera from core-top samples: (1) use of the oxygen isotope signature to derive an ocean temperature for the species and then

calibrate the Mg/Ca ratio to this figure (e.g. Elderfield and Ganssen, 2000; Anand et al., 2003; Clroux et al., 2008). Or (2) use knowledge of foraminifera ecology to estimate the depth range and season that the foraminifera calcite was most likely formed at (based on stratified plankton tows and regional seasonal assemblage data, and use ocean temperatures from modern measurements) (e.g. Mashiotta et al., 1999; McConnell and Thunell et al., 2005).

Data from each of the core-top sites used in this study are critically assessed for variable foraminiferal preservation and age, and the temperature of calcification is derived from established foraminiferal ecological information prior to derivation of the final calibration equation.

1.2.2 Manganese (Mn) and Aluminium (Al)

Mn and Al occur in high concentrations in terrigenous sediment. Thus, clay and secondary calcite that forms on the test while foraminifera are on the sea floor is likely to have elevated values of Mn and Al, any adhering clays can also be detected by the elevated concentrations of Al (e.g. Barker et al., 2003; Eggins et al., 2003). Mn is also an oceanic micronutrient raising the possibility that this element may act as a water mass tracer if the primary calcite signature is able to be isolated and analysed. Recently, Mn/Ca ratios in foraminiferal calcite have been identified as a potential proxy for terrigenous input, and mixed layer depth from in the Panama Basin (Klinkhammer et al., 2006). Mn and Al are routinely monitored in this study to screen for contamination of the primary test calcite by secondary calcite and/or adhering clays, in addition to assessing any changes correlated to environmental variability, such as the water mass chemistry that characterises the water column above each core-top site.

1.2.3 Zinc (Zn)

Zn is a micronutrient in the ocean and, therefore, it is important in controlling biological productivity (Coale et al., 1996; Lea, 2003). Zn/Ca ratios in foraminiferal calcite may thus be a potential water mass tracer if the foraminifera incorporate the element in equilibrium with the ocean. Zn may also record carbonate ion concentrations of deep ocean water in benthic foraminifera (Marchitto et al., 2000), but this has not yet been applied to paleo-records. Studies of Zn isotope ratios in the ocean have found that biological productivity incorporates the light isotopes therefore, Zn isotopes could potentially be used as a proxy of productivity (Maréchal et al., 2000). Zn concentration data are also important in establishing a framework for future Zn isotope studies of foraminifera. Zn will be investigated in this research to determine if there is any concentration variability from the modern surface ocean reflected in foraminiferal calcite found in different water masses.

1.2.4 Strontium (Sr)

Previous studies investigating the incorporation of Sr into planktonic foraminiferal calcite have failed to identify any systematic, unambiguous relationships with temperature, salinity or pH (e.g. Delaney et al., 1985; Martin, 1999; Elderfield and Ganssen, 2000). Benthic foraminifera Sr/Ca ratios are used to estimate global, average river Sr fluxes and have been used in conjunction with seawater strontium isotope evolution to calculate changes in global average river $^{87}\text{Sr}/^{86}\text{Sr}$ through the Cenozoic (Lear et al., 2003). However, because Sr typically occurs in very uniform levels throughout planktonic foraminiferal tests it is a useful indicator of any severe alteration or secondary calcification of the foraminifera using the LA-ICP-MS technique (Eggins et al., 2003).

1.2.5 Barium (Ba)

Ba in the ocean is primarily controlled in surface waters by the precipitation of barite and the uptake of Ba in carbonate test production, which is then partially decomposed in the sediment to enrich deep ocean water (Dymond et al., 1992; Lea, 1999). As a scavenged element with a very short ocean residency time (Table 1), Ba has the potential to be utilized either as a productivity indicator or tracer of abyssal circulation of paleoceans (Dymond et al., 1992). However, there is also a high contribution of Ba from terrigenous aluminosilicate sources, which can overwhelm biogenic inputs, compromising the use of Ba as a proxy in nearshore environments (Dymond et al., 1992). The distribution of Ba in the ocean generally has a linear relationship with alkalinity and silica and, therefore, may potentially be a proxy for alkalinity (Mortyn and Martínez-Botí, 2007). Previous experimentation examining Ba uptake in planktonic foraminifera have shown that variations in Ba are consistent with surface water variations in ocean basins (Lea and Boyle, 1991). A linear relationship exists between Ba/Ca in cultured *Orbulina universa* and seawater ratios (Lea and Spero, 1992 and 1994). Ba is also thought to be incorporated in high concentrations into non-spinose planktonic foraminifera (Lea, 1999).

1.3 Processes controlling elemental concentrations in foraminifera

The development of foraminiferal test geochemistry has enabled researchers to investigate important questions in paleoceanography that relate to the physical nature and movement of past water masses, both at the sea surface and deeper in the water column (Sen Gupta, 1999a). Because of the importance placed upon the determination of reliable paleo-ocean temperatures, most researchers have

focused primarily on factors affecting Mg concentrations in foraminiferal calcite. As a result, the primary and secondary controls that affect concentrations of other trace elements (e.g. Mn, Zn, Ba) are, by comparison, poorly constrained.

Determination of the reliability of foraminiferal geochemical proxies requires an understanding of the species-specific ecology, which is important for two reasons:

(1) The advantage of using a laser ablation system for geochemical analysis of foraminifera, is that it enables the user to target an area for analysis down to a spot 10 μm in diameter, concentrating analysis on specific areas of the test (e.g. multiple analyses on a single chamber of an individual test). Given this, understanding the conditions under which foraminiferal calcite develops is crucial. For example, Mg/Ca values represent calcification temperature, which varies with depth in the water column, and as foraminifera can migrate several hundreds of metres within the water column during their life cycle, adding chambers and calcite to previously formed chambers during this migration (e.g. Hemleben et al., 1989; Sen Gupta, 1999a; Mortyn and Charles, 2003).

(2) Mg/Ca may also be influenced by non-temperature related variables such as vital effects, gametogenesis, species ecophenotypes, dissolution and secondary calcite deposition (e.g. Elderfield and Ganssen, 2000; Lea, 2003; Sadekov et al., 2008). These factors may bias or totally obscure the relationship between temperature and Mg/Ca, if they are not understood and eliminated from the calibration calculations and their subsequent application (Table 2).

	Magnitude of affect on Mg/Ca (mmol/mol)
Foraminifera species	0.1 to 4
Depth range/geographic distribution	0.01 to 5
Vital effects	0.01 to 10
Gametogenic calcite	1 to 1000
Secondary/diagenetic calcite	1 to 10000
Nutrients	unknown
Salinity	0.01 to 1 ^a
Carbonate ion effect	-0.2 to -2.5 ^b
Calcification rate	unknown

Table 2. Estimated magnitude of effects other than temperature which impact upon Mg/Ca values in *G. bulloides* calcite based on constraints from this research unless otherwise indicated. Additional sources of information were taken from ^aKisakürek et al. (2008) ^bRussell et al. (2004).

1.3.1 Foraminifera species selected for this study

The planktonic species selected for this study are *Globigerina bulloides* (Fig. 1a) and *Globoconella inflata* (Fig. 1b), which dwell at sub-surface water depths (Table 3) and have a wide ranging biogeography (Hemleben et al., 1989). Limited, previously published, Mg/Ca thermometry calibrations exist for these species (Table 4). Using planktonic foraminifera means that the significant environmental variables affecting planktonic species are limited to temperature, salinity, nutrient levels and mixing of water masses. This enables a more direct correlation between planktonic foraminifera geochemical data and the environmental proxies being established (Table 3) (Sen Gupta, 1999a; Lea, 2003).

Figure 1. Electron microprobe image of the front of a mature (a) *Globigerina bulloides* and (b) *Globoconella inflata*. Note the large aperture centred below the final chamber (f), and the two/three visible lower chambers (f-1, f-2, f-3).

	<i>Globigerina bulloides</i>	<i>Globoconella inflata</i> (<i>Globorotalia inflata</i>)
Highest abundance temperature range in New Zealand waters (Crundwell et al., 2008; Weaver et al., 1998)	Eutrophic (7.0-19.1)	Temperate (6.8-12.9)
Spinose (Hemleben et al., 1989)	Yes	No
Symbionts (Hemleben et al., 1989)	No	No
Reproductive cycle (Hemleben et al., 1989)	Lunar-month	Monthly
Optimal phosphate level (µg at/l) (Bé and Tolderlund, 1971)	1.0 (0.6-0.9)	0.5 (1.2-1.2)
Salinity range (p.s.u.) (Hilbrecht, 1996; Bé and Tolderlund, 1971)	33.5-37.4 (34.4-35.4)	33.6- 37.3 (34.4-35.3)
Assumed depth (m) (Mortyn and Charles, 2003; Hemleben et al., 1989)	200 m Strongly associated with ocean upwelling	300 m

Table 3. Ecological preferences and characteristics for *G. bulloides* and *G. inflata*. The relevant environmental conditions for this study are given in brackets next to the published preferences. The assumed species depth ranges are discussed further in section 1.2.4.

Reference	Size fraction	Weight	Geochemistry method	Foraminifera Collection	Location	Source of calibration temperature	Temperature range (°C)	A	B	r ²
<i>G. Bulloides</i>										
Mashirota et al. (1999)		0.45 - 0.50 mg	Solution technique 8 - 12 individuals	Culture			10 - 25	0.102	0.528	0.98
	250 - 350 µm	0.45 - 0.50 mg	Solution technique 10 - 20 individuals	Core-top, culture	Subantarctic Indian Ocean, Subantarctic Pacific Ocean	Observed SST	10 - 25	0.107	0.474	
			Solution technique ~20 individuals	Core-top	North Atlantic	$\delta^{18}\text{O}$ with seasonal effects (assumed depth range 300-400 m)	8 - 22	0.081 $\pm$ 0.005	0.81 $\pm$ 0.04	
Elderfield and Ganssen (2000)			Solution technique 6 - 63 individuals	Sediment trap	Gulf of California	Observed SST	16 - 31	1.23	0.057	0.88
McCormell and Thunell (2005)	212 - 355 µm		Solution technique 20 - 30 individuals	Core-top	North Atlantic	$\delta^{18}\text{O}$ temperature measurement	10 - 18	0.082 $\pm$ 0.010	0.78 $\pm$ 0.12	0.87
Cleroux et al. (2008)	250 - 315 µm									
<i>G. inflata</i>										
Elderfield and Ganssen (2000)			Solution technique ~20 individuals	Core-top	North Atlantic	$\delta^{18}\text{O}$ (assumed depth range 300-400 m)		0.10	0.49	
Anand et al. (2003)	350 - 500 µm		Solution technique 5 - 15 individuals	Sediment trap	Sargasso Sea	$\delta^{18}\text{O}$ (assumed depth range 100-400 m)	~ 18	0.058 ($\pm$ 0.015)	0.56 ($\pm$ 0.16)	0.74
Cleroux et al. (2008)	250 - 400 µm		Solution technique ³ 12 individuals	Core-top	North Atlantic	$\delta^{18}\text{O}$ temperature measurement	10 - 18	0.056 $\pm$ 0.006	0.71 $\pm$ 0.06	0.72

Table 4. Mg/Ca-temperature calibrations for *G. bulloides* and *G. inflata* taken from the literature.

1.3.2 Mechanisms of trace element incorporation into foraminiferal calcite

There are two general mechanisms theorized for the incorporation of trace elements into foraminiferal calcite: (1) Solid solution whereby the trace element substitutes directly for Ca^{2+} in the calcite structure, and (2) ‘trapping’ whereby the ion of the trace element becomes embedded within the calcite lattice during growth of the foraminifera test (Lea, 1999 and 2003; Erez, 2003). However, the specific details for trace element incorporation are not known, and the mechanism is likely to vary depending on the foraminiferal species and nature of each trace element.

1.3.3 Calcification and test growth

Each newly added chamber is composed of two layers of calcite (bilamellar): (1) a very thin internal primary calcite layer, which outlines the new chamber and becomes the inner lamella; (2) external primary calcite which covers the inner lamella and also the entire existing shell (Fig. 2) (Hemleben et al., 1989; Erez, 2003). The bulk of the calcium carbonate test is therefore composed of external primary calcite.

Most research into trace element incorporation in foraminiferal test calcite has focused on Mg due to the thermodynamic relationship between Mg and Ca in foraminiferal calcite. Generally, there are high Mg and low Mg components of a foraminifera test (Erez, 2003; Eggins et al., 2003, 2004; Sadekov et al., 2008). For example, *Orbulina universa* has alternating thin ‘bands’ of high-Mg/Ca (typically 8–11 mmol/mol) and thicker, low-Mg/Ca (typically 1–5 mmol/mol) calcite that are $\sim 1\text{--}3\ \mu\text{m}$ in thickness through the test wall (Sadekov et al., 2005)

with similar results found in *Globigerinoides ruber* and *Globigerinoides sacculifer* and the cortex layer of *Pulleniatina obliquiloculata* (Sadekov et al., 2009).

Figure 2. A schematic diagram illustrating the calcite lamination scheme for the final three (visible) chambers of the planktonic foraminifera *G. inflata*. ‘f-2’ indicates the oldest chamber, through to ‘f’ which is the youngest and therefore has the least amount of external primary calcite.

The thick outer primary calcite lamella (relatively low in Mg, S and perhaps other trace elements) are sandwiched between layers or bands of internal primary calcite, which are enriched in trace elements (Erez, 2003) and where present external gametogenic/secondary calcite, which incorporates significantly different concentrations of trace elements (Eggins et al., 2003; Erez, 2003; Sadekov et al., 2008). For the purposes of this research, it is assumed that there is inherent variability in Mg levels through a single test wall, depending on the lamination scheme. However, this signal becomes partially homogenized during the ablation process and the purpose of this study is to measure the average

primary trace element signature through the whole test wall, after secondary and gametogenic calcite have been removed.

1.3.4 Depth range/geographic distribution

The depth habitats of individual species can seldom be defined within narrow limits because they exhibit diurnal, ontogenetic, seasonal, and long-term variation that are beyond the scope of most studies to fully document (Table 3) (Arnold and Parker, 1999). To date there have been no systematic stratified plankton tows for New Zealand latitudes to enable assessment of living foraminifera depth preferences and migration. The depth ranges presented here are a general guide, based upon depth ranges in the literature and the limited plankton tow data that are available (Table 5). The occurrence and strength of upwelling affects the preferred depth habitat of some planktonic species such as *G. bulloides* (Hemleben, 1989).

Factors such as temperature, salinity, dissolved oxygen, photic conditions, and nutrient levels have direct control over foraminiferal depth habitat (Hemleben et al., 1989). However, the relationship between life cycle and environmental gradients (e.g. the thermocline) means that mixing of stratified layers in the ocean rather than temperature, salinity and nutrients is the main influence on productivity (Hemleben et al., 1989; Arnold and Parker, 1999; King and Howard, 2001).

Superimposed on these ‘normal’ foraminiferal distribution patterns within the water column are upwelling events, which bring nutrients from deep waters up

to the surface. This is a common feature in water masses around New Zealand (Weaver et al., 1997). Upwelling affects the abundance of planktonic foraminifera at different water depths where, for example, *G. bulloides* migrates to the part of the water column with higher nutrient levels and increased productivity. In addition to upwelling events, general seasonal variability also affects overall foraminiferal abundance on a yearly cycle (see section 2.2 for further details) (Hemleben et al., 1989; King and Howard, 2001; Northcote and Neil, 2005).

In this study, the water column depth for *G. bulloides* is taken to be ~200 m for all sites except P69 and S938, which is based on surface mixed layer depths, peak fluorescence depths and plankton tow information where ~85% of *G. bulloides* were located in the upper 100–200 m of the water column near Campbell Plateau (NIWA Cruise Report TAN 9814, 1998; Sutton and Roemmich, 2001; Mortyn and Charles, 2003; Connie and Dunn, 2006; Wilke et al., 2009). *G. bulloides* numbers in a plankton tow were sparse for the Wairarapa Eddy region (P69 and S938), but most (~70%) occurred in a depth of 50–100 m (unpublished data, NIWA). This shallower assigned depth is consistent with known upwelling along this margin and nutrient entrainment and mixing associated with the Wairarapa Eddy, as well as the depth peak in fluorescence (Weaver et al., 1997; Murphy et al., 2001; unpublished data, NIWA). Therefore, for sites P69 and S938, we use observed SSTs from 75 m depth for *G. bulloides*.

An assumed water column depth of 150–400 m is used for *G. inflata* with an observed water column temperature at 300 m for all sites. The selection of these

depths is supported by stratified plankton tow abundance data for sites off the East Cape of New Zealand, which shows at least 50% more *G. inflata* at a depth range of 200 to 400 m (L. Northcote, pers. comm. 2008).

Source of foraminifera depth ranges	Mortyn and Charles (2003)	L. Northcote, pers. comm. (2008)	Wilke et al. (2009)	Erez and Honjo (1981)
Method	Stratified plankton tow (0 - 800 m)	Stratified plankton tow (0 - 400 m)	Stratified plankton tow (0 - 500 m)	Core tops, sediment trap, plankton tow
Location	Atlantic Sector of the Southern Ocean	Southwest Pacific Ocean	Canary Islands	Central North Atlantic
<i>G. bulloides</i>	0-800 m <i>greatest abundance:</i> 75 - 175 m	0-400 m <i>greatest abundance:</i> 0 - 200 m	0-500 m <i>greatest abundance:</i> 50 - 300 m	
<i>G. inflata</i>	0-800 m <i>greatest abundance:</i> 200 - 350 m	0-400 m <i>greatest abundance:</i> 200 - 400 m		245-630 m <i>greatest abundance:</i> 450 m

Source of foraminifera depth ranges	Hemleben et al. (1989)	Elderfield and Ganssen (2000)	Anand et al. (2003)	Mortyn and Charles (2003)	Wilke et al. (2009)
Method	Core top	Core top	Core top	Core top	Sediment trap (700 m)
Location		North Atlantic	Sargasso Sea	Atlantic Sector of the Southern Ocean	Canary Islands
<i>G. bulloides</i>	Above 400 m	300-400 m ($\delta^{18}\text{O}$) <i>with seasonal effects</i>		25-700 m	~130 m (250-350 μm) ~55 m (150-250 μm)
<i>G. inflata</i>	200-400 m	300-400 m ($\delta^{18}\text{O}$)	100-400 m	275-675 m	

Table 5. Calcification depth ranges (in metres from the sea surface in the water column) for planktonic foraminifera species used in this study. Depths assumed are *G. bulloides* = 200 m and *G. inflata* = 300 m. Depth ranges obtained from sediment traps and core-tops were derived from $\delta^{18}\text{O}$ based temperature estimates, which were then compared against modern water column temperatures.

1.3.5 Vital effects

In addition to the specific depth range of individual foraminifera, species-specific biological mechanisms (vital effects) for incorporating trace elements into the test (biomineralisation) can also affect trace element incorporation in foraminiferal calcite. As a result, it is important to assess the species' ecological traits to determine if changes in trace elements are an accurate reflection of environmental change or vital effects. In other words, determine biologically mediated offsets from pure thermodynamic behaviour during trace element incorporation.

The individual effects of different ecological traits on trace element incorporation into a test are not well understood due to the complex interaction of multiple factors during biomineralisation. For example, Mg/Ca banding through the test wall in foraminifera species with spines and/or symbionts reflects a diurnal cycle in which high Mg/Ca bands form at night and low-Mg/Ca bands form during the day (Eggins et al., 2007), or foraminifera with symbionts potentially exhibiting higher temperature sensitivity (Anand et al., 2003; Griffith et al., 2008). Culturing studies are used to understand species-specific vital effects (Sen Gupta, 1999a). However, there is currently no definitive understanding about the impact of species-specific vital effects. The lack of understanding about foraminifera vital effects including potential regional variations makes it essential for local Mg/Ca paleothermometry calibrations to be determined. Regional calibrations will include all vital effects, any post-depositional factors and other locally based secondary influences, such as nutrient, salinity and carbonate ion levels, on trace element incorporation (Rosenthal et al., 2004).

1.3.6 Secondary/diagenetic calcite

The secondary calcite crust is deposited toward the end of the foraminiferal life cycle, after the primary and secondary calcification of the final chamber. Secondary calcite can form either during the foraminifera's descent through the water column, on the seabed sediment surface, or post-burial. It creates a trace element enriched crust on either the foraminifera's outer or inner surfaces as the test surfaces favour carbonate nucleation (Mucci, 2004; Pena et al., 2005). During deposition of diagenetic calcite, the mechanism of calcification is different, leading to formation of euhedral calcite crystals on the outer surface of the test, gradually thickening to form a robust final layer with either a rough textured surface or a very smooth crust (Bé, 1977, 1980; Hemleben et al., 1989; Erez, 2003). The smooth secondary calcite crust is produced in both spinose and non-spinose planktonic foraminiferal species when subjected to low temperatures, for example, when normal surface dwelling species sink into colder, deep oceanic water (Hemleben et al., 1989).

1.3.7 Gametogenic calcite

Calcification in individuals that have lost their buoyancy, as normally observed during gametogenesis (reproduction of foraminifera by the release of flagellated cells or gametes), can add a substantial amount of calcite (on average an additional ~28% by weight of calcite to the pre-gametogenic shell) (Hemleben et al., 1989; Schrag et al., 1995; Pearson et al., 2001; Williams et al., 2005). This calcite is secreted on the outer surface of the last formed chambers during the ~16 hr period prior to gamete release. This process is called gametogenic calcification and is characterized by major changes in shell morphology (Bé,

1980; Hemleben et al., 1989). There is debate in the literature as to whether gametogenic calcite has elevated values of Mg due to differing biological controls (e.g. Erez, 2003; Sadekov et al., 2008) or low values of Mg due to the deeper water where calcification occurs (e.g. Eggins et al., 2003; Lea, 2003). Calcite formed as a result of gametogenesis will be referred to as “gametogenic calcite” i.e., formed in a process separate and distinct from the secondary calcite, but having similar trace element signatures to the secondary calcite layers. Gametogenic calcite is occasionally found on *G. bulloides* tests and is commonly found on *G. inflata*, along with secondary calcite (d’Orbigny, 1842; Cushman, 1950; Caron et al., 1990; Sen Gupta, 1999b).

1.3.8 Nutrients

Currently, it is not well understood if variability in the concentration of macro/micronutrient elements in ocean water can effect the concentration of trace elements in test calcite. Micronutrient concentrations generally increase with depth and will be explored further in this project. Nutrient elements measured in this project include Mn and Zn (micronutrients).

1.3.9 Salinity

Although primarily controlled by temperature, the Mg/Ca ratio of foraminiferal calcite also changes in response to water salinity. For example, Kisakürek et al. (2008) reported changes of Mg/Ca dependence of $\sim 6 \pm 2\%$ /psu for cultured *G. ruber* which Sadekov et al. (2009) found to be consistent with their results. There is, however, variability between the level of dependence identified, with Ferguson et al. (2008) reporting Mg/Ca dependence of $16 \pm 15\%$ /psu for

foraminifera from the Mediterranean. As many of these factors vary according to specific local conditions, it emphasizes the importance of developing local species-specific calibrations to take these regional variations into account (Table 1). For the salinity range of sites used in this study (~ 1 psu change between southern (Subantarctic Water) and northern (Subtropical Water) water masses), the effect of salinity on Mg/Ca would be ~ 0.04 - 0.21 mmol/mol.

1.3.10 Carbonate ion effect

The carbonate ion effect is important for assessing whether trace element concentrations measured in foraminifera have retained their original signature. The carbonate ion effect on foraminifera involves the susceptibility of the individual calcite tests to dissolution, which can vary depending on the foraminifera species (Berger, 1972, 1976; Brown and Elderfield, 1996; Russell et al., 2004; Regenberg et al., 2006). As the pressure-normalized carbonate ion concentration decreases with increasing depth there can be a loss of test weight of up to $0.30 \pm 0.05 \mu\text{g } \mu\text{mol}^{-1} \text{ kg}^{-1}$ (although test wall thickness can vary greatly on even small spatial scales) (Broecker and Clark, 2001) and Mg/Ca begins to decline linearly below $[\text{CO}_3^{2-}]$ levels of ~ 18 - 26 mmol/kg by ~ 0.04 - 0.11 mmol/mol per 1 mmol/kg $[\text{CO}_3^{2-}]$ (Regenberg et al., 2006).

Depending on the species, major and systematic decreases in weight and Mg/Ca ratios can start below critical water depths, which are situated in the depth interval between 2000-3000 m (5 out of 10 core-tops used in this research fall close to or within this depth range; P71, P81, S793, P69, S938) (Regenberg et al., 2006). Critically, decreases in Mg/Ca ratios and calcite dissolution can begin

above the calcite saturation horizon, which is between 2800 m and 3200 m to the east of New Zealand (Regenberg et al., 2006; Feely et al., 2002 and 2004) (Fig. 3). Above these depths, Mg/Ca ratios remain stable as indicated by higher levels of intra-species Mg/Ca variability – Mg/Ca values would otherwise be homogenised by dissolution (Regenberg et al., 2006). *G. bulloides* has been found to decrease in Mg/Ca by $16 \pm 6\%$ per 0.1 unit increase in pH below ambient pH (< 8.2) (Russell et al., 2004). However, currently there has been no species-specific carbonate ion research on *G. inflata*.

Figure 3. Saturation depth in metres for calcite estimated from water column dissolved inorganic carbon (DIC) and total alkalinity (TA) concentrations (from Feely et al., 2002). Note that samples at latitudes $>40^{\circ}\text{S}$ (P71, P81, S793) will be susceptible to dissolution at shallower depths and S938 ($\sim 40^{\circ}\text{S}$, 180°E) is sampled from a depth close to the calcite saturation horizon.

An additional complexity in carbonate ion dissolution is the potential for preferential removal of Mg enriched parts of the foraminifera calcite test after death (Brown and Elderfield, 1996; Regenberg et al., 2006), thereby reducing

the intra-species Mg/Ca scatter. Samples in this study, which are from sites located in $\geq \sim 2000$ m water depth, were rigorously assessed for the effects of dissolution including comparisons with shallower samples from similar oceanographic conditions (looking for reduction in intra-species Mg/Ca scatter) and SEM imaging to assess any visible signs of dissolution. Surface ocean carbonate ion concentrations (e.g. Orr et al., 2005; Feely et al., 2008) are unlikely to have significantly varied in the last 6500 yr ($\sim$ age of the oldest core-top).

1.3.11 Calcification rate

It is unlikely that the foraminifera calcification rate influences the incorporation rate of Mg into the test (Erez, 2003), although this possibility has been raised by other studies (e.g. Lea et al., 1995 and 1999). Inorganic calcite experimentation has found that variations in the levels of proteins found in ocean floor sediments can influence Mg uptake (Stephenson et al., 2008). If a trace element was found to be affected by calcification rates, elemental values in the test calcite would be obscured. The element therefore is unlikely to be a robust proxy of physical oceanographic changes in the past, as test calcification can be mediated by many different environmental factors including symbiotic dinoflagellate activity (Lea, 1999).

1.4 Thesis Objectives

This thesis has three main objectives:

- 1) To develop LA-ICP-MS techniques to measure trace elements in foraminifera test calcite. I will: (i) establish a protocol for picking and mounting foraminifera, which maximizes the reproducibility and accuracy of the results while minimizing potential bias from species morphotype mixing and oblique laser ablation through the test wall; (ii) establish a cleaning protocol, which balances the need to limit contamination while avoiding unnecessary damage to foraminifera.
- 2) To develop a local ocean temperature calibration using Mg/Ca geochemistry for two species of planktonic foraminifera (*G. inflata*, *G. bulloides*) using LA-ICP-MS techniques. In addition, I will investigate intra-test complexities for Mg/Ca.
- 3) To assess the potential of other trace elements (Al, Mn, Zn, Sr, Ba) incorporated into the foraminifera test as ocean environmental proxies.

Chapter 2.0 Regional Setting

In addition to understanding the ecology of foraminifera species and foraminiferal test geochemistry, knowledge of the local oceanography is also required. This section presents the regional oceanography of the area from which the core-tops were sampled.

2.1 Oceanography

2.1.1 General surface water masses off the east coast of New Zealand

Major ocean currents flow through a wide range of latitudes and longitudes, carrying different water masses which are, characterised by their salinity, oxygen and nutrient concentrations. Ocean currents, thus, have the ability to influence the trace element chemistry of foraminiferal calcite either directly through water temperature, concentration of trace elements in the water mass or, indirectly, by enhancing secondary effects such as carbonate ion concentration.

The oceanography east of New Zealand is dominated by two surface water masses that are separated by the Subtropical Front (STF) situated along the east-west crest of Chatham Rise (Fig. 4). North of this front, the uppermost ocean is primarily warm, saline, macronutrient-poor, micronutrient-rich Subtropical Water (STW). South of this front, cold, less saline, macronutrient-rich, micronutrient-poor Subantarctic Water (SAW) prevails (Heath, 1985; Carter et al., 1998; Sutton and Roemmich, 2001). Broadly located around 45-47°S the position of the STF is better defined by the 15°C surface isotherm in summer and the 10°C surface isotherm in winter, and corresponds to the 34.7-34.8 psu surface salinity isopleth (Heath, 1985) (Figs. 4, 5). The STF marks a zone of rapid north-south decrease in temperature (~ 4-5°C) and salinity (~ 0.5 psu), and increase in dissolved nutrients, such as nitrate and phosphate (Deacon, 1982; Orsi et al., 1995).

Figure 4. Generalized modern surface ocean currents and bathymetric features surrounding New Zealand (modified from Carter et al., 1998, see section 3.0 for detail). Circles mark the core-top sites used in this study. Circles are coloured for the dominant surface water mass above the core-tops, black = STW, grey = STW and SAW, white = SAW. Triangles mark the sites of stratified plankton tows (L. Northcote, pers. comm. 2008). Squares (a, b, c) mark the locations of the hydrographic sections used in this study (see Fig. 5 for detail). TF = Tasman Front of Subtropical Inflow; STF = Subtropical Front; SAF = Subantarctic Front; SC = Southland Current; ECC = East Cape Current; WCC = Wairarapa Coastal Current; ACC = Antarctic Circumpolar Current; CSW = Circumpolar Surface Water; MS = Mernoo Saddle; HB = Hawke's Bay, WE = Wairarapa Eddy.

Figure 5. Hydrographic profiles from eastern New Zealand water masses showing Subtropical Surface Water (STW) (a, b), Subantarctic Surface Water (SAW) (c), Antarctic Intermediate Water (AIW), and Circumpolar Deep Water (CDW) (see Fig. 4 for specific locations) (hydrographic section data taken from Locarnini et al., 2006; major water mass definitions taken from Carter et al., 1999).

2.1.2 General ocean circulation off the East Coast of New Zealand

The warmer waters of the Subtropical Inflow originate from the central Pacific. The Subtropical Inflow reaches New Zealand as the Tasman Front (TF) (Fig. 4), which is disrupted by the regional bathymetry into a series of coastal currents and eddy systems (Roemmich and Sutton, 1998; Chiswell 2000, 2002, 2005). Once the eastward flow along the TF reaches the northernmost point of New Zealand, it turns south-eastward, becoming the East Auckland Current (EAUC) and follows the northeast coastline.

Although some of the EAUC flow is maintained within semi-permanent eddies, it continues as a coastal current to the easternmost tip of North Island, East Cape. As the flow rounds East Cape, it becomes the East Cape Current (ECC). The ECC lies east of the Wairarapa Coastal Current (WCC), and carries STW along the outer continental shelf/upper slope to Chatham Rise where the current turns east along the Rise's northern flank (Fig. 4) at approximately 42°S (Heath, 1985; Tilburg et al., 2001).

Seaward of the ECC is the anticyclonic, warm-core Wairarapa Eddy (Fig. 6), situated within the East Cape eddy system. The original eddy sheds near East Cape and propagates slowly along the continental margin until Hawke's Bay (an along shore distance of ~300 km) where it stalls or merges with a previous eddy, forming what is otherwise known as the 'Wairarapa Eddy' (Fig. 6) (Roemmich and Sutton, 1998; Tilburg et al., 2001; Chiswell, 2005). Approximately 2-3 eddies are shed per year with a mean period of ~120–180 days, travelling downstream at 1.6-3.2 cm s⁻¹ (Chiswell, 2005). There is some inter-annual variability in the eddy system, where the strength, broadness and scale of eddy propagation changes (Chiswell, 2005). Core-top site P69 sits on the edge of the eddy where the water transport volume is between 0-5 Sv. Site S938 is situated near the seaward limit of the eddy path (Chiswell, 2005).

Figure 6. Transport stream function (in Sverdrups; $1 \text{ Sv} = 10^6 \text{ m}^3 \text{ s}^{-1}$) for the Wairarapa Eddy. Also shown are two core-top sites used in this study (P69 and S938) affected by the eddy transport system. A simple progression of eddy spawning involves translation north to south along the Hikurangi Trough (dashed line - interaction between eddies is generally more complex, with eddies meandering, occasionally merging, and spawning smaller eddies). Therefore, both P69 and S38 core-top sites are likely to be affected by periodic eddy migrations and the circulation of the waters when the eddy is stable in this location. Dashed line is the 2000 m isobath, the solid lines indicate the 500 m isobath (from Chiswell, 2005).

In the south, the interaction of polar easterly and mid-latitude westerly weather systems, coupled with climatic shifts (such as the Southern Annular Mode and Antarctic Circumpolar Wave) influence the region on synoptic to decadal time scales (e.g. White and Cherry, 1999; Barrows et al., 2000; Carter et al., 2002). The modern main oceanic flows are the ACC and Deep Western Boundary Current (DWBC). The DWBC mainly transports CDW at $> 2000 \text{ m}$ depth. It underlies the ACC along the Campbell Plateau (Fig. 4), before extending into the central Pacific Ocean after the ACC swings east.

The Southland Current (SC) is the main coastal inflow, bringing a mixture of STW and SAW to the STF, along the southern flank of the Chatham Rise with some passing through Mernoo Saddle (Chiswell, 1996, Sutton, 2003). Seaward of the SC, lies the STF which is steered northwards along the continental margin of the South Island near site Q220, then along the Chatham Rise (Orsi et al., 1995; Carter et al., 1998; Barrows et al., 2000; Sutton, 2003).

Due to the location of Campbell Plateau, the ACC is steered along its southern and eastern flanks whereas the SC passes to the west (Heath, 1985; Sutton, 2003; Stanton and Morris, 2004). This circulation pattern results in the central Campbell Plateau being a thermally isolated region of SAW (Northcote and Neil, 2005).

In the subsequent discussion of the foraminifera geochemistry results, I informally group and refer to sites as ‘subtropical sites’ (P71, P81, S793, P69 and S938; STW – black circles), ‘mixing sites’ (R623 and Q220; mixing of STW and SAW – grey circles), and the ‘subantarctic sites’ (F111, D178 and B32; SAW – white circles) (Fig. 4).

2.2 Seasonality of foraminifera productivity east of New Zealand

The seasonality of foraminifera reflects specific periods of peak productivity for a particular foraminifera species, when the highest abundance of a species is generally deposited on the ocean floor. The impact of seasonality is significant for the interpretation of foraminifera Mg/Ca and other trace element signals, because a strong seasonality will tend to record ocean conditions during the peak productivity seasons. Variability between seasons is measured by changes in the abundance of planktonic foraminifera in sediment traps corresponding with seasonal changes in oceanography

(Erez and Honjo, 1981; Thunell and Honjo, 1987; Sautter and Thunell, 1989; Gupta et al., 1997; King and Howard, 2001). Seasonal peaks in the productivity mean that any temperature signal gained from downcore and core-top analysis of foraminifera is likely to reflect the season in which the majority of foraminifera lived (assuming a monthly life cycle for planktonic species), and this includes the majority of sites used in this research.

Figure 7. Foraminifera species-specific shell fluxes (*G. bulloides* - blue circles; *G. inflata* - red circles) taken from sediment traps: (a) north Chatham Rise; 42°42' S, 178°38' E and (b) south Chatham Rise; 44°37' S, 178°37' E (King and Howard, 2001), (c) Pukaki Rise; 50°00' S, 171°00' E and (d) Campbell Plateau margin; 52°00' S, 174°00' E (Northcote and Neil, 2005). There is a distinct foraminifera bloom in spring for Pukaki Rise, Campbell Plateau margin and south Chatham Rise. The foraminifera flux cycles of the north Chatham Rise are unique within this data set, in that the flux of *G. bulloides* and *G. inflata* are relatively consistent throughout spring, summer and autumn (adapted from Northcote and Neil, 2005; King and Howard, 2001).

In general, the modern total planktonic foraminiferal assemblage north of Chatham Rise is dominated by *G. inflata* (~ 60% of total shell flux) and *G. bulloides* (~ 15% of total shell flux) (King and Howard, 2001). These assemblages are in good agreement with the expected geographic distribution patterns based on the abundance of foraminifera at different sea surface temperatures (SST) (*G. inflata* - subtropical-temperate; *G. bulloides* - eutrophic or sub-polar) (Weaver et al., 1998; King and Howard, 2001; Crundwell et al., 2008).

Seasonal effects are limited north of the Chatham Rise (Fig. 7). However, south of the Chatham Rise both *G. inflata* and *G. bulloides* peak in productivity during the spring months of September - November (Fig. 7) (King and Howard, 2001; Northcote and Neil, 2005). There has been no specific investigation into the seasonality of foraminifera between 30.0°S to 37.0°S, east of New Zealand. Based on extrapolation of the seasonal distribution of chlorophyll-*a* in the upper North Island, there would most likely be a seasonal productivity peak in spring (Murphy et al., 2001). Due to seasonal peaks in productivity, where possible, temperatures from the corresponding season have been used for Mg/Ca-temperature calibration. For example, at the SAW sites, temperatures were taken from September 1 - November 31 (Northcote and Neil, 2005).

Chapter 3.0 Sample data set

G. bulloides (~180) and *G. inflata* (~170) individuals were hand-picked from 10 modern core-top sites from waters east of New Zealand. These 10 sites span a range of latitudes (~33°0'S to ~54°0'S) including three different water masses, variable depths (~580 to ~3000 m) and variable sub-surface temperatures (200 m, 7.0-19.1 °C; 300 m, 6.8-12.9 °C) (Table 6). As the oceanography from this region is complex, the temperatures generated through the World Ocean Atlas (Locarnini et al., 2006) did not reflect this variability and therefore, where possible observed ocean temperatures from a number of publications were used (Table 6).

Although the core-top samples are 'modern', they may have variable age depending on the sedimentation rate at the core site, and not all of the samples have undergone radiocarbon dating. *G. inflata* from site R623 was dated at 6220 ± 35 yr BP (C. Prior, GNS Science, pers. comm., 2008) and is the oldest analysed core-top with a sedimentation rate <1 cm/ka (based on the relative sedimentation rates for sites F111 and D178 – Table 6). For the purposes of constructing a calibration, the effect of this age variability is limited because the sample ages are significantly younger than the residency times for Mg and Ca in the ocean (~13 Ma and ~1 Ma respectively - Broecker and Peng, 1982) and SST variability during the last ~6000 yr is limited (Pahnke and Sachs, 2006).

The core-top sites above ~3000 m are above the regional calcite lysocline and, therefore, should not be affected by dissolution/carbonate ion variation (Berger et al., 1976; Russell et al., 2004; Regenberg et al., 2006). Sites below or close to 2000 m were monitored (e.g., sites P71, S793, P69, S938) by examining the individual trace

Core top	Water Depth (m)	Latitude	Longitude	Water Mass	Sedimentation Rate (cm/ka)	Radiocarbon Age	Depth of Temperature (m)	Temperature (°C)	Source - Temperature ¹
P71	1919	33.86°S	174.69°E	STW	0.9		200	14.3	Stanton (1973)
							300	12.9	
P81	2036	34.02°S	173.51°E	STW	0.9		200	14.3	Stanton (1973)
							300	12.9	
S793	2411	36.32°S	176.80°E	STW	7.1		200	14.6	Locarnini et al. (2006)
							300	12.9	
P69	2195	40.40°S	178.00°E	STW	13.6		75	19.1	Unpublished data NIWA (U1729, U1730)
							300	12.8	
S938	3003	40.03°S	180.00°E	STW	8.3	570 ± 35 (<i>G. inflata</i>)	75	18.8	Unpublished data NIWA (U1729, U1730)
							300	12.8	
R623	1128	43.20°S	186.00°E	STW/SAW		6220 ± 35 (<i>G. inflata</i>)	200	11.2	Locarnini et al. (2006)
							300	10.3	
Q220	580	44.29°S	174.98°E	SAW/STW	2.8		200	8.0	Heath (1985)
							300	7.4	
F111	704	48.95°S	174.98°E	SAW	1.0	4582 ± 36 (<i>G. inflata</i>)	200	7.3	Neil et al. (2004)
							300	7.0	
D178	629	51.72°S	169.83°E	SAW	1.7	4835 ± 33 (<i>G. inflata</i>)	200	7.5	Neil et al. (2004)
							300	7.0	
B32	799	53.63°S	169.87°E	SAW			200	7.0	Morris et al. (2001)
							300	6.8	

Table 6. Core-top locations, radiocarbon ages, sedimentation rates and associated ocean temperatures.

¹Temperatures were from the time closest to peak productivity for each site as indicated by ‘chlorophyll-*a*’ measurements (Murphy et al., 2001) and sediment trap data (King and Howard, 2001; Northcote and Neil, 2005). STW = subtropical water; SAW = subantarctic water.

Chapter 4.0 Ecological, oceanographic and temperature controls on the incorporation of trace elements into *Globigerina bulloides* and *Globoconella inflata* in the Southwest Pacific Ocean

Note: this chapter will be submitted to the journal Paleocyanography and, as such, it has been written and styled in the format of this journal including the numbering of sections and subheadings.

Abstract

We present trace element ratios (Mg/Ca, Al/Ca, Mn/Ca, Zn/Ca, Sr/Ca, Ba/Ca) for two planktonic foraminifers, *Globigerina bulloides* and *Globoconella inflata*, to determine the relationship between test chemistry and sea surface temperatures (SST) and ocean chemistry. Samples of modern sediment taken from the top of 10 cores in the Southwest Pacific Ocean were analysed by laser ablation inductively coupled plasma mass spectrometry. Mg/Ca in *G. bulloides* exhibits a strong correlation with observed ocean temperatures at 200 m depth and when the data are combined with previously published data, yields a new regional calibration where $\text{Mg/Ca} = 0.998 \exp^{0.066 \cdot T}$ ($r^2 = 0.97$). This extends the Mg/Ca-temperature calibration for the species to 5-30°C. Significant variability of Mg/Ca values (20-30%) was found between the four visible chambers of *G. bulloides* with the final chamber consistently recording the lowest Mg/Ca values, and is interpreted to reflect changes in the depth habitat with ontogeny. Normalized *G. bulloides* test weights (weight/size) are also observed to correlate with ocean temperature ($T = 28.6 \exp^{(-29.8 \times W_{\text{th}})}$, $r^2 = 0.88$) rather than sea water carbonate ion variability. In contrast to previous studies, no relationship between ocean temperatures and Mg/Ca or normalized weights was evident for *G. inflata*. The lack of a *G. inflata* Mg/Ca-temperature relationship is interpreted to reflect the growth of secondary/gametogenic calcite on foraminifera tests obscuring the primary calcite

Mg/Ca values. Systematic analysis of Zn/Ca, Mn/Ca and Al/Ca values in *G. bulloides* revealed that it is possible to differentiate between subantarctic and subtropical surface waters are potentially able to be differentiated between and are possibly related to the elevated micronutrient levels of the warmer Subtropical Waters.

1.0 Introduction

Trace element ratios in foraminiferal calcite are increasingly being used to reconstruct the thermal and chemical state of Earth's oceans during past climate fluctuations (e.g. Lea et al., 1999; Elderfield and Ganssen, 2000; Eggins et al., 2003; Billups and Schrag, 2003; Elderfield et al., 2006; Rosenthal, 2007). In particular, Mg/Ca paleothermometry, which is based upon the temperature-dependent incorporation of Mg into foraminiferal calcite, is a rapidly developing area of paleoceanography (Mashiotto et al., 1999; Rosenthal et al., 2002; Anand et al., 2003; Anand and Elderfield, 2005; Sadekov et al., 2008). Furthermore, other trace elements such as Ba and Zn are now also the subject of study to assess if foraminiferal calcite records the distinct trace element signatures of different nutrient-rich and -poor water masses (Reichart et al., 2003).

Geochemical studies of foraminifera have traditionally utilized bulk analytical methods in which up to ~100 foraminifera are crushed and dissolved (e.g. Rosenthal et al., 1997; Lea et al., 1999, 2000; Elderfield and Ganssen, 2000; Barker et al., 2003, 2005). Significant advances in microanalytical techniques, such as laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and ion microprobe, now make it possible for the individual chambers of a foraminiferal test to be analysed repeatedly at a spatial resolution of tens of microns, yielding accurate and precise *in situ* data for a number of trace elements and isotopes (Eggins et al., 2003, 2004; Bice et al., 2005;

Rollion-Bard et al., 2008; Sadekov et al., 2008; Kasemann et al., 2008, 2009). Studies that have utilised LA-ICP-MS techniques have revealed the existence of significant trace element heterogeneity (up to 50%) between the different chambers of an individual foraminifer (Sadekov et al., 2008) and also from individual-to-individual in the same sample. Variable thicknesses and numbers of bands of high and low Mg/Ca calcite have been used to explain differences between individual chambers, whereas repeated testing within the same chambers has generally demonstrated good repeatability (e.g. Eggins et al., 2004; Sadekov et al., 2005, 2008).

The complexities of trace element incorporation in foraminiferal calcite revealed by *in situ* techniques, provides a significant challenge to the use of this method as a proxy for past ocean temperatures. For example, the significant variations in Mg/Ca reported between modern core-top and sediment trap populations of foraminifera (e.g. Anand et al., 2003; McConnell and Thunell, 2005; Clroux et al., 2008) suggest important secondary controls such as 1) biological affects on calcification may effect the incorporation of Mg into foraminiferal calcite. The reliable use of the Mg/Ca paleothermometer therefore requires, 2) investigation into these secondary controls for which *in situ* methods such as LA-ICP-MS are ideally suited. The test is likely to reflect a combination of ecological and environmental (temperature, salinity, carbonate ion concentration) influences and we hope that detailed examination using LA-ICP-MS will reveal intriguing new insights into past environmental change.

The incorporation of trace elements into foraminiferal calcite is also controlled in part by species-specific biological mechanisms (Erez, 2003). As such, it is important to investigate these mechanisms to determine if the observed variability in foraminiferal

Mg/Ca is an accurate reflection of temperature variability or ‘vital effects’ i.e. ecological niches inhabited by different species of foraminifera, or the biologically mediated offsets from pure thermodynamic behaviour during trace element incorporation (Hemleben et al., 1989; Sen Gupta, 1999). However, the effects of different ecological behaviour on the level of trace element incorporation into foraminiferal tests are currently not well understood (Anand et al., 2003; Griffith et al., 2008).

Figure 8. Scanning electron microprobe images of the two foraminifera species analysed in this study: *Globigerina bulloides* (8a - recovered from site R623) and *Globoconella inflata* (8b - recovered from site S938). Each chamber is labelled, where f represents the youngest chamber with each subsequently older chamber being labelled f-1, f-2 and f-3. Measurement of the size data presented in this study is taken from the longest axis between chambers f and f-2. Laser ablation pits measuring 25 μm across are visible in the images.

Here we present LA-ICP-MS analyses of two planktonic species *Globigerina bulloides* and *Globoconella inflata* (Fig. 8) from the Southwest Pacific Ocean, east of New Zealand, in order to further evaluate the ecological, temperature and oceanographic controls on the incorporation of trace elements into these species. *G. bulloides* is a

spinose, non-symbiont species, which inhabits a range of water temperatures from tropical to subantarctic waters with highest abundances found in eutrophic conditions (Hemleben, 1989; Sen Gupta, 1999; Crundwell et al., 2008). *G. inflata* is a deep-dwelling planktic, non-spinose, non-symbiont species, which also inhabits a range of water temperatures from tropical to subantarctic, with the highest abundance in temperate waters (Crundwell et al., 2008). Here we use SST as a generic term that encompasses the uppermost ~200 m of the ocean.

Figure 9. Generalised modern surface ocean currents and bathymetric features surrounding New Zealand (modified from Carter et al., 1998). Circles mark the core-top sites used in this study, black = subtropical, grey = mixed and white = subantarctic sites. Triangles mark the sites used for the stratified plankton tows (L. Northcote, pers. comm. 2008). TF = Tasman Front; STF = Subtropical Front; SAF = Subantarctic Front; SC = Southland Current; ECC = East Cape Current; ACC = Antarctic Circumpolar Current; STW = Subtropical Water; SAW = subantarctic water; CSW = circumpolar surface water; MS = Mernoo Saddle; WE = Wairarapa Eddy; EE = East Cape Eddy; HB = Hawke's Bay.

The trace element data presented here includes Mg/Ca, Al/Ca, Mn/Ca, Zn/Ca, Sr/Ca and Ba/Ca ratios. Foraminifera were sampled from 10 core-tops located from a range of latitudes (33.86°S, to 53.63°S) within two major surface water masses subtropical and subantarctic waters (Fig. 9, Table 7). Geochemical data are complemented by weight and size measurements of all individuals analysed in this study.

We use this dataset for three purposes. Firstly, to develop a LA-ICP-MS Mg/Ca-temperature calibrations for *G. bulloides* and *G. inflata* suitable for application to surface water temperature reconstructions in the Southwest Pacific Ocean. This is important as laser ablation (LA) analyses are not necessarily compatible with solution-based analyses where chemical cleaning of samples differs from the protocols used in LA-analysis to remove contaminants from the foraminiferal tests. Secondly, to identify possible relationships between foraminiferal trace element characteristics and specific water masses. Finally, to evaluate potential ecological controls on foraminiferal trace element chemistry and implications for paleoceanographic reconstructions.

2.0 Background

2.1 Oceanography

The surface waters east of New Zealand feature a suite of dynamically driven water masses with different temperatures, salinities and nutrient levels (Fig. 9). The surface ocean is partitioned by the Subtropical Front (STF), situated approximately along the east-west crest of Chatham Rise. The front separates warm, saline, micronutrient-poor, macronutrient-rich Subtropical Water (STW) in the north from cold, less saline, micronutrient-rich, macronutrient-poor Subantarctic Water (SAW) to the south (Heath, 1985; Carter et al., 1998; Sutton and Roemmich, 2001). The surface circulation north of

Core top	Water Depth (m)	Latitude	Longitude	Water Mass	Sedimentation Rate (cm/ka)	Radiocarbon Age	Depth of Temperature (m)	Temperature (°C)	Source - Temperature ¹
P71	1919	33.86°S	174.69°E	STW	0.9		200 300	14.3 12.9	Stanton (1973)
P81	2036	34.02°S	173.51°E	STW	0.9		200 300	14.3 12.9	Stanton (1973)
S793	2411	36.32°S	176.80°E	STW	7.1		200 300	14.6 12.9	Locarnini et al. (2006)
P69	2195	40.40°S	178.00°E	STW	13.6		75 300	19.1 12.8	Unpublished data NIWA (U1729, U1730)
S938	3003	40.03°S	180.00°E	STW	8.3	570 ± 35 (<i>G. inflata</i>)	75 300	18.8 12.8	Unpublished data NIWA (U1729, U1730)
R623	1128	43.20°S	186.00°E	STW/SAW		6220 ± 35 (<i>G. inflata</i>)	200 300	11.2 10.3	Locarnini et al. (2006)
Q220	580	44.29°S	174.98°E	SAW/STW	2.8		200 300	8.0 7.4	Heath (1985)
F111	704	48.95°S	174.98°E	SAW	1.0	4582 ± 36 (<i>G. inflata</i>)	200 300	7.3 7.0	Neil et al. (2004)
D178	629	51.72°S	169.83°E	SAW	1.7	4835 ± 33 (<i>G. inflata</i>)	200 300	7.5 7.0	Neil et al. (2004)
B32	799	53.63°S	169.87°E	SAW			200 300	7.0 6.8	Morris et al. (2001)

Table 7. Details of core-top locations, radiocarbon ages, sedimentation rates and relevant ocean temperatures for the sites examined in this study.

¹Temperatures were generated from a number of publications by selecting the time closest to peak productivity for each site as indicated by ‘chlorophyll-a’ measurements (Murphy et al., 2001) and sediment trap data (King and Howard, 2001; Northcote and Neil, 2005). STW = Subtropical Surface Water; SAW = Subantarctic Water.

Chatham Rise is dominated by the East Cape Current (ECC) which flows south-westwards along the eastern margin of the North Island, as an extension of the subtropical inflow associated with the South Pacific Gyre. Seaward of the ECC is the anticyclonic, warm-core Wairarapa Eddy (Fig. 9), associated within the East Cape eddy system. An eddy sheds near East Cape and propagates along the continental margin to offshore Hawke's Bay, where it stalls or merges with a previous perturbation forming the Wairarapa Eddy (Fig. 9) (Roemmich and Sutton, 1998; Tilburg et al., 2001; Chiswell, 2005).

Separating the narrow band of STW coastal water along the east coast of the South Island from the offshore SAW is the Southland Current (SC) which flows mainly north-eastwards and then eastwards along the southern flank of Chatham Rise (Fig. 9) (Chiswell, 1996, Sutton, 2003). Part of the SC is diverted through the Mernoo Saddle to pass along the shelf off the eastern North Island (Fig. 9) (Carter et al., 1998; Sutton, 2003). South of the Campbell Plateau is the Antarctic Circumpolar Current (ACC) whose leading edge is the Subantarctic Front (SAF). This flows north to the Bounty Trough before turning eastward. The front separates cool, fresh, SAW on Campbell Plateau from colder circumpolar surface water to the east (Fig. 9).

In subsequent discussions of the foraminifera geochemistry results, we informally group and refer to sites from STW as 'subtropical' (P71, P81, S793, P69 and S938), STW and SAW as 'mixed' (R623 and Q220) in association with the STF, and those from SAW as 'subantarctic' (F111, D178 and B32) (Fig. 9).

2.2 Foraminifera ecology

Knowledge of general foraminiferal habitats and individual species' life cycles is required to test or verify interpretations of foraminifera test chemistry e.g. factors such as depth habitat in the water column and timing of productivity. The depth habitats of individual species can seldom be defined precisely because foraminifera exhibit diurnal, ontogenetic, seasonal and long-term variations (Arnold and Parker, 1999). Superimposed on depth distribution patterns is the effect of upwelling of deep, nutrient-rich waters, which is locally significant in water masses around New Zealand (Weaver et al., 1997).

In this study, the water column depth for *G. bulloides* is taken to be ~200 m for all sites except P69 and S938, which is based on surface mixed layer depths, peak fluorescence depths and plankton tow information where ~85% of *G. bulloides* were located in the upper 100–200 m of the water column near Campbell Plateau (NIWA Cruise Report TAN 9814, 1998; Sutton and Roemmich, 2001; Mortyn and Charles, 2003; Connie and Dunn, 2006; Wilke et al., 2009). *G. bulloides* numbers in a plankton tow were sparse for the Wairarapa Eddy region (P69 and S938), but most (~70%) occurred in a depth of 50–100 m (unpublished data, NIWA). This shallower assigned depth is consistent with known upwelling along this margin and nutrient entrainment and mixing associated with the Wairarapa Eddy, as well as the depth peak in fluorescence (Weaver et al., 1997; Murphy et al., 2001; unpublished data data, NIWA). Therefore, for sites P69 and S938, we use observed SSTs from 75 m depth for *G. bulloides* (Table 7).

An assumed water column depth of 150 – 400 m is used for *G. inflata* with an observed water column temperature at 300 m for all sites. The selection of these depths is supported by stratified plankton tow abundance data for sites off the East Cape of New

Zealand which shows at least 50% more *G. inflata* are found at a depth of 300 to 400 m than any other depth range (L. Northcote, pers. comm. 2008).

Many of the core-top sites are likely to be influenced by seasonal productivity cycles (Hemleben et al., 1989; King and Howard, 2001; Murphy et al., 2001; Northcote and Neil, 2005). Thus, foraminiferal abundance from a single core-top is likely to be dominated by the season or seasons which have peak productivity. However, as the seasonal variability of water column temperature is significantly reduced with depth, this effect is unlikely to influence the temperature calibrations developed in this study. For example, the difference between summer and winter temperatures can vary by up to 5°C between seasons at the sea surface, but below 200 m, where it is common for *G. bulloides* and *G. inflata* to dwell, the difference is generally < 1°C (e.g. Northcote and Neil, 2005; Locarnini et al., 2006).

3.0 Materials and Methods

G. bulloides and *G. inflata* were recovered from 10 and 9 sites, respectively, which encompass a range of environmentally and biogeochemically distinct water masses (Hunter and Boyd, 1999; Mackie and Hunter, 2005) (Table 7). Sea surface temperatures during the summer months at 200 m range from ~20°C at the northernmost site (P71) to ~4.5°C at the southernmost site (B32). Water depths of the core-top samples range from 580 to 3000 m, with the deepest sites being close to the calcite saturation horizon, which east of New Zealand lies at 2800 to 3200 m depth (Feely et al., 2002; 2004, Regenberg et al., 2006). The foraminifera from deeper sites (> 2000 m) were carefully examined for signs of dissolution.

Prior to weighing and LA-ICP-MS analysis, all foraminifera tests were cleaned to remove loosely adhering clay and other detrital material by 2–3 ultrasonication rinses for 2–3 s in $> 18.2 \text{ M}\Omega$ ultra-clean water and two AR-grade methanol rinses. Samples were subsequently examined under a binocular microscope and any individuals with visible adhering contaminants were treated to a further one or two ultrasonic cycles. Ultrasonic cleaning for longer than 3 s often resulted in significant fragmentation to foraminifera tests, particularly for foraminifera from the more northerly (warmer) sites. The foraminifera were then dried in an oven at 40°C for 24 hr. All *G. inflata* and *G. bulloides* individuals were then individually weighed using a Mettler Toledo (MX/UMX 2) ultramicro-balance. Analytical uncertainty on these weight measurements are $< \pm 5\%$ (2 sd relative) based upon 15 replicate measurements of a single *G. bulloides* test weighing $8.7 \mu\text{g}$.

Trace element ratios of foraminiferal tests were measured using a New Wave deep-UV (193 nm) solid-state laser ablation system coupled to an Agilent 7500CS ICP-MS at Victoria University of Wellington, New Zealand (Table 8). Analyses were 120 or 180 s long, which consistently penetrated the *G. bulloides* test wall, however, the *G. inflata* test wall was not always breeched. After subtraction of background signals, trace element ratios of foraminifera were calculated by reference to ratios obtained from analyses of NIST610 and by normalisation to the known trace element values in this standard using the following elemental concentrations: Mg = 465, Al = 10798, Ca = 82191, Mn = 485, Zn = 456, Sr = 516, Ba = 435 ppm (Pearce et al., 1997). Pre-ablation was not employed in this study, but each profile was screened for contaminants in the outer part of the test. The internal precision of trace element/Ca ratios for the foraminifera data estimated from repeated analyses of *G. bulloides* are typically: Mg/Ca

$\pm 4.5\%$, Al/Ca $\pm 53.9\%$, Mn/Ca $\pm 9.9\%$, Zn/Ca $\pm 13.2\%$, Sr/Ca $\pm 2.3\%$, Ba/Ca $\pm 22.9\%$
(n = 14; 2 se relative).

Laser ablation parameters	
Laser ablation system	New Wave 193 nm (deep UV) solid state
Ablation mode	Static spot analyses
Spot size	25 μm
Depth ablated/pulse	$\sim 0.1 \mu\text{m}$
ICP-MS	
ICP-MS system	Agilent 7500CS
Acquisition mode	Peak hopping
Detection mode	Pulse counting
Tuning	
Tuning standard	NIST 610
Ablation mode	Rastering (2 $\mu\text{m/s}$) with a 25 μm spot
Monitored isotopes	^{24}Mg , ^{27}Al , ^{43}Ca , ^{55}Mn , ^{66}Zn , ^{88}Sr , ^{138}Ba
Repetition rate	5 Hz
Laser power	60%
Carrier gas (Ar)	0.83–0.90 L/min
Ablation gas (He)	77–90%
RF Power	1500 W
Standards and calibration	
Calibration standard	NIST-SRM610
Repetition rate	5 Hz
Laser power	60%
Background acquisition	60 s
Sample data acquisition	60 s
Washout time	120 s
Measured isotopes	^{24}Mg , ^{27}Al , ^{43}Ca , ^{55}Mn , ^{66}Zn , ^{88}Sr , ^{138}Ba
Integration time	10 ms
Foraminifera Method	
Repetition rate	2 or 5 Hz
Laser power	45 or 50 %
Background acquisition	60 s
Sample data acquisition	180 or 120 s
Washout time	120 s
Measured isotopes	^{24}Mg , ^{27}Al , ^{43}Ca , ^{55}Mn , ^{66}Zn , ^{88}Sr , ^{138}Ba
Integration time	10 ms

Table 8. Summary of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) instrumental and analytical conditions.

The outermost calcite of all tests show significant enrichments in Mg and other trace elements, consistent with observations reported in previous *in situ* geochemical investigations of foraminifera (e.g. Eggins et al., 2003; Pena et al., 2005; Sadekov et al., 2008) (Fig. 3). This high Mg ‘crust’ was not integrated in the ‘final’ trace element ratios summarised in the data set presented in this paper (Appendix 2.0). The data were screened by examining the ablation profiles of the trace elements, paying particular

attention to Al/Ca and Mn/Ca (indicators of clay and Fe-Mn oxyhydroxide contamination) and Sr/Ca. Final trace element/Ca ratios were averaged from ‘integrated profiles,’ which include those sections of the foraminifera test which were deemed to be ‘normal’ (Fig. 10a), where sections of the test with contamination on either the inner or outer test or through the test wall (in rare cases) were excluded from the average profile (Fig. 10b). The different geochemical profile averages for all chambers were then plotted on bivariate plots (e.g. Al/Ca versus Ba/Ca) and sample outliers removed (~0.01 % of total analyses).

Figure 10. Typical (a) and atypical (b) time-resolved depth profiles from a 180 s laser ablation analysis of the final chamber (f) of two *G. bulloides* individuals. These depth profiles were used to screen the geochemical data for outliers or abnormal sections of a test profile. The ‘integrated profile’ indicates the section of the analysis profile that is integrated when calculating the final trace element/Ca ratios.

After trace element analysis, a 25 nm thick carbon coating was applied to the foraminifera in preparation for imaging by scanning electron microscopy (SEM) using a JEOL Superprobe 733 at Victoria University of Wellington, New Zealand. The SEM images of *G. bulloides* and *G. inflata* individuals were used to measure test sizes from chamber *f* to *f*-2 (Fig. 8) and assess the state of test preservation.

4.0 Results

4.1 Foraminiferal trace element chemistry

The trace element/Ca chemistry of foraminifera are presented and discussed at different scales that include: (a) mean data of all visible chambers for all individuals from a core-top sample (b) mean data of one visible chamber for all individuals from a core-top sample. We use the terms *sample mean* (a) and *chamber mean* (b) to describe these different ways of examining the foraminiferal geochemical data sets (Fig. 11).

Figure 11. Schematic illustration explaining the terminology used when examining different trace element datasets for foraminifera.

4.1.1 Sample mean trace element variations

The sample mean of Al/Ca, Mn/Ca, Zn/Ca and Ba/Ca ratios for *G. bulloides* and *G. inflata* show approximately an order of magnitude difference between sites that are separated by as little as 3°-5° of latitude (Table 9, Fig. 12). For example, the sample mean Zn/Ca of *G. bulloides* at sites D178 and Q220 are 0.0036 and 0.037, respectively (~5° latitudinal separation). Although Al/Ca, Mn/Ca, Zn/Ca and Ba/Ca typically occur in low (<0.1 mmol/mol) values in foraminifera (Rosenthal et al. 1999; Hathorne et al., 2003) and individual analyses of these elements have relatively large uncertainties

(Table 9), the large variability of these elemental ratios is significantly larger than analytical uncertainties.

G. bulloides and *G. inflata* record markedly different trace element ratios at the same sites, including those from STW where very few *G. inflata* have secondary/gametogenic calcite overgrowths. With the exception of Sr/Ca, which is relatively uniform for both species across all sites (Fig. 12e), *G. inflata* trace element/Ca values are generally lower for Mn/Ca, Al/Ca, Zn/Ca, Mg/Ca than those of *G. bulloides*. Although this is counter to what would be expected for nutrient elements, which generally are depleted in surface waters and gradually increase in concentration with depth (Locarnini et al., 2006), these findings are consistent with the results of Clroux et al. (2008). The sample mean Mg/Ca ratios are higher for *G. bulloides* relative to *G. inflata* at all sites, although this difference is significantly reduced for subantarctic sites.

Compared to subtropical sites, subantarctic sites F111, D178 and B32 record the lowest sample mean Zn/Ca, Al/Ca and Mn/Ca ratios (Fig. 12). Site Q220 also has similarly low values of Mn/Ca but does not share the same signature for Zn/Ca and Al/Ca. These geochemical signatures mirror the southern water masses, which are dominated by micronutrient-poor SAW south of the Chatham Rise and the micronutrient-rich STW to the north (Fig. 9) (Heath et al., 1985; Carter et al., 1998). While foraminifera of both species from the subtropical zone generally record similar trace element/Ca ratios, *G. bulloides* from P71 and P81 has very different Mn/Ca and Ba/Ca values, despite the close proximity (< 25 km) of the sites.

Figure 12. (a) to (f) Comparison of sample mean trace element/Ca ratios for *G. bulloides* (grey bars) and *G. inflata* (white bars) from all core-top sites.

Core-top weight, size and trace element/Ca summary													
Core top	<i>n</i>	Water Temperature (°C)	Size Range (µm)	Size Mean (µm)	Weight Range (µg)	Weight Mean (µg)	Mg/Ca (mmol/mol)	Al/Ca (mmol/mol)	Mn/Ca (mmol/mol)	Zn/Ca (mmol/mol)	Sr/Ca (mmol/mol)	Ba/Ca (mmol/mol)	
<div><div><i>G. bulloides</i></div><div>Subtropical sites</div><div>Mixing sites</div><div>Subantactic sites</div></div>	P71	20	14.3	321 - 422	352 <i>54.1</i>	4.10 - 15.5	8.91 <i>10.4</i>	2.67	0.1237	0.0242	0.0267	1.22	0.00163
	P81	7	14.3	257 - 355	302 <i>67.9</i>	4.70 - 8.50	6.92 <i>1.80</i>	2.41	0.0929	0.1649	0.0446	1.39	0.01270
	S793	18	14.6	239 - 310	272 <i>32.0</i>	2.10 - 7.60	4.47 <i>5.66</i>	2.71	0.1517	0.0691	0.0214	1.33	0.00755
	P69	14	19.1	196 - 302	236 <i>31.4</i>	2.70 - 7.00	4.68 <i>7.15</i>	3.33	0.0641	0.0379	0.0686	1.41	0.00237
	S938	14	18.8	228 - 334	279 <i>62.7</i>	1.10 - 9.00	5.17 <i>9.74</i>	3.48	0.0238	0.1530	0.0307	1.39	0.00463
	R623	19	11.4	273 - 385	318 <i>79.0</i>	3.60 - 13.1	8.41 <i>13.5</i>	2.21	0.2976	0.0399	0.0792	1.38	0.00418
	Q220	11	8.9	252 - 369	312 <i>67.8</i>	5.60 - 23.1	12.1 <i>28.1</i>	1.54	0.2696	0.0051	0.0370	1.11	0.00273
	F111	26	7.8	314 - 429	391 <i>100</i>	6.90 - 32.6	19.7 <i>32.6</i>	1.42	0.0205	0.0030	0.0120	1.31	0.00192
	D178	19	7.2	295 - 482	397 <i>93.6</i>	6.10 - 36.4	17.0 <i>16.5</i>	1.67	0.0205	0.0014	0.0036	1.38	0.00149
	B32	25	6.3	326 - 498	407 <i>54.1</i>	7.30 - 38.5	19.3 <i>10.4</i>	1.32	0.0342	0.0065	0.0099	1.10	0.00182
<div><div><i>G. inflata</i></div><div>Subtropical sites</div><div>Mixing sites</div><div>Subantactic sites</div></div>	P71	22	12.9	290 - 389	330 <i>53.4</i>	14.8 - 36.8	25.3 <i>28.9</i>	1.42	0.0351	0.0182	0.0256	1.36	0.00292
	P81												
	S793	22	12.9	267 - 417	329 <i>73.7</i>	7.80 - 25.2	14.4 <i>13.7</i>	0.98	0.0155	0.0304	0.0132	1.37	0.00497
	P69	13	12.8	290 - 415	353 <i>81.5</i>	9.80 - 30.4	15.8 <i>24.2</i>	1.42	0.0329	0.0355	0.0407	1.34	0.00192
	S938	17	12.8	268 - 433	331 <i>104</i>	8.50 - 26.8	15.4 <i>28.3</i>	1.27	0.0569	0.0641	0.0082	1.39	0.00579
	R623	15	10.3	275 - 377	321 <i>69.2</i>	9.20 - 26.6	15.2 <i>18.4</i>	1.61	0.0868	0.0501	0.0531	1.34	0.00860
	Q220	8	8.1	279 - 349	310 <i>40.4</i>	7.20 - 17.1	11.5 <i>13.7</i>	1.37	0.0587	0.0078	0.0750	1.31	0.00667
	F111	11	6.9	314 - 429	373 <i>83.0</i>	16.6 - 51.8	34.6 <i>41.5</i>	0.70	0.0025	0.0001	0.0024	1.39	0.00081
	D178	19	6.9	295 - 482	397 <i>93.6</i>	11.4 - 55.3	27.7 <i>46.6</i>	1.55	0.0465	0.0065	0.0074	1.35	0.00569
	B32	15	4.0	332 - 476	374 <i>87.9</i>	8.80 - 64.7	25.9 <i>65.6</i>	1.16	0.0084	0.0034	0.0058	1.32	0.00163

Table 9. Summary of the size, weight and trace element chemistry (presented here as sample means) for *G. bulloides* and *G. inflata* from 10 core-top sites in the Southwest Pacific Ocean, east of New Zealand (Fig. 9). Values in italics are the 2 standard deviation of the mean.

In this study, we compare our trace element data for *G. bulloides* and *G. inflata* with that of Anand et al. (2003) (Sargasso Sea), McConnell and Thunell (2005) (Gulf of California) and Cléroux et al. (2008) (North Atlantic). The methods of data acquisition in these studies differ in two key aspects to that of our study: (1) all previously published studies employed traditional solution-based analytical methods as opposed to the *in situ* LA-ICP-MS method used here and, (2) the temperatures used to construct the Mg/Ca-temperature calibrations in Anand et al. (2003) and Cléroux et al. (2008) were derived from oxygen isotope measurements of the foraminifera, which yielded calcification temperatures, as opposed to observed ocean temperature measurements utilised here and by McConnell and Thunell (2005). However, McConnell and Thunell (2005) used observed ocean SST rather than temperatures at 200 m depth. The samples used by McConnell and Thunell (2005) were collected in a sediment trap placed at an ocean depth of 485 m from a coastal setting which experiences upwelling. Therefore, the surface water is likely to be well mixed with a significantly reduced temperature difference between surface and 200 m depth, enabling comparability with *G. bulloides* data from this study.

Sample mean Mg/Ca ratios for *G. bulloides* exhibit a clear positive correlation with the observed water column temperature (for their assumed depth) and data from our study overlaps and extends the temperature range for modern *G. bulloides* reported by Cléroux et al. (2008) and McConnell and Thunell (2005) (Fig. 13). An exponential regression through our data (where T = temperature) yields:

$$\text{Mg/Ca} = 0.941 \exp^{0.0693 \cdot T} \text{ with } r^2 = 0.95$$

and for all studies:

$$\text{Mg/Ca} = 0.998 \exp^{0.066 \cdot T} \text{ with } r^2 = 0.97 \text{ (Fig. 14a)}$$

Figure 13. Sample mean Mg/Ca versus temperature for (a) *G. bulloides* (observed ocean temperature; 200 m depth) and (b) *G. inflata* (observed ocean temperature; 300 m depth). The individual analyses shown in (a) demonstrate the range in Mg/Ca values from single core-tops. Data from this study are compared with those of Cléroux et al. (2008) (calcification temperature), Anand et al. (2003) (calcification temperature) and McConnell and Thunell (2005) (observed SST). Temperature calibration for *G. bulloides* in graph (a) is for all three sets of data.

Figure 14. Plots of observed water column temperature versus measured mean Mg/Ca ratios in (a) *G. bulloides* (from 200 m) and (b) *G. inflata* (from 300 m). In this figure, both chamber means and sample means are plotted. The three curves on (a) represent Mg/Ca-temperature calibration lines for *G. bulloides* based on all measurements from the three oldest visible chambers (*f*-1, *f*-2 & *f*-3), the final chamber (chamber *f*) and the sample means as annotated. Chamber *f* values in *G. bulloides* samples consistently yield the lowest values of Mg/Ca. There is no correlation between Mg/Ca and water temperature for *G. inflata*.

Clroux et al. (2008) reported a positive correlation between Mg/Ca and the calcification temperature for *G. inflata* (Fig. 13). In contrast, we find no clear correlation, although there is some overlap of our warmer sites, and some of our colder sites tentatively extend the range exhibited by the data of Clroux et al. (2008) (Fig. 13b). Mg/Ca in *G. inflata* from the Sargasso Sea also had no clear temperature-dependent effects of Mg incorporation (Anand et al., 2003).

Clroux et al. (2008) also reported a positive temperature correlation with Sr/Ca for *G. inflata*. While some of our Sr/Ca data overlap that of Clroux et al. (2008), the Southwest Pacific values *G. inflata* are relatively uniform, with no discernable correlation between Sr/Ca and water temperature (Fig. 15a).

Figure 15. Sample mean Sr/Ca versus temperature for (a) *G. inflata* and (b) *G. bulloides*. Data acquired in this study (triangles) are compared with those of Clroux et al. (2008; diamonds).

4.1.2 Chamber-to-chamber trace element variability

A single *G. bulloides* individual from subtropical site S793 was analysed 14 times by LA-ICP-MS, including replicate analyses from each of the four visible chambers (Fig.

16). Comparison of the analyses from different chambers of the individual, revealed significant intra-test trace element heterogeneity. The four analyses of chamber *f-1* in the individual yielded a mean Mg/Ca of 2.13 ± 0.26 mmol/mol (2 sd) (Fig. 16). The observed variation in Mg/Ca in this chamber ($\sim 12\%$) exceeds analytical uncertainties ($\pm 5\text{-}10\%$) and demonstrates that chemical heterogeneity persists even at the single chamber scale. Intra-test comparison between chambers of the same individual gave average Mg/Ca values that were $\sim 65\%$ lower in chamber *f-3* than chamber *f*. The inter-chamber findings on the same individual are consistent with the large ($\sim 50\%$) differences in inter-chamber Mg/Ca in *Globigerinoides ruber* individuals reported by Sadekov et al. (2008) although there were no consistent trends between chambers reported for *G. ruber* individuals.

Figure 16. *G. bulloides* individual from site S793 analysed 14 times. Twice in the oldest chamber (*f-3*), four times in chamber *f-2* and the youngest chamber, *f* and five times in chamber *f-1*. The trend of decreasing Mg/Ca from chamber *f-3* to *f* is not consistent between all *G. bulloides* individuals.

The chamber mean trace element ratios of *G. bulloides* reveals an important feature. At any given site, the lowest chamber mean values of Mg/Ca for *G. bulloides* occur in the

final chamber (*f*) (Fig. 14a). The relationship between the *G. bulloides* chamber *f* mean Mg/Ca and water temperature is:

$$\text{Mg/Ca} = 0.809 \exp^{0.062 \cdot T} \text{ with } r^2 = 0.93$$

The other, older, visible chambers define a relationship with water temperature where:

$$\text{Mg/Ca} = 0.985 \exp^{0.0712 \cdot T} \text{ with } r^2 = 0.95 \text{ (Fig. 14a)}$$

No other trace element/Ca values in *G. bulloides* were found to be consistently higher or lower in any particular chamber. None of the other trace element/Ca values in *G. inflata* vary systematically between the chambers (Fig. 14b).

4.2 Test weight and size

All *G. inflata* and *G. bulloides* individuals were weighed prior to chemical analysis. Foraminifera weights have been used in previous studies to indicate the significance of post-depositional dissolution of foraminiferal calcite, which has been linked to the preferential loss of Mg (relative to Ca) during dissolution (e.g. Brown and Elderfield, 1996; Dekens et al., 2002; Rosenthal and Lohmann, 2002; Barker et al., 2005). Foraminifera with the lowest measured test weights in this study were typically characterised by the highest levels of Mg/Ca and therefore dissolution is unlikely to be important in controlling either test weight or Mg/Ca. This is also supported by the robust Mg/Ca-temperature correlation observed for *G. bulloides*.

G. bulloides also shows a correlation between normalised weight ratios and Mg/Ca (Fig. 17a). *G. bulloides* from subtropical and subantarctic sites are clearly separated when mean Mg/Ca is plotted against normalised weight. Sample mean weight normalised to test size for *G. bulloides* exhibit a negative correlation with the observed water column temperature (for their assumed depth). An exponential regression fitted through our

sample mean weight (normalised to test size) is defined by the equation:

$$T = 28.6 \exp^{(-29.8 \times W_{tn})} \text{ with } r^2 = 0.88 \text{ (Fig. 17b)}$$

No clear correlation exists between sample mean normalised weight and observed temperature or Mg/Ca for *G. inflata* (Fig. 17b).

Figure 17. Sample mean (core-top sample) foraminifera weights (a, b) and normalised weights (sample mean normalised weight calculated from the normalised weights (weights/length) for individual foraminifera in a sample) (c, d) plotted against observed temperatures and mean Mg/Ca for *G. bulloides* (triangles) and *G. inflata* (circles). Symbols are shaded according to the core-top site location; subtropical sites = white, mixed sites = light grey, subantarctic sites = dark grey. Trendline in graph (b) indicates a possible temperature calibration for *G. bulloides* normalised weight.

5.0 Discussion

Early experiments revealed that Mg incorporation into biogenic calcite was temperature dependent (Clarke and Wheeler, 1922) and could be expressed as an exponential relationship i.e. $Mg/Ca = B \exp^{(A \times T)}$ where T is the calcification temperature, and A and

B are the exponential and pre-exponential constants (Bender et al., 1975). Here, we discuss the controls on Mg and other trace element incorporation into *G. bulloides* and *G. inflata* from the Southwest Pacific Ocean. The impact of variable salinity on Mg incorporation into foraminiferal calcite has been highlighted as a potential issue for Mg/Ca paleothermometry (Kisakürek et al., 2008; Ferguson et al., 2008; Sadekov et al., 2009). The difference in latitudes in this study yield a difference in salinity of ~ 1 psu, at 25 m water depth which using the Kisakürek et al. (2008) Mg/Ca dependence of $\sim 6 \pm 2\%$ /psu for cultured *G. ruber*, would equate to $\sim 0.04 - 0.21$ mmol/mol change in Mg/Ca. Variation of salinity with water depth is also limited, where salinity generally varies by less than 0.5 psu between 25-400 m water depth. However, the difference that salinity makes on Mg/Ca variability of this study is an order of magnitude less than both the Mg/Ca variability between chambers from one sample, and between samples (Table 9, Appendix 2.0). Therefore salinity is not further addressed in this work as it is not considered to constitute either a primary or significant secondary control on the incorporation of Mg into the calcite lattice.

5.1 *Globigerina bulloides*: Mg/Ca-temperature relationships

Mg/Ca data for *G. bulloides* in this study has a strong correlation with observed water temperature and is in good agreement with the results of McConnell and Thunell (2005) and Cléroux et al. (2008), despite employing differing techniques for trace element analysis. Scatter in the results (Fig. 14a), is comparable to or better than that found in solution-based work, and is likely to reflect secondary effects on Mg incorporation such as carbonate ion concentration or biomineralisation in foraminiferal calcite (e.g. Elderfield and Ganssen, 2000; Cléroux et al., 2008). Such effects are evident from the significant trace element variation through the test wall and between chambers on a

single individual. The lack of offset between the McConnell and Thunell (2005) data and this study, despite measured water observed temperatures being taken from ~0 m and 200 m respectively, is most likely a reflection of surface water mixing in northern sites of this study (Weaver et al., 1997) and *G. bulloides* dwelling at deep depths with increased latitude (Mortyn and Charles, 2003; Wilke et al., 2009).

Within the adult test chambers there is considerable variability in Mg/Ca values (Fig. 14a) and, in particular, there is a significant difference between the mean of the older three visible chambers (older chamber mean) for *G. bulloides* ($f-1, f-2, f-3$) ($\text{Mg/Ca} = 0.985 \exp^{0.0712 \cdot T}$) and the final visible chamber (f) ($\text{Mg/Ca} = 0.809 \exp^{0.062 \cdot T}$) (Fig. 14a). This is interpreted to be a reflection of foraminiferal migration within the water column reflecting temperature variation with a decrease in Mg/Ca values in the final chamber. This difference between the older chamber mean, final chamber and sample mean calibrations is greater at high temperatures. For example, at 7°C the difference between the mean Mg/Ca values of the three oldest visible chambers and the final chamber is 22% whereas the difference at 19°C is 32%. As *G. bulloides* is strongly associated with phytoplankton blooms in the ocean (Mortyn and Charles, 2003), it may be expected that chambers $f-3$ to $f-1$ would have no consistent trends in their Mg/Ca test chemistry because of migration related to food source. However, spinose foraminifera are general thought to migrate down through the water column late in their life cycle as they shed their spines either to reproduce or soon after they produce gametes (Hemleben, 1989; Hilbrecht and Thierstein, 1996). We interpret the lower values of Mg/Ca in the final chamber f of *G. bulloides* to reflect this ontology. If *G. bulloides* migrates to a specific depth or oceanic boundary in the water column near the end of its lifecycle, for example, the bottom of the thermocline, then this marked change in Mg/Ca values might

be used in future studies to track the depth to these oceanographic features through time.

The primary control on the Mg/Ca signature of each of the final four chambers is interpreted to reflect the conditions of calcification, which respond to secondary effects such as position in the water column varying with ontogeny, seasonal changes and upwelling. However, the observed variability of mean Mg/Ca values from both single individuals and in a single chamber in different individuals at a specific site suggests that there are other factors contributing to the incorporation of Mg into foraminiferal calcite (Fig. 16). For example, the 5.72, 4.81, 4.05, 2.96 mmol/mol range of Mg/Ca values (Appendix 2.0) for *G. bulloides* chambers (*f*-3 – *f* respectively) at site P71 is too large to be solely due to seasonal variations in ocean temperature at depths of 200 m at this site ($< 1^{\circ}\text{C}$) (Locarnini et al., 2006). Nor can this range reflect migration through the water column. Using our sample mean Mg/Ca-temperature calibration (Fig. 14a), the $\sim 9^{\circ}\text{C}$ difference at P71 between 25 and 400 m depth, (a wider depth habitat range for *G. bulloides* at this latitude (Mortyn and Charles, 2003)) would equate to a ~ 2.2 mmol/mol range in Mg/Ca. Thus, the entire Mg/Ca variability observed in *G. bulloides* at site P71 cannot be explained by the sampled individuals residing at different depths between the sea surface and ~ 400 m depth. Similarly, the $\sim 0.7^{\circ}\text{C}$ temperature difference between surface waters and 400 m depth at site B32, which using our calibration would equate to a ~ 0.07 mmol/mol change in Mg/Ca, cannot account for the observed 1.99, 2.13, 2.31, 1.63 mmol/mol (chambers *f*-3 – *f* respectively – Appendix 2.0) range in chamber mean Mg/Ca for *G. bulloides* at this site.

Given these observations, it is likely that vital effects or species-specific biological effects which influence the individual test compositions of Mg/Ca (e.g. Russell et al.,

2004; Pena et al., 2005; Sadekov et al., 2008), also cause the range of Mg/Ca values observed in the sample means at core-top sites. Previous studies have shown that Mg/Ca values tend to increase in larger specimens (Elderfield et al., 2002). However, this is not the case for *G. bulloides* in this study as the Mg/Ca values are high in tests which are small in size (Fig. 17). The data of this study reveal no temperature dependence of the incorporation of Sr into the calcite of *G. bulloides* (Fig. 15a), which is consistent with the study of Cléroux et al. (2008).

5.2 *Globoconella inflata*: Mg/Ca-temperature relationships

There was no relationship between Mg/Ca values and observed temperature for *G. inflata* either for single sample or chamber means (Fig. 14b). This contrasts with Anand et al. (2003) and Cléroux et al. (2008) (Fig. 14b) who identified a Mg/Ca-temperature correlation for this thermocline dwelling species. The Mg/Ca values of this study are within error of the other published results, although the relatively small variations in the Mg/Ca values between chamber means within the same sample and between samples. This suggests that *G. inflata* at the cooler sites may migrate through the water column to inhabit a preferred temperature range, as opposed to occupying a specific depth range at the base of the thermocline for example. However, morphological change affects the test calcite Mg/Ca values of the individual foraminifera. Species that have a heavy coating of secondary calcite tend to produce Mg/Ca values ~0.4-1.0 mmol/mol less than that of textured or hispid forms of the foraminifera from the same sample. More research into the consistency of the relationship between lower Mg/Ca values and heavy overgrowths of secondary calcite and how this affects the Mg/Ca-temperature calibrations is required.

5.3 Comparison of solution and laser ablation trace element analysis methods for foraminiferal thermometry

The use of oxidative and/or reductive cleaning protocols prior to solution analysis of foraminifera (e.g. Martin and Lea, 2002; Barker et al., 2003) removes contaminant phases of bulk samples by progressively removing the outer layers of the foraminiferal test wall. Time-resolved trace element profiles from all LA-ICP-MS analyses in this study revealed that most foraminifera had only relatively minor contamination on the inner and outer test wall. These zones of contamination were typically removed during the first and last ~ 20 s of ablation for each 2-3 min analysis. Data corresponding to these contaminated zones were not used when calculating the trace element/Ca ratios reported here (Table 9; Figs. 12-22). However, despite the fact that all samples were treated with the same cleaning technique, some specimens were considerably more affected by contamination. In these specimens, trace element/Ca ratios were of an order of magnitude higher than primary calcite mean values. For example, Al/Ca and Mg/Ca increased by up to 2 to 3 orders of magnitude, through a significant portion of the test wall (Fig. 18).

This type of contamination affected only a single chamber in some individuals, whereas other individuals had all chambers affected. *G. bulloides* appeared to be more susceptible to contamination than *G. inflata*. The latter had no distinctive characteristics that indicated the severity of the contamination, including examination under binocular microscopy, size or weight measurements, or SEM imaging after ablation. If one of these highly contaminated individuals had been included in the data used to calculate

Figure 18. Time-resolved trace element/Ca ratio plots of selected LA-ICP-MS analyses illustrating *G. bulloides* (a) and *G. inflata* (b) tests with highly ‘contaminated’ ablation profiles. These plots highlight how contaminant phases can affect the chamber walls to varying degrees. For example (a) and (b) show contamination affecting trace element values through a segment of the test wall (from the primary integrated calcite to the inner test wall). Note that in both cases the Sr/Ca ratio relatively remains constant indicating that a constant Sr/Ca ratio does not provide a suitable indicate of whether a test contains contaminant phases.

our sample mean trace element/Ca ratios, substantial bias would have been introduced into the dataset. For example, if the entire profile for a single chamber of *G. bulloides* (Fig. 11b) from site B32 had been integrated into the sample chamber mean ($n = 17$), mean Mg/Ca would have been elevated from 1.32 mmol/mol to 4.1 mmol/mol. The sample bias effect of integrating contaminated foraminifera is particularly severe for sites where only relatively small numbers of foraminifera were analysed (e.g. site P81).

Although screening for Al/Ca (associated with clay contamination) would have identified this bias using the solution technique, the foraminiferal sample would have been homogenised and therefore the entire sample from this site would be rejected, an issue for sites with low foraminiferal abundance where re-analysis is not possible. Using *in situ* techniques, the trace element profile from only the primary calcite is integrated, preserving the integrity of the sample site mean as a whole.

5.4 Variability of Zn/Ca, Mn/Ca and Ba/Ca in Southwest Pacific water masses

Micronutrient and macronutrient concentrations help characterise biogeographically distinct water masses (Hunter and Boyd, 1999). The micronutrients Mn and Zn (Sunda and Huntsman, 1998) and Al/Ca values from this study are lower by 65-95% in SAW than in STW (Table 9). Manganese (Mn) is a scavenged particle with a very short ocean residence time (76 yr; Savenko, 2008). Zn is a key element for phytoplankton growth with a relatively short ocean residency time (510 yr), which is similar to that of Al (620 yr) (Broecker and Peng, 1982; Brand et al., 1983; Morel et al., 1991). The potential for using Zn and Mn signatures in copepods and diatoms, which are types of phytoplankton, have been evaluated by Mackie and Hunter (2005) and Elwood and Hunter (2005). Our results indicate that it is possible to distinguish the STW from SAW based on the Mn/Ca, Zn/Ca and Al/Ca values of *G. bulloides* (Fig. 12). While the typical values of these elements in foraminifera are very low (<0.10 mmol/mol) and analytical uncertainty on these elements is relatively large (ca. 100%), an order of magnitude difference is found in these trace elements/Ca between the STW and SAW (Table 9).

Mixing sites R623 and Q220 are grouped separately from the subtropical and subantarctic sites due to their proximity to water mass mixing at the STF. Site R623 is

located on the north-eastern flank of Chatham Rise (Fig. 9), where deep water eddies sourced from southern water masses propagate into the subtropical realm (Chiswell and Sutton, 1998). Site Q220 is located on the boundary between the STW and SAW near the boundary of the STF (Fig. 10). For several weeks every year an eddy is positioned in the Mernoo Saddle which forces STW southwards towards site Q220 (Greig and Gilmour, 1992; Shaw and Vennell, 2000). The trace element/Ca signal from R623 (Al/Ca, Mn/Ca, Zn/Ca Fig. 12) indicates that it is mainly influenced by STW, with peaks in Mn/Ca while Zn/Ca and Al/Ca exceed those of the other (southern) sites. The sample mean Zn/Ca and Al/Ca from site Q220 are more similar to those observed in foraminifera from STW except that the sample mean Mn/Ca is at least a factor of two less than STW sites, and is more in line with the SAW realm (Fig. 12). Zn measured in water samples from across Chatham Rise. Elwood (pers. comm., 2009) confirms the elevated concentrations in STW from LA-ICP-MS measurements, which co-vary with another key micronutrient iron (Fe) (Boyd et al., 2000). The source of the Zn and Fe is unclear, but the observed values are within the path of the ECC which extends past New Zealand's highest input rivers (Waipaoa and Waiaapu – Kniskern et al., 2009) en route to the Chatham Rise (Fig. 9).

Ba is thought to be a productivity tracer in the ocean (Dymond et al., 1992; Dean et al., 1997). However, our results indicate that Ba/Ca values exhibit no correlation with the level of productivity of the region as indicated by other proxies for productivity (e.g. sedimentation rate, chlorophyll concentrations and sediment trap data) (King and Howard, 2001; Murphy et al., 2001; Northcote and Neil, 2005).

5.5 Test weight-temperature calibration

Early research into the relationship between the size of *G. bulloides* tests and ocean temperature found a negative correlation defined by $SST (^{\circ}C) = -0.1184 \times (\text{mean } G. \text{ bulloides width in } \mu m) + 45.06$ (Malmgren and Kennett, 1978) for the southern Indian Ocean. The size-normalized test weights of planktonic foraminifera may also reflect the intensity of down-core dissolution of foraminiferal tests (Lohmann, 1995; Broecker and Clark, 2001; de Villiers, 2005). The variability in *G. bulloides* test weights from core-top and down-core observations has also been linked to changes in surface ocean carbonate ion levels (e.g. Bemis et al., 2000; Barker and Elderfield, 2002; Russell et al., 2004; Gonzalez-Mora et al., 2008; Moy et al., 2009). Barker and Elderfield (2002) explained that size-normalized test weights are heavier during glacial periods due to the primary control on shell weight being surface water carbonate ion concentration. Moy et al. (2009) used this observation to infer that recent anthropogenic increases in atmospheric CO₂ and an accompanying decrease in surface ocean carbonate ion concentration has produced the observed 30-35% reduction in weight of modern *G. bulloides* from sediment traps in the Austral Southern Ocean as compared to that of Holocene foraminifera from core-tops in the same locations.

(Fig. 19).

Figure 19. Comparison of the relationships between temperature, surface water carbonate ion concentration, Mg/Ca, and normalized weights. Dissolved carbon dioxide for *G. bulloides* is derived from surface water measurements to enable direct comparison to previous *G. bulloides* carbonate ion studies which also used this measurement for *G. bulloides* (e.g. Moy et al., 2009).

6.0 Conclusions

A LA-ICP-MS analysis of planktonic foraminifera trace element chemistry (Mg/Ca, Al/Ca, Mn/Ca, Zn/Ca, Sr/Ca, Ba/Ca) from 10 core-top sites in the Southwest Pacific Ocean, east of New Zealand has shown that: (1) Core-top Mg/Ca-temperature calibrations of *G. bulloides* can be used to determine water temperature ($0.998 \exp^{0.066 \cdot T}$ with $r^2 = 0.97$), (2) the final chamber of *G. bulloides* has a significantly lower Mg/Ca signature from earlier chambers, which may reflect the ecology of the species, for example, moving to deeper depths with ontogeny, (3) there is no clear relationship between Mg/Ca and ocean temperature for *G. inflata* and that prevents its use as a ocean paleothermometer in this region, (4) micronutrients Mn and Zn, and Al in *G. bulloides* could potentially be used to trace ocean water masses, (5) the normalised weight-temperature relationship of *G. bulloides* has the potential to be used to determine water temperature and concentrations of carbonate ion concentrations.

Acknowledgements

We would like to thank Lisa Northcote, Helen Bostock and Helen Neil from the National Institute of Water and Atmosphere for their advice and assistance with providing core-top samples and plankton tow data and Christine Prior from GNS Science, Rafter Radiocarbon Laboratory for core-top radiocarbon dates. Martin Crundwell from GNS Science provided helpful discussion about foraminiferal ecology. John Patterson and Kylie Christensen are thanked for technical assistance. Annette Bolton contributed to many helpful discussions into aspects of foraminiferal ecology.

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5.0 Synthesis, conclusions and future work

In addition to the findings presented in Chapter 4 this section presents further discussion of the results and conclusions of this thesis.

5.1 Synthesis

5.1.1 Comparison of solution- and laser-ablation based ICP-MS analytical techniques for determining foraminifera geochemistry

Both solution- and laser-ablation based ICP-MS techniques can generate accurate and precise trace element data from foraminiferal calcite. However, both analytical methods have advantages and disadvantages. While the cleaning of samples for traditional solution-based techniques is time consuming, involving a number of steps with no uniform method adopted by laboratories (e.g. Barker et al., 2003; Rosenthal et al., 2004), the cleaning method prior to LA-ICP-MS analysis is relatively simple, quick and uniform between laboratories (Eggins et al., 2003; Sadekov et al., 2005). However, once solution-based cleaning is complete the process of analysis and interpreting the solution analytical data is relatively fast, requiring little data processing, and relying on the fact that contamination has been removed during physical and chemical cleaning of the test.

Every trace element depth profile from LA-ICP-MS analysis requires careful examination to ensure that only primary calcite is incorporated into sample means (i.e. contamination are excluded), which is a relatively time consuming task. However, using traditional solution techniques, if the cleaning of foraminifera prior to analysis has been inadequate and remnants of contamination, secondary or gametogenic calcite remains,

there is no opportunity to identify contamination during analysis. The inclusion of non-primary calcite cannot be rectified post-analysis, therefore an entire sample is lost (Benway et al., 2003).

The novel ‘flow-through’ solution-based technique of analysing foraminifera overcomes many of the issues encountered using laser ablation and traditional solution-based analytical techniques. The flow-through technique analyses ~12 foraminifera where an automated, flow-through leaching module is coupled to an ICP-MS instrument for rapid time-resolved analysis (Haley and Klinkhammer, 2002; Klinkhammer et al., 2004, 2006). This novel solution technique has the advantage of precise measurement of low concentration trace elements in foraminiferal calcite, whilst still providing detailed geochemical information from test calcite as it is progressively dissolved.

However, only LA-ICP-MS analyses are able to extract detailed trace element/Ca profiles from individual foraminiferal chambers and relate this to spatial location, enabling interpretation of foraminiferal life cycle stages such as water column migration for reproductive purposes. In addition, the separate profiles enable the construction of a more generalised ecological interpretation about the biomineralisation of foraminifera test calcite, similar to that gained from the flow-through technique (Haley and Klinkhammer, 2002; Benway et al., 2003; Klinkhammer et al., 2004). However, both the detailed and generalized geochemical-based interpretations of foraminiferal ecology are obscured by traditional solution-based techniques, which homogenise large numbers of foraminifera to provide only a mean trace element/Ca value for an entire sample (see section 5.1.2).

A further advantage of the LA-ICP-MS technique is that only a minute part of the test is used allowing for further analyses to be performed (e.g. oxygen or boron isotopes). Single chamber oxygen and boron isotope analyses are now possible to perform (e.g. Kasemann et al., 2009; Kozdon et al., 2009) and provides additional information on ocean water conditions. Neither ‘flow through’ nor traditional solution-based techniques leave enough sample after analysis on which to perform additional analyses.

5.1.2 The comparability of solution and LA-ICP-MS technique developed Mg/Ca-temperature calibrations

Traditional solution and LA-ICP-MS techniques for foraminiferal trace element analysis differ in their treatment of the test and therefore could potentially produce significantly different Mg/Ca-temperature calibrations. As yet, the flow-through technique has not been used to calibrate *G. bulloides* and *G. ruber*. The number and duration of the steps, and the types of chemicals varies with the method employed varies between laboratories for traditional solution-based analysis (Barker et al., 2003). The calcite tests are crushed before undergoing several ultrasonic baths in ultraclean water. Traditional solution analysis cleaning methods may then include any (or all) of the following steps: an *oxidative step* to remove organic matter in alkali buffered 1% H₂O₂ solution, a *reductive step* whereby any remaining authigenic coating is removed in a buffered solution of hydrous hydrazine and/or, a *dilute acid leaching* step where adsorbed contaminants are removed from the test fragments in weak (0.001 M HNO₃) acid (e.g. Mashiotta et al., 1999; Dekens et al., 2002; Barker et al., 2003; McConnell and Thunell, 2005).

Currently there are two main cleaning techniques followed by researchers using solution-based analysis: one that employs oxidative and reductive stages, and the other

that uses only an oxidative step (e.g. Martin and Lea, 2002; Barker et al., 2003; Rosenthal et al., 2004). Some researchers also employ a dilute acid leaching to remove absorbed contaminants from the test fragments - a process which has been identified as causing foraminiferal calcite dissolution (Benway et al., 2003; Barker et al., 2003). Comparison of foraminiferal Mg/Ca data from different laboratories employing different cleaning techniques has revealed that Mg/Ca data may vary depending on the type and intensity of the cleaning process(es) employed (Rosenthal et al., 2004). For example, spurious datasets resulting from inconsistent or inadequate cleaning can result in mean inter-laboratory foraminiferal Mg/Ca values being offset by ± 0.6 -1.0 mmol/mol (Rosenthal et al., 2004). This is exacerbated in low temperature specimens for which Mg/Ca thermometry calibrations predict that a small error on the Mg/Ca value will propagate into a significant error in the Mg/Ca derived water temperature.

With LA-ICP-MS analysis, minimal cleaning is required and therefore minimal alteration of the test is likely (e.g. Eggins et al., 2003, Sadekov et al., 2008, 2009). Contaminated sections of the test wall can be isolated and removed from the measured LA-ICP-MS integrated element profile, thereby maintaining the integrity of the sample and reproducibility of the results. The flow-through technique does clean and dissolved the tests using hydroxylamine, diethylene triamine pentaacetic acid (DTPA), dilute HNO₃ and deionized water (Haley and Klinkhammer et al., 2002). During the cleaning process the trace element values of the leachates are immediately measured thereby ensuring that only primary calcite is used in the sample mean (Klinkhammer et al., 2004). However, differences in test wall thickness and degree of secondary/gametogenic calcite formation, means that the samples potentially still contain an element of contamination or offer a very limited primary calcite profile able to be used for mean

calculations.

Recently published Mg/Ca-temperature calibrations of *G. ruber* and *G. bulloides* are summarized in Table 10 and illustrated in Fig. 20. Published Mg/Ca-temperature calibrations for the surface dwelling *G. ruber* are generally consistent regardless of whether the Mg/Ca data were derived by *in situ* (LA-ICP-MS, ion probe) or solution techniques (Fig. 20). The differences between these published *G. ruber* calibrations are predominantly in the pre-exponential constant, which is due to dissolution and other laboratory specific factors such as different cleaning methods (Fig. 20) (Anand et al., 2003).

Mg/Ca-temperature calibrations for *G. bulloides* have been determined in five studies with the foraminifera being sourced by various methods including culturing, core-top sediments and sediment trap samples (Fig. 22, Table 10, Lea et al., 1999; Mashiotta et al., 1999; Elderfield and Ganssen, 2000; McConnell and Thunell, 2005; Clroux et al., 2008).

In contrast to the relatively consistent published calibrations for *G. ruber*, the published calibrations for *G. bulloides* (and that derived in this thesis) are clearly divided into those calibrations carried out since 2001 and those prior to 2001. This probably reflects the evolution in solution technique cleaning methods (Fig. 20). Prior to recent attempts to standardize cleaning methods employed in solution-based Mg/Ca analysis (e.g. Barker et al., 2003; Rosenthal et al., 2004), sample preparation techniques between laboratories were inconsistent, and knowledge about the effects that different cleaning treatments had on Mg/Ca values was limited. This resulted in Mg/Ca-temperature

calibrations published after 2001 predicting more moderate incorporation of Mg at higher temperatures when compared to those published prior to 2001 (Fig. 20).

Figure 20. Comparison of foraminifera Mg/Ca thermometry calibrations for the planktonic foraminiferal species *Globigerina bulloides* (black and blue) and *Globigerinoides ruber* (red and yellow) as determined by LA-ICP-MS (bold) and solution methods (normal). The blue and yellow reflect the age of the publication the calibration was published in, and therefore the cleaning technique applied. The length of each calibration line indicates the temperature range over which each calibration was established.

Three Mg/Ca-temperature calibrations for *G. bulloides* from this study are presented in Fig. 21 (chambers *f*, *f*-1, *f*-2 and *f*-3; chambers *f*-1, *f*-2 and *f*-3; and chamber *f* only) and compared to the calibrations of Cléroux et al. (2008) and McConnell and Thunell (2005). A calibration based on the three oldest analysed chambers (*f*-1, *f*-2 and *f*-3) aligns more closely with the Cléroux et al. (2008) calibration (Fig. 21). In contrast, the calibration reported by McConnell and Thunell (2005) is closest to the 4 chamber calibration presented in this thesis.

Clroux et al. (2008) and Elderfield and Ganssen (2000) (Fig. 21) have sites with higher maximum surface water carbonate ion values ($>50 \mu\text{mol/kg}$) and core-tops from greater depths ($> 1500 \text{ m}$) than those of this study and McConnell and Thunell (2005). Both factors would act to preferentially dissolve Mg from the calcite, and therefore deplete the Mg/Ca ratios. In the case of Clroux et al. (2008), there appears to be no offset in the measured Mg/Ca values (Fig. 13). Elderfield and Ganssen (2000) corrected for depth (dissolution). Neither differing carbonate ion values nor water depth are significant factors for Mg/Ca values in the study. Lea et al. (1999) and Mashiotto et al. (1999) derived the majority of their Mg/Ca values from cultured samples and therefore carbonate ion variability or sample depth will not affect these data. The observed offsets in the *G. bulloides* Mg/Ca calibrations may indicate that the dilute HNO_3 acid leaching employed by Mashiotto et al. (1999), Lea et al. (1999), Elderfield and Ganssen (2000) and Clroux et al. (2008) during sample preparation, led to partial dissolution of the final (and thinnest walled) chamber *f* of *G. bulloides*. Removal of final chamber *f*, which is shown in this study to record consistently lower Mg/Ca values, compared to the 3 older analysed chambers (Chapter 4.0), would yield a Mg/Ca calibration that predicts higher temperatures than if the final chamber was not partially digested during cleaning.

Mg/Ca-temperature calibration details for <i>Globigerina bulloides</i> and <i>Globigerinoides ruber</i>										
<i>G. bulloides</i> Calibration		Reference	Cleaning method	Temperature Range (°C)	Surface water carbonate ion (μmol/kg)	Collection method	Analysis Technique	Core-top water depth (m)	Location	Number of foraminifera/ sample
B	A									
0.94	0.069	This Study	Rinse methanol / >18.2 MΩ	6 - 19	-180 - 250	Core-top	LA-ICP-MS	580 - 3000	Southwest Pacific	7 - 26
1.00	0.066	Combined calibration	Rinse methanol / >18.2 MΩ	6 - 31	-129 - 300	Core-top / Sediment trap	LA-ICP-MS / Solution technique	485 - 4800	Southwest Pacific / Gulf of California / North Atlantic	
0.78	0.082	Cleroux et al. (2008)	Oxidative stage & dilute acid leach	10 - 17	-220 - 300	Core-top	Solution technique	480 - 4800	North Atlantic	20 - 30
1.23	0.057	McConnell and Thunell (2005)	Oxidative stage	16 - 31	-129	Sediment trap	Solution technique	480 (trap depth)	Gulf of California	
0.56	0.100	Elderfield and Ganssen (2000)	Oxidative stage	8 - 15	-250 - 300	Core-top	Solution technique	2210 - 4480	North Atlantic	
0.53	0.100	Lea et al. (1999)	Oxidative stage & dilute acid leach	16 - 27		Culture	Solution technique	2000 - 3200		3 - 5
0.47	0.107	Mashicotta et al. (1999)	Oxidative stage & dilute acid leach	8 - 22	-176	Culture / Core-top	Solution technique	110 & 4170	Subantarctic Indian Ocean & Subantarctic Atlantic Ocean	3 - 5 (culture samples)
<i>G. ruber</i> (white morphotype - where available)										
0.40	0.094	Regenberg et al. (2009)	Oxidative stage	21 - 28	-260 - 328	Core-top	Solution technique	890 - 4700	Tropical Atlantic Ocean & the Caribbean Sea	~40
0.53	0.080	Sadokov et al. (2009)	Rinse >18.2 MΩ	22 - 29	-252 - 262	Core-top	Solution technique	840 - 2550	Warm-water equatorial regions	10 - 35
0.76	0.070	Cleroux et al. (2008)	Oxidative stage	17 - 28	-220 - 300	Core-top	Solution technique	480 - 4800	North Atlantic	20 - 30
0.69	0.068	McConnell and Thunell (2005)	Oxidative stage	21 - 33	-129	Sediment trap	Solution technique	490 (trap depth)	Gulf of California	
0.34	0.102	Anand et al. (2003)	Oxidative stage	17 - 28	-253	Sediment trap	Solution technique	2600	Sargasso Sea	5 - 15
0.38	0.090	Dekens et al. (2002)	Oxidative & reductive stage	23 - 29	-179 - 264	Core-top	LA-ICP-MS	1600 - 5100	Pacific and Atlantic Ocean	25 - 40

Table 10. Published Mg/Ca-temperature calibrations for *G. bulloides* and *G. ruber*.

Figure 21. A comparison of the *G. bulloides* Mg/Ca-temperature calibrations of Cléroux et al. (2008) and McConnell and Thunell (2005) (both acquired by solution-based methods) to those from this study (LA-ICP-MS). Three calibration lines are shown from this study corresponding to chambers *f*, *f*-1, *f*-2 and *f*-3 ('4 chamber calibration', black curve), chambers *f*-1, *f*-2, *f*-3 ('3 chamber calibration', red curve) and chamber *f* only (orange curve).

Differing cleaning techniques have been previously highlighted as potentially having a significant role in determining the accuracy of Mg/Ca-temperature calibrations (Sadekov et al., 2008). Such issues surrounding the incidental dissolution of primary foraminiferal calcite during cleaning and sample preparation will inevitably lead to misinterpretation of geochemical data and inaccurate reconstructions of paleoceanographic conditions. Further investigation into the effects of cleaning protocols, particularly reductive cleaning and dilute acid leaching, on Mg/Ca measurements is necessary to ensure the reliable use of foraminiferal trace element proxies measured by solution methods. A detailed account of the cleaning methodology should be presented alongside the analytical data to ensure that a direct comparison

between analytical techniques is viable. This is particularly important when comparing data for foraminiferal species, such as *G. bulloides*, where partial dissolution of the test calcite may have a significant impact on Mg/Ca ratios derived using traditional solution techniques.

5.1.3 Selection of habitat depth for *G. bulloides* in Mg/Ca-temperature calibrations

In addition to the different analytical techniques used to derive Mg/Ca-temperature calibrations for *G. bulloides*, two different methods are commonly utilised to determine the temperatures for the calibration: 1) $\delta^{18}\text{O}$ measurements (calcification temperature), and 2) observed/calculated water temperature. As with trace element analytical techniques, both approaches have drawbacks. This study takes a conservative approach by generally using the temperature from 200 m water depth for the Mg/Ca-temperature calibration. *G. bulloides* is commonly used as an indicator for surface waters (Table 11) (e.g. Spero and Lea, 1996; Pak et al., 2004; Moy et al., 2009), where the assumed depth habitat is between 0-30 m. The Mg/Ca thermometry calibrations of McConnell and Thunell (2005) and this study are compared the depth that the water temperature was derived from appeared to make little difference (Fig. 20).

Published depth ranges for <i>G. bulloides</i>				
	Depth range (m)	Method	Measured range (m)	Location
Northern Hemisphere				
Fairbanks et al. (1980)	0 - 200	Plankton tow	0 - 200	Northern Sargasso Sea
Schiebel et al. (1997)	0 - 65 m	Plankton tow	0 - 500	Eastern North Atlantic
Pujol et al. (1995)	20 - 400	Plankton Tow	0 - 400	Mediterranean Sea
Ganssen and Kroon (2000)	Sea Surface	Core-top - $\delta^{18}\text{O}$	2010 - 4480	North Atlantic
Pak and Kennett (2002)	20 - 30 (sink with ontology)	Sediment trap - $\delta^{18}\text{O}$	0 - 480	Santa Barbara Basin
Wilke et al. (2009)	0 - 500 m (highest abundance = 25 - 300 m)	Plankton Tow	0 - 500	Canary Islands
Southern Hemisphere				
Spero and Lea (1996)	0 - 40 (ontology - deeper when juvenile)	Core-top - $\delta^{18}\text{O}$		South Chatham Rise
Mortyn and Charles (2003)	0 - 800 m (highest abundance = upper 200 m)	Plankton tow - $\delta^{18}\text{O}$	0 - 800	Southern Ocean - Atlantic sector
L. Northcote pers. com. (2008)	0 - 400 m	Core-top - $\delta^{18}\text{O}$	2850 - 4980	
		Plankton Tow	0 - 400	Southwest Pacific Ocean

Table 11. Depth ranges for *G. bulloides* determined by $\delta^{18}\text{O}$ - core-top or sediment trap measurements and stratified plankton tow abundances.

At high ocean water temperatures (e.g. equatorial regions) the choice in depth habitat could have a larger impact as there is greater stratification of the thermocline, but as *G. bulloides* is predominantly located in temperate water masses this is unlikely to have a significant impact on future applications of the calibration. Ultimately, the choice in depth for observed ocean temperatures is a generalisation, as foraminifera migrate in the water column during their life cycle. Using $\delta^{18}\text{O}$ to determine the calcification temperature of foraminifera is an alternative option. Traditional $\delta^{18}\text{O}$ techniques give a single value for a foraminifera which produces a generalised depth temperature for the entire foraminiferal life cycle. However, the estimated $\delta^{18}\text{O}$ calcification temperature and actual water temperature the foraminifera species inhabits (Wilke et al., 2009) are offset, adding another layer of analytical complexity while still producing generalised results.

5.1.4 Comparison of Zn/Ca, Mn/Ca, Al/Ca and Ba/Ca results with previous data for planktonic foraminifera

A range of ‘typical’ trace element/Ca (including Mn, Zn and Ba) values in primary planktonic foraminiferal calcite was presented by Rosenthal et al. (1999) and Lea (2003). More recently, Ferguson et al. (2008) reported data for Al, Mn, Zn and Ba in planktonic foraminifera from the Straits of Gibraltar, Mediterranean Sea (Table 12). Data for Al, Mn and Zn presented in this thesis fall within the range of ‘typical’ values for these trace elements in primary foraminiferal calcite for all elemental ratios except Ba/Ca. The minimum sample mean Ba/Ca value of this study falls inside the range of Lea (2003). However, the maximum sample mean Ba/Ca value exceeds the ranges of Rosenthal et al. (1999) and Lea (2003) by ~ 0.01 mmol/mol. The maximum value also fell outside the range presented by Ferguson et al. (2008). Of the sites investigated P81

was notable for an unusually high sample mean Ba/Ca (0.0127 mmol/mol) for *G. bulloides*. This is 0.005 mmol/mol higher than the next highest sample mean Ba/Ca value (site S938). Site P81 was also notable for the low abundance of foraminifera in the sediment sample. Its high Ba/Ca may be a reflection of low productivity that has resulted in less demand for this micro-nutrient element in the surface waters at the site. However, there was no evidence of Ba/Ca correlating with productivity at other sites and therefore the reason for elevated Ba/Ca values in this location and not at site P71 (in close proximity) remains unclear.

	Rosenthal et al. (1999)	Lea (2003)	Fergusson et al. (2008) (<i>G. bulloides</i>)	This Study (<i>G. bulloides</i>)
Al/Ca			0.52 - 2.16	0.021 - 0.30
Mn/Ca	0.01 - 0.2	0.001 - 0.1	0.0038 - 0.045	0.0014 - 0.16
Zn/Ca		0.01 - 0.075	0.020 - 0.064	0.0036 - 0.069
Ba/Ca	0.002 - 0.003	0.0005 - 0.002	0.0030 - 0.0074	0.0015 - 0.013

Table 12. Ranges in trace element/Ca values for planktonic foraminifera for Al, Mn, Zn and Ba in foraminiferal calcite (all values are given in mmol/mol). The values of Rosenthal et al. (1999) and Lea (2003) are considered ‘typical’ values for all species of planktonic foraminifera measured using traditional solution ICP-MS techniques. The values of Ferguson et al. (2008) were also measured by solution ICP-MS and give the observed ranges in *G. bulloides* from six Mediterranean Sea sites.

The Zn/Ca values of *G. bulloides* from the Mediterranean Sea (Ferguson et al., 2008) exhibit a range comparable to those from this study (Table 12), whereas the Al/Ca values are 2 to 4 orders of magnitude higher. Mn/Ca values reported here encompass the range of Ferguson et al. (2008) and extend to slighter lower and significantly higher values (Table 12). The smaller range in Mn/Ca reported by Ferguson et al. (2008) may reflect the limited extent and uniformity of surface water masses in the Mediterranean Sea compared to the Southwest Pacific with its wide range of macro- and micro-nutrients.

The Ferguson et al. (2008) *G. bulloides* study found no correlation between Mg/Ca and temperature, and the range of Mg/Ca values were an order of magnitude higher than those in this study even though both studies investigated sites within the same oceanic temperature range. Ferguson et al. (2008) concluded that this was due to elevated salinity (36-40 psu), which is both higher and significantly more varied than the salinity in this Southwest Pacific study (34.5-35.5 psu). The carbonate ion concentration (170-300 $\mu\text{mol/kg}$) and depth range (296-2654 m) from which the Ferguson et al. (2008) core-top samples were retrieved are comparable to those of this thesis (182-251 $\mu\text{mol/kg}$ and 580-3003 m respectively). High Al/Ca in foraminifera is commonly attributed to clay contamination (Rosenthal et al., 2004), which is also associated with abnormally high Mg/Ca values and therefore the high values of these elements in the Ferguson et al. (2008) dataset could be explained by contamination. However, a rigorous cleaning protocol, consisting of both oxidative and reductive stages was employed (Ferguson et al., 2008).

If the Ferguson et al. (2008) values are not due to sample contamination, pressure or temperature differences, then the only plausible primary variable of test calcification is salinity, which is known to cause offsets in biomineralisation and therefore trace element incorporation (Kisakürek et al., 2008; Sadekov et al., 2009). The extreme environmental conditions of the Mediterranean Sea caused by high salinity may prevent foraminifera from incorporating trace element/Ca in equilibrium with ocean water and therefore cause the offset in trace element concentrations.

5.1.5 Ecological interpretation of G. inflata weight data

When *G. inflata* test weights are plotted against carbonate ion concentrations of the

surface waters above the core top sites, there is an apparent grouping of sites (Fig. 22). This grouping persists after weights are normalized to size, potentially indicating changes in how this species calcifies its test in cooler conditions. There are no unique mean trace element/Ca values from SAW or P71/P81 sites (P81 = 25 μg , $n = 30$, 34.02°S, 173.51°E) (Table 9) that accompany this feature. However, a morphological change is clearly evident from visual inspection of *G. inflata* from representative SAW and STW sites. *G. inflata* from SAW typically have a smooth and glassy appearance interpreted to be a heavy coating of secondary calcite, and weigh $\sim 29 \mu\text{g}$ (Fig. 23), whereas STW sites maintain either a textured or hispid forms of the test, and have a mean weight of $\sim 15 \mu\text{g}$ (excluding sites P71 and P81) (Fig. 23).

This morphological change does affect the Mg/Ca values of the individual foraminifera. Species which have a heavy coating of secondary calcite tend to produce Mg/Ca values ~ 0.4 - 1.0 mmol/mol less than that of textured or hispid forms for the foraminifera from the same sample. When the sites are compared to the distribution of chlorophyll *a* around New Zealand, low weight *G. inflata* sites are consistently located in regions with high chlorophyll *a* in the upper surface waters (Fig. 24) (Murphy et al., 2001). This could reflect changes in pH in the upper ocean during blooms with oxidation of the descending carbon detritus affecting the concentration of carbonate ions that discourages *G. inflata* to form the glassy coat of secondary calcite (Boyd et al., 2000, Cullen and Boyd, 2008).

Figure 22. Comparison of the relationships between *G. inflata* weight (a) and normalized weight (m/g) (b) with different environmental parameters. Carbonate ion concentration data is for 200 m depth (data at 300 m were unavailable) (GLODAP).

Figure 23. SEM images of representative *G. inflata* from sites P69 (a - (STW) and B32 (b. -SAW) showing how the morphological characteristics and textures of the chambers differ between these water masses. The *G. inflata* from P69 (a) has three chambers with different textures, with chamber *f* displaying a hispid test texture. The *G. inflata* from B32 (b) has an increased amount of secondary calcite. *G. inflata* with this degree of morphological change was only identified at sites B32, D178, D178 (SAW) and P71 (STW).

Figure 24. New Zealand chlorophyll-*a* levels from (a) October 1998 - spring, (b) March 1999- autumn, (adapted from Murphy, 2001). Sites with mean *G. inflata* test weights >25 μg are given black circles, and those <16 μg white circles.

5.2 Conclusions

LA-ICP-MS trace element analysis (Mg, Al, Mn, Zn, Sr, and Ba) of the planktonic foraminifera species *Globigerina bulloides* and *Globorotalia inflata* from 10 core-top sites in the Southwest Pacific Ocean, east of New Zealand has shown that:

(1) Core-top Mg/Ca-temperature equations of *G. bulloides* can be reliably used to construct water temperatures. Data from this study gives a calibration of

$$\text{Mg/Ca} = 0.941 \exp^{0.0693 \cdot T} \text{ with } r^2 = 0.95$$

for a temperature range of 6-19°C. Combining data from this study with that of McConnell and Thunell (2005), extends the temperature range from 6-33°C and yields a calibration of

$$\text{Mg/Ca} = 0.998 \exp^{0.066 \cdot T} \text{ with } r^2 = 0.97$$

This calibration can be applied to *G. bulloides* Mg/Ca-thermometry as measured by LA-ICP-MS (chambers *f* – *f*-3) and traditional solution-based ICP-MS techniques, when a dilute acid leach has not been used.

(2) The final chamber (*f*) of *G. bulloides* records a significantly different Mg/Ca signature from earlier chambers (*f*-1, *f*-2 and *f*-3). The difference in Mg/Ca values between the final and older chambers are more moderate at cooler water temperatures. This feature is interpreted to reflect the ecology of the species, e.g., migration of individuals down to the thermocline for reproduction late in the life cycle.

(3) *G. inflata* does not have a clear relationship between Mg/Ca and ocean temperature. This may reflect the residence of this species within a limited temperature range in the

water column, yielding minor Mg/Ca variability between sites.

(4) Foraminiferal Mn/Ca, Ba/Ca, Al/Ca and Zn/Ca values are within the ranges of previously published values. Of special note are the micronutrients Mn/Ca and Zn/Ca, and Al/Ca concentrations in *G. bulloides*, which potentially identify ocean water masses where trace element/Ca ratios in test calcite vary by at least an order of magnitude between STW and SAW. To assess the validity of these observations further analysis of foraminifera from high resolution, Holocene, sediment cores are required. This would allow observation of these elements during a period of ~10 ka where ocean conditions have been relatively stable and, therefore, the concentrations of these elements should also remain stable if the foraminifera are incorporating the element in equilibrium with ocean concentrations.

(5) A correlation between size normalised test weights of *G. bulloides*, water temperature and carbonate ion is observed, suggesting that these relationships could be developed as a potential proxy to reconstruct past water temperatures and carbonate ion concentrations. Weight variability in *G. inflata* is neither a function of temperature, nor carbonate ion concentration in the water column. However, there is potentially a relationship between *G. inflata* normalized test weight and chlorophyll-*a* levels.

(6) LA-ICP-MS and solution-based techniques for analysing *G. bulloides* Mg/Ca values in foraminiferal calcite are compatible only in instances where: (i) partial dissolution of primary test calcite **does not** occur during reductive, oxidative and dilute acid leaching cleaning techniques prior to solution analysis, or (ii) by comparing the mean values of chambers *f*-1, *f*-2 and *f*-3 of *G. bulloides* measured by LA-ICP-MS when partial

dissolution of primary calcite occurred during cleaning for solution analysis.

(7) LA-ICP-MS analysis is more effective for analysis of samples with limited numbers of foraminifera. However, heterogeneity within tests means that there is the potential for samples to be biased using this technique if only a single chamber from an individual foraminifera within a sample is used. Solution analysis is effective for analysing large numbers of foraminifera and producing a mean result for the entire foraminiferal life cycle. This technique dilutes any potential heterogeneity bias due to the large quantity of foraminiferal calcite analysed.

(8) Future work will apply the *G. bulloides* calibration to a down-core study. Based on the results of this study, the recommended approach for large foraminiferal sample sizes (>12 foraminifera tests) is to use the mean of two analyses from a single chamber, *f-1*, in conjunction with this study's calibration for chambers *f-1*, *f-2*, *f-3*. For small sample sizes (<12 foraminifera) chambers *f-1*, *f-2*, *f-3* need to be analysed twice each to account for natural trace element/Ca heterogeneity in foraminiferal test calcite. However, if the results are used in conjunction with $\delta^{18}\text{O}$ or solution-based ICP-MS methods, which do not utilize a dilute an acid leach, then analyzing chambers *f*, *f-1*, *f-2*, and *f-3* is recommended for comparability between the results.

5.3 Suggestions for future studies

The results of this study have identified a number of areas of potential future work:

(1) Assess the use of normalised weight-temperature relationship for *G. bulloides* as an independent paleotemperature proxy using more core-top, sediment trap and plankton tow samples with larger sample sizes in conjunction with water carbonate ion analyses.

(2) Assess the possible impact of diagenetic alteration of foraminiferal calcite in areas with low sedimentation rates by conducting sediment trap studies and comparing with the core top results from this study.

(3) Assess the possible influence of the carbonate ion effects at shallow depths (upper 400 m – above thermocline) by setting a number sediment traps at a variety of water column depths and comparing the Mg/Ca values against that data obtained for core-top and stratified plankton tow. This should be conducted in areas of high and low algal productivity (high and low chlorophyll *a*).

(4) Conduct stratified plankton tow studies throughout areas using observed strata-specific water temperatures to ensure that the temperatures selected for Mg/Ca-temperature calibrations are valid. Such studies could also (i) establish whether water mass stratification impacts on the preferred depth range of the species in the water column and (ii) evaluate the ecological behaviour of *G. bulloides* and assess Mg/Ca values in the final chamber of *G. bulloides* relative to the earlier chambers, and assess if this is a feature of habitat migration or biomineralisation.

- (5) Extend the lower range of the *G. bulloides* Mg/Ca-temperature calibration through analysis of core top samples from Southern Ocean sites. This would enhance the reliability of down-core studies that extend back to the Last Glacial Maximum and other cold intervals.
- (6) Determine a technique to assess the thickness of the diagenetic secondary calcite layer on the foraminiferal test using cross-sections of the *f* test wall and SEM-microprobe analysis and evaluate any bearing on the trace element chemistry of the primary calcite, i.e. establish whether tests are more susceptible to recrystallisation.
- (7) Conduct longitudinal sediment trap sampling of planktonic foraminifera to capture short term environmental oscillations and any associated geochemical responses related to, for example, the Inter-decadal Pacific Oscillation or El Nino-La Nina cycles.
- (8) Measurement of oxygen isotopes and Mg/Ca on the same individuals at both the whole foraminiferal (solution-based methods) and single chamber (ion microprobe and LA-ICP-MS) scales. This would be insightful if the foraminifera were collected by several different methods (e.g. core-top, sediment trap, and plankton tow) to determine any offsets in thermometry proxy values and potential impacts of diagenetic effects on test chemistry. Measurement of the $\delta^{18}\text{O}$ calcification temperature of individual chambers, using ion probe methods (Kozdon et al., 2009) and followed by Mg/Ca determination by LA-ICP-MS, may allow derivation of chamber-specific Mg/Ca-temperature calibrations. This would be particularly useful in developing a specific final chamber Mg/Ca-temperature calibration for *G. bulloides* and verifying the lower Mg/Ca values recorded by chamber *f* reflects depth migration to deeper, cooler waters later in its life cycle.

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Appendix 1.0 Analytical Methods

A1.1 Sample Preparation

Fossil tests of each species (*G. bulloides*, *G. inflata*) were obtained from a small number of modern, deep ocean core tops (Table 6, Fig. 9). Each core top sample of *G. bulloides* and *G. inflata* consisted of between 8 and 30 tests randomly picked from a sieved 150 – 350 µm sediment size fraction. Given that not all of the foraminifera were of this size range, some larger individuals were also picked for analysis for purposes of comparison.

The foraminifera tests were cleaned prior to LA-ICP-MS analysis by ultrasonication for 2–3 s in ultra-pure water (>18.2 MΩ), followed by two additional >18.2 MΩ water and AR-grade methanol rinses to remove clay and other detrital material (e.g. nano-fossils). Trials of analytical protocols for cleaning of core-top samples showed that ultrasonic cleaning for longer than 3 s often resulted in significant damage to the foraminifera tests. Samples that were identified under the binocular microscope for additional cleaning to remove, for example, remaining clays or nanofossils, underwent an additional two cycles of ultrasonic cleaning in >18.2 MΩ water if the chamber strength was determined to be able to withstand further ultrasonic cleaning, based on the effect of previous cleaning and the force needed to crush one foraminifera. The foraminifera were then dried overnight at 40 °C in a fan oven.

Each foraminifera was individually weighed on a Mettler Torledo (MX/UMX 2) balance before being mounted onto a wafer of the silicate glass NIST 610 standard for LA-ICP-MS analysis (Fig. A1). Analytical uncertainty of these weight measurements

are $< \pm 5\%$ (2 SD relative) based upon 15 replicate measurements of a single *G. bulloides* test weighing $8.7 \mu\text{g}$ (Table A1). The difference between maximum and minimum mean weights between sites are $15.2 \mu\text{g}$ for *G. bulloides* and $23.1 \mu\text{g}$ for *G. inflata* which far exceeds the uncertainty of individual weight measurements. Prior to analysis, the sample was loaded onto the sample tray (Fig. A2) and placed into the sample cell in the New Wave laser ablation system. A depth profiling technique using a 193 nm solid state laser coupled to an Agilent 7500CS ICP–MS system was then used to measure trace element depth profiles through the foraminifera test walls (Table A2).

Figure A1. Plain-light photograph of a polished silicate glass standard NIST 610 with several core-top samples of foraminifera mounted on it using double sided cellotape.

Figure A2. Schematic illustration of laser ablation sample chamber. (a) and (c) are blanks used to stabilise the signal through improved mixing of the helium and laser-produced aerosol in the chamber and enhance the precision of the analysis, (b) NIST 610 such as that in Fig. A1.

Analysis number	Weight (µg)
1	18.9
2	18.6
3	19.4
4	18.9
5	18.9
6	19.7
7	18.7
8	18.6
9	18.6
10	17.7
11	18.3
12	19.4
13	19.0
14	18.5
15	19.2
Mean	18.8
2SD	1.0

Table A1. Weight measurements for a *G. bulloides* individual repeatedly weighed.

Laser ablation	
Laser ablation system	New Wave 193 nm (deep UV) solid state
Ablation mode	Static spot analyses
Spot size	25 µm
Depth ablated/pulse	~ 0.1 µm
ICP-MS	
ICP-MS system	Agilent 7500CS
Acquisition mode	Peak hopping
Detection mode	Pulse counting
Tuning	
Tuning standard	NIST 610
Ablation mode	Rastering (2 µm/s) beneath a 25 µm spot
Monitored isotopes	²⁴ Mg, ²⁷ Al, ⁴³ Ca, ⁵⁵ Mn, ⁶⁶ Zn, ⁸⁸ Sr, ¹³⁸ Ba (% RSD for each isotope typically 4 - 8%)
Carrier gas (Ar)	0.83–0.90 L/min
Ablation gas (He)	77–90%
RF power	1500 W
RF matching	1.72 V
Repetition rate	2 - 5 Hz
Laser power	60%
Standards and calibration	
Calibration standard	NIST-SRM610
Repetition rate	5 Hz
Laser power	60%
Background acquisition	60 s
Sample data acquisition	60 s
Washout time	120 s
Measured isotopes	²⁴ Mg, ²⁷ Al, ⁴³ Ca, ⁵⁵ Mn, ⁶⁶ Zn, ⁸⁸ Sr, ¹³⁸ Ba
Dwell time	10 ms
Foraminifera Method	
Repetition rate	2 or 5 Hz
Laser power	45 or 50 %
Background acquisition	60 s
Sample data acquisition	180 or 120 s
Washout time	120 s
Measured isotopes	²⁴ Mg, ²⁷ Al, ⁴³ Ca, ⁵⁵ Mn, ⁶⁶ Zn, ⁸⁸ Sr, ¹³⁸ Ba
Dwell time	10 ms

Table A2. Summary of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) instrumental and analytical conditions.

A1.2 Trace Element Analytical Methods

The two primary analytical techniques used to analyse the trace element concentrations of foraminifera are LA-ICP-MS and solution ICP-MS techniques where the primary difference is the ability to analyse specific regions on individual foraminifera (LA-ICP-MS) compared to a acid-digested sample of multiple foraminifera (solution ICP-MS technique). Mg/Ca results produced using the solution technique from laboratories operating under different protocols (standards and foraminifera samples) has highlighted significant variability and highlighted the need for development and standardisation of techniques (Rosenthal et al., 2004). This study utilises the LA-ICP-MS technique but a brief summary of the solution technique is also described below.

A1.2.1 Solution technique

Solution techniques have traditionally been used to analyse trace element concentrations in foraminifera. The technique involves the acid dissolution of generally >6 foraminifera for analysis. Cleaning of the foraminifera prior to dissolution involves a number of steps, including dilute HNO₃ acid leaching and oxidative/reductive cleaning (e.g. Martin and Lea, 2002; Barker et al., 2003; Rosenthal et al., 2004). As the foraminifera are homogenised by crushing the foraminifera between glass slides at the start of the cleaning process, it is imperative that the selected sample is free from individuals affected by dissolution and/or recrystallised calcite, in addition to the species being correctly identified (excluding juveniles and morphotypes). Furthermore, the cleaning process also has to ensure that robust individuals with the heaviest encrustation of secondary calcite and/or gametogenic calcite are thoroughly cleaned, whilst ensuring that sample size is not

significantly reduced through early dissolution (and disposal) of thinner walled specimens, which is an issue that becomes significant for smaller sample sizes (Ferguson et al., 2008).

A1.2.2 LA-ICP-MS technique

LA-ICP-MS techniques are increasingly being used to analyse the trace element chemistry of foraminifera (e.g. Hathorne et al., 2003; Eggins et al., 2003; 2004; Pena et al., 2005; Sadekov et al., 2008, 2009). A key advantage of using laser ablation techniques is that the foraminiferal test is preserved for further analytical work (e.g. oxygen isotopes) or examination by electron microscopy. If a species identification error is made or an individual test is contaminated, the individual can be excluded post-analysis. It is also possible to screen each LA-ICP-MS analysis to exclude zones of contamination which ensures that only the primary calcite is integrated into the final foraminiferal profiles and included in the final data analysis (Eggins et al., 2003; Sadekov et al., 2008).

Before conducting analysis of foraminifera, the LA-ICP-MS system was tuned to maximise signal sensitivity and stability (Table A2). During the tuning the relative standard deviations (RSD) of the ion signals are monitored ($\leq 7\%$) to ensure stability. Each depth profile analysis through foraminifera generally required between 120 to 180 s of ablation time. It should be noted that although each laser pulse shaves a uniform thickness (~ 10 nm) from the ablated material leaving a flat bottomed pit in materials such as the silicate glass standard, reduced laser fluence, absorption and increased reflection at inclined surfaces means that uniform ablation does not occur across the target site of either *G. inflata* or *G. bulloides* (e.g. Eggins et al., 2003).

The laser power and repetition rate were adjusted for the foraminifera samples to ensure a depth profile of at least 60 s was generated through a test wall and to ensure that the primary calcite component of the test wall was penetrated so a full geochemical depth profile could be assessed. Samples with thicker and more robust tests were ablated at 50% and 5 Hz (e.g. *G. inflata* from B32) and samples with delicate/thinner tests were ablated at 45% and 2 Hz (e.g. *G. bulloides* from P81).

Backgrounds were measured for 60 s before ablating either the standard or samples. Standard measurement of NIST-SRM610 was carried out before and after every subsequent 8–9 foraminifera analyses. Instrumental elemental fractionation as recorded by standard element/Ca values does not vary significantly over (< 2%) this period of analysis. After analysis of a foraminifera core-top sample, the foraminifera were double carbon coated (~25 nm thick) and images taken using an electron microprobe (JEOL 733 Superprobe) to measure length, examine potential sources of contamination at the chamber sites that were ablated, and confirm species identification (such as excluding juveniles and morphotypes from the data (Appendix 2.0)).

Foraminiferal calcite in an individual is not homogeneous as it is precipitated at different times over the life cycle of the foraminifera. Trace elements concentrations have been shown to vary significantly between (inter-) and within (intra-) chambers of individual foraminifera (e.g. Eggins et al., 2004; Sano et al., 2005; Sadekov et al., 2009). Reproducibility of LA-ICP-MS analysis of foraminiferal tests was tested by repeated ablation of a single foraminifera chamber. This experiment was repeated for

all four chambers tested on *G. bulloides* (*f* x 4; *f*-1 x 5; *f*-2 x 3; *f*-3 x 2) (Table A3).

The internal precision of trace element/Ca ratios for the foraminifera data estimated from repeated analyses of *G. bulloides* are typically: Mg/Ca $\pm$ 4.5%, Al/Ca $\pm$ 53.9%, Mn/Ca $\pm$ 9.9%, Zn/Ca $\pm$ 13.2%, Sr/Ca $\pm$ 2.3%, Ba/Ca $\pm$ 22.9% (n=14; 2 se relative).

***G. bulloides* - S793 - *f*23**

						Chamber		
Chamber 1						mean	2sd	% 2se
Mg/Ca	3.821	3.584				3.703	0.336	6.4
Al/Ca	0.133	0.170				0.152	0.051	23.9
Mn/Ca	0.164	0.164				0.164	0.001	0.3
Zn/Ca	0.073	0.075				0.074	0.002	1.7
Sr/Ca	1.351	1.324				1.337	0.039	2.1
Ba/Ca	0.010	0.010				0.010	0.0002	1.2
Chamber 2								
Mg/Ca	3.037	2.968	3.068			3.025	0.102	2.0
Al/Ca	0.098	0.069	0.336			0.167	0.293	101.2
Mn/Ca	0.109	0.110	0.121			0.113	0.014	7.1
Zn/Ca	0.040	0.044	0.041			0.042	0.004	5.1
Sr/Ca	1.303	1.271	1.220			1.265	0.084	3.8
Ba/Ca	0.010	0.010	0.022			0.014	0.014	58.3
Chamber 3								
Mg/Ca	2.049	2.262	2.206	2.187	1.938	2.128	0.264	5.6
Al/Ca	0.560	0.211	0.846	0.474	1.098	0.638	0.685	48.1
Mn/Ca	0.050	0.072	0.073	0.068	0.036	0.060	0.033	24.4
Zn/Ca	0.027	0.040	0.032	0.026	0.022	0.029	0.014	21.3
Sr/Ca	1.339	1.320	1.288	1.315	1.310	1.315	0.037	1.2
Ba/Ca	0.008	0.011	0.012	0.011	0.008	0.010	0.004	18.9
Chamber 4								
Mg/Ca	1.236	1.324	1.200	1.282		1.260	0.108	4.3
Al/Ca	0.245	0.244	0.073	0.224		0.196	0.166	42.3
Mn/Ca	0.056	0.059	0.061	0.067		0.061	0.009	7.7
Zn/Ca	0.028	0.048	0.044	0.032		0.038	0.019	24.8
Sr/Ca	1.199	1.183	1.189	1.242		1.203	0.053	2.2
Ba/Ca	0.008	0.008	0.010	0.009		0.009	0.002	13.3

Table A3. Repeated ablation of an individual *G. bulloides* chambers from site S793.

LA-ICP-MS analyses of the trial carbonate standard produced by Gert-Jan Reichart (Utrecht University, The Netherlands) revealed variable levels of repeatability using laser ablation analysis (Table A4) (unpublished data, Bolton and Dunbar, 2008). However, as the standard is chemically precipitated it is likely to have heterogeneous trace element concentration distributions throughout the standard and, therefore, these values represent the worst case scenario for the analytical reproducibility of this study. The low concentration elements (Al, Zn, Ba) show even less repeatability as

the detection limits of the LA-ICP-MS system are approached for these elements with very low concentrations in the standard (e.g. Al/Ca, Zn/Ca, Ba/Ca). Accuracy as assessed by comparison between solution ICP-OES (unpublished data, Reichart and Wit, 2008) and LA-ICP-MS data (unpublished data, Bolton and Dunbar, 2008) was revealed to be Mg/Ca = -3.6%, Al/Ca = -12%, Mn/Ca = -9.6%, Zn/Ca = -57%, Sr/Ca = -6.0%, Ba/Ca = -98%. Thus the two methods yield comparable data, particularly considering the different sampling scale of the two techniques, for most elemental ratios except Ba/Ca where the synthetic carbonate standard Ba concentrations were too low to be measurable by LA-ICP-MS (Fig. A3). This suggests that the ‘bulk’ sample may contain Ba-rich areas not samples by LA-ICP-MS.

ICP-OES	1	2	3	4	5	6	7	8	9	Mean	2SD	%2SD
Mg/Ca	3.28	3.40	3.34	3.23	3.24	3.34	3.22	3.22	3.26	3.28	0.13	4.1
Al/Ca	0.0319	0.0273	0.0288	0.0258	0.0244	0.0382	0.0291	0.0322	0.0310	0.0299	0.0082	28
Mn/Ca	0.210	0.215	0.213	0.210	0.215	0.213	0.210	0.211	0.212	0.212	0.0040	1.9
Zn/Ca	0.00620	0.00516	0.00573	0.00574	0.00504	0.00576	0.00520	0.00624	0.00571	0.00564	0.00086	15
Sr/Ca	0.232	0.234	0.233	0.233	0.228	0.231	0.233	0.231	0.229	0.232	0.0041	1.8
Ba/Ca	0.00128	0.00176	0.00040	0.00090	0.00178	0.00201	0.00109	0.00126	0.00124	0.00130	0.00099	76
LA-ICP-MS										Mean	2SD	%2SD
Mg/Ca	3.26	3.27	3.18	3.10	3.12	3.04				3.16	0.18	5.6
Al/Ca	0.0230	0.0160	0.0252	0.0205	0.0266	0.0464				0.0263	0.021	80
Mn/Ca	0.192	0.193	0.188	0.188	0.195	0.195				0.192	0.0058	3.0
Zn/Ca	0.00164	0.00159	0.00031	0.00017	0.00618	0.00464				0.00242	0.0049	200
Sr/Ca	0.227	0.224	0.209	0.212	0.217	0.217				0.218	0.013	6.1
Ba/Ca	0.0000367	0.0000294	-0.0000062	0.0000235	0.0000062	0.0000478				0.0000229	0.000040	170

Table A4. Measured trace element/Ca values for the trial carbonate standard using LA-ICP-MS and ICP-OES. All values are given in mmol/mol.

Figure A3. Comparison between trace element/Ca values for the synthetic carbonate standard measured by LA-ICP-MS (blue) and ICP-OES (purple).

A1.3 LA-ICP-MS data reduction

During LA-ICP-MS analysis increased ion transmission with increasing mass of an isotope causes deviations of measured elemental ratios from true elemental ratios (Rosenthal et al., 1999). Unfortunately, there is no homogeneous carbonate standard currently available which matches the matrix of foraminifera and, therefore, a silicate glass standard (NIST-SRM610) was used in this study for correction of instrumental fractionation effects. Elemental fractionation is corrected for by external normalisation to NIST-SRM610 (reference values used: Mg/Ca = 9.38, Al/Ca = 195.9, Mn/Ca = 3.86, Zn/Ca = 3.42, Sr/Ca = 2.78, Ba/Ca = 1.51 mmol/mol, Pearce et al., 1997), after correcting standard and sample data for background on the analyte isotopes. Percentage of total signal for the monitored isotope that is made up from background (gas blank during a typical analysis of a foraminifera) on the analytical isotopes are typically: ^{24}Mg = 0.09%, ^{27}Al = 1.45%, ^{55}Mn = 80.7%, ^{66}Zn = 4.58%, ^{88}Sr = 0.03%, ^{138}Ba = 0.74%. After data normalisation, each trace element depth profile was screened for outliers before being integrated into the sample data set (Fig. A4).

There are distinct and often recurring changes in the test chemistry observed through the test walls of the foraminifera in this study: (1) the outer test has elevated levels of all elements in a zone of varying thickness (2) stepwise changes through the profile to higher or lower trace element/Ca values (3) the inner test wall, which is also elevated in trace elements such as Mn/Ca or Al/Ca (Fig. A5). Outer (1) and inner (3) parts of the test which are not part of the primary foraminiferal calcite were not included in the average trace element/Ca values calculated for each profile (Fig. A5). After the individual test wall profile has been interrogated, all analyses from a sample are

graphed onto bivariate plots and individual outliers removed from the sample (Fig. A6).

Figure A4. Schematic flow diagram showing the method used to generate and process trace element (TE)/Ca data for modern foraminifera.

Figure A5. An example of a foraminiferal trace element profile through the test wall of *G. inflata* generated from a single LA-ICP-MS analysis. This profile is a 3 min analysis of a single 25 μm spot. (1) and (3) are sections through the test wall with elevated trace element/Ca whereas values section (2) of the profile represents that integrated into mean sample values. In section (2) of the profile a stepwise variation in the trace element ratios results in an increase in Mg/Ca, Ba/Ca values, a decreases in Al/Ca while Sr/Ca remains constant.

Figure A6. Example of a bivariate plot of all Al/Ca and Sr/Ca analyses from sample P71 - *G. bulloides*. Green = chamber *f*-3, yellow = chamber *f*-2, light blue = chamber *f*-1, dark blue = chamber *f* analyses. Circled in red are the sample outliers. All elemental ratios derived from each analysis in the red circles are removed from the sample and chamber mean.

Once the data have been processed for individual foraminifera it is then compiled into chamber and sample means for each core-top. Trace element/Ca values are then plotted against environmental parameters such as temperature, salinity, water depth, water mass, and foraminifera normalised weight data to identify trends and assess the degree to which temperature is the primary control over Mg/Ca values in the foraminifera species.

Appendix 2.0 – Summary of the chamber mean trace element/Ca values for the sites examined in this study

Trace element/Ca values by chamber for *G. bullioides* and *G. inflata*

<i>G. bullioides</i>				<i>G. inflata</i>			
Chamber 1				Chamber 1			
P71	3.034	3.025	2.875	1.881	1.873	1.885	1.885
Mg/Ca	0.146	0.189	0.118	0.078	0.113	0.133	0.133
Al/Ca	0.0250	0.021	0.0227	0.002	0.002	0.0024	0.0024
Mn/Ca	0.024	0.031	0.040	0.006	0.006	0.011	0.011
Zn/Ca	1.211	0.139	1.372	0.225	0.225	1.385	1.385
Sr/Ca	0.0018	0.002	0.0173	0.075	0.075	0.0025	0.0025
Ba/Ca							
Chamber 2				Chamber 2			
P71	2.885	2.338	2.874	2.126	2.126	2.885	2.885
Mg/Ca	0.133	0.169	0.1077	0.113	0.113	0.133	0.133
Al/Ca	0.0237	0.039	0.01370	0.022	0.022	0.0237	0.0237
Mn/Ca	0.028	0.030	0.033	0.009	0.009	0.028	0.028
Zn/Ca	1.215	0.223	1.388	0.228	0.228	1.385	1.385
Sr/Ca	0.0017	0.001	0.0130	0.075	0.075	0.0025	0.0025
Ba/Ca							
Chamber 3				Chamber 3			
P71	2.874	2.539	2.022	1.066	1.066	2.874	2.874
Mg/Ca	0.134	0.166	0.092	0.131	0.131	0.134	0.134
Al/Ca	0.0248	0.025	0.01599	0.010	0.010	0.0248	0.0248
Mn/Ca	0.022	0.026	0.061	0.072	0.072	0.022	0.022
Zn/Ca	1.230	0.184	1.389	0.298	0.298	1.370	1.370
Sr/Ca	0.0017	0.001	0.0104	0.069	0.069	0.0025	0.0025
Ba/Ca							
Chamber 4				Chamber 4			
P71	1.893	1.584	1.875	1.066	1.066	1.893	1.893
Mg/Ca	0.082	0.107	0.084	0.068	0.068	0.082	0.082
Al/Ca	0.0235	0.023	0.01350	0.077	0.077	0.0235	0.0235
Mn/Ca	0.033	0.026	0.044	0.063	0.063	0.033	0.033
Zn/Ca	1.238	0.224	1.402	0.179	0.179	1.370	1.370
Sr/Ca	0.0013	0.001	0.0102	0.073	0.073	0.0025	0.0025
Ba/Ca							
Chamber 1				Chamber 1			
P71	1.250	0.880	1.250	0.880	0.880	1.250	1.250
Mg/Ca	0.044	0.045	0.044	0.045	0.045	0.044	0.044
Al/Ca	0.0169	0.039	0.0169	0.039	0.039	0.0169	0.0169
Mn/Ca	0.016	0.026	0.016	0.026	0.026	0.016	0.016
Zn/Ca	1.304	0.221	1.304	0.221	0.221	1.304	1.304
Sr/Ca	0.0030	0.006	0.0030	0.006	0.006	0.0030	0.0030
Ba/Ca							
Chamber 2				Chamber 2			
P71	1.223	0.707	1.223	0.707	0.707	1.223	1.223
Mg/Ca	0.052	0.053	0.052	0.053	0.053	0.052	0.052
Al/Ca	0.0133	0.029	0.0133	0.029	0.029	0.0133	0.0133
Mn/Ca	0.014	0.031	0.014	0.031	0.031	0.014	0.014
Zn/Ca	1.346	0.173	1.346	0.173	0.173	1.346	1.346
Sr/Ca	0.0020	0.003	0.0020	0.003	0.003	0.0020	0.0020
Ba/Ca							
Chamber 3				Chamber 3			
P71	1.783	1.011	1.783	1.011	1.011	1.783	1.783
Mg/Ca	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Al/Ca	0.0244	0.041	0.0244	0.041	0.041	0.0244	0.0244
Mn/Ca	0.046	0.039	0.046	0.039	0.039	0.046	0.046
Zn/Ca	1.435	0.115	1.435	0.115	0.115	1.435	1.435
Sr/Ca	0.0037	0.005	0.0037	0.005	0.005	0.0037	0.0037
Ba/Ca							

Appendix 3.0 – Summary of chemical, weight and size data for foraminifera

3.1 *G. bulloides*

3.2 *G. inflata*

Note: When picked under transmitted light microscopy, this individual was thought to be a *G. bulloides*. However, analysis of the SEM image shows that it is not *G. bulloides*. Therefore, the trace element chemistry of this foraminifera was excluded from the final dataset.

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	1.14	2.21	1.01	1.82
Al/Ca	0.381	8.10	0.0734	22.4
Mn/Ca	0.0431	13.3	0.00178	162
Zn/Ca	-0.00203	336	0.00557	70.7
Sr/Ca	1.19	1.91	1.22	1.59
Ba/Ca	0.00168	46.7	0.000855	48.0

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.63	1.62	1.10	1.83
Al/Ca	0.140	12.8	0.0749	29.6
Mn/Ca	0.00587	53.6	-0.000547	709
Zn/Ca	0.0153	27.8	0.00486	125
Sr/Ca	1.11	1.58	1.17	1.47
Ba/Ca	0.00115	40.5	0.00137	52.9
Test weight (µg)	25.1			
Test length (µm)	396			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	5.34	2.47	3.60	2.36
Al/Ca	0.0537	38.6	0.0416	39.5
Mn/Ca	0.0247	20.3	0.00837	31.0
Zn/Ca	0.0422	15.1	0.0538	8.56
Sr/Ca	1.28	2.32	1.33	2.26
Ba/Ca	0.00321	18.8	0.00331	115

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.59	1.91	1.93	2.27
Al/Ca	0.0913	22.4	0.0144	140
Mn/Ca	0.0113	28.8	0.00272	130
Zn/Ca	0.0311	17.6	0.0235	25.4
Sr/Ca	1.26	1.82	1.26	2.33
Ba/Ca	0.00193	29.7	0.00167	38.7
Test weight (µg)	7.3			
Test length (µm)	325			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	1.38	2.98	0.711	2.49
Al/Ca	0.211	9.78	0.0828	23.6
Mn/Ca	0.108	15.1	0.0932	7.51
Zn/Ca	0.0293	58.3	0.0137	33.1
Sr/Ca	1.20	3.06	1.33	2.12
Ba/Ca	0.0889	11.3	0.00249	21.0

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.908	2.34	1.06	1.91
Al/Ca	0.278	12.1	0.0261	61.4
Mn/Ca	0.0534	5.25	0.0484	7.66
Zn/Ca	0.00968	31.1	0.0161	24.8
Sr/Ca	1.33	1.92	1.32	1.38
Ba/Ca	0.00761	4.06	0.0327	7.34
Test weight (µg)	7.8			
Test length (µm)	319			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	4.36	1.47	3.74	1.45
Al/Ca	0.0972	16.6	0.0477	30.9
Mn/Ca	0.0391	7.69	0.0192	11.6
Zn/Ca	0.0431	22.1	0.0281	12.8
Sr/Ca	1.26	1.39	1.33	1.65
Ba/Ca	0.00102	42.1	0.00101	35.0

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	5.01	2.19	3.17	2.06
Al/Ca	0.189	8.44	0.101	17.7
Mn/Ca	0.0462	8.37	0.0479	14.0
Zn/Ca	0.0337	14.1	0.0571	10.1
Sr/Ca	1.34	1.38	1.26	1.77
Ba/Ca	0.00184	23.6	0.00176	26.6
Test weight (µg)	9.5			
Test length (µm)	345			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.23	1.88	1.70	1.67
Al/Ca	0.0615	22.9	0.332	5.41
Mn/Ca	0.0302	9.67	0.0544	7.84
Zn/Ca	0.0197	28.6	0.0292	12.8
Sr/Ca	1.18	1.47	1.06	1.57
Ba/Ca	0.00115	27.7	0.00148	25.7

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.33	1.29	0.81	1.86
Al/Ca	0.153	8.23	0.103	15.6
Mn/Ca	0.0243	12.6	0.0178	15.8
Zn/Ca	0.0122	21.4	0.0292	12.9
Sr/Ca	1.12	1.33	1.11	1.64
Ba/Ca	0.00109	27.1	0.00108	30.6
Test weight (µg)	10.2			
Test length (µm)	335			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.76	2.48	1.95	2.22
Al/Ca	0.145	18.9	0.353	6.36
Mn/Ca	0.0482	10.5	0.0520	13.9
Zn/Ca	0.0372	17.3	0.0308	33.2
Sr/Ca	1.20	3.48	1.15	2.13
Ba/Ca	0.00631	12.4	0.0133	13.6

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.35	1.71	1.12	3.02
Al/Ca	0.0542	29.8	0.00773	258
Mn/Ca	0.0234	31.7	0.0204	22.5
Zn/Ca	0.0202	20.6	0.0411	15.8
Sr/Ca	1.19	2.14	1.06	2.87
Ba/Ca	0.00287	16.4	0.00108	48.5
Test weight (µg)	9.2			
Test length (µm)	363			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.60	4.22	5.00	2.00
Al/Ca	0.792	10.6	4.51	3.05
Mn/Ca	0.131	40.6	1.14	3.81
Zn/Ca	0.0526	33.7	0.107	9.22
Sr/Ca	1.30	6.45	1.38	1.97
Ba/Ca	0.00134	145	0.0100	8.77

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	4.15	1.69	2.10	1.17
Al/Ca	0.154	14.2	0.388	5.87
Mn/Ca	0.0273	13.0	0.0257	11.3
Zn/Ca	0.0212	25.6	0.0419	12.0
Sr/Ca	1.37	2.22	1.39	1.19
Ba/Ca	0.00144	34.3	0.00192	21.7
Test weight (µg)	7			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.41	1.31	1.47	1.80
Al/Ca	0.110	15.0	0.148	11.0
Mn/Ca	0.0183	16.5	0.0188	16.5
Zn/Ca	0.0140	32.3	0.0279	18.3
Sr/Ca	1.31	0.961	1.31	0.985
Ba/Ca	0.00113	36.2	0.000699	66.8

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.32	3.14	1.58	1.94
Al/Ca	0.178	23.9	0.0789	22.4
Mn/Ca	0.0260	24.8	0.0296	18.1
Zn/Ca	0.0139	66.9	0.0108	43.7
Sr/Ca	1.35	2.73	1.39	1.36
Ba/Ca	0.00160	55.6	0.00117	35.7
Test weight (µg)	10.6			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	10.17	1.87	8.06	1.26
Al/Ca	0.235	13.6	0.220	9.17
Mn/Ca	0.0363	14.3	0.0556	10.4
Zn/Ca	0.0121	54.1	0.0749	9.89
Sr/Ca	1.31	2.55	1.31	1.98
Ba/Ca	0.00315	24.5	0.00207	20.1

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	8.47	1.95	6.45	2.20
Al/Ca	0.147	18.9	-0.0200	136
Mn/Ca	0.108	9.88	0.0247	22.0
Zn/Ca	0.0418	17.0	0.0429	20.2
Sr/Ca	1.32	2.10	1.31	2.24
Ba/Ca	0.00264	26.1	0.00135	49.3
Test weight (µg)	10.7			
Test length (µm)	367			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.93	2.21	3.05	2.66
Al/Ca	0.135	14.8	0.0775	22.3
Mn/Ca	0.0216	16.2	0.0163	19.8
Zn/Ca	0.0414	16.4	0.0416	13.2
Sr/Ca	1.27	1.55	1.30	1.96
Ba/Ca	0.00206	25.1	0.00236	22.2

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.71	1.89	1.80	2.74
Al/Ca	0.0862	25.3	0.0359	82.7
Mn/Ca	0.028	13.2	0.0201	28.7
Zn/Ca	0.0308	19.2	0.0428	20.3
Sr/Ca	1.33	2.03	1.35	2.79
Ba/Ca	0.00185	28.3	0.00165	44.4
Test weight (µg)	11.6			
Test length (µm)	321			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.63	1.40	3.69	1.47
Al/Ca	0.0795	24.9	0.116	16.6
Mn/Ca	0.0187	19.7	0.0259	13.4
Zn/Ca	0.00576	87.2	0.0180	26.2
Sr/Ca	1.18	1.55	1.16	1.61
Ba/Ca	0.00136	41.3	0.00237	23.0

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	5.37	1.72	2.03	2.61
Al/Ca	0.383	6.69	0.0763	39.6
Mn/Ca	0.0435	10.0	0.0338	15.5
Zn/Ca	0.0169	32.4	0.0463	18.5
Sr/Ca	1.26	2.19	1.13	2.35
Ba/Ca	0.00259	24.2	0.00122	57.4
Test weight (µg)	15.5			
Test length (µm)	422			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	6.95	1.58	6.28	1.45
Al/Ca	0.300	7.06	0.150	15.9
Mn/Ca	0.0214	44.1	0.00965	35.1
Zn/Ca	0.0157	25.9	0.00776	54.9
Sr/Ca	1.22	1.68	1.29	1.60
Ba/Ca	0.00140	35.1	0.00112	42.3

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	4.32	1.57	3.77	1.75
Al/Ca	0.0537	31.0	0.130	18.9
Mn/Ca	0.0150	20.4	0.0165	24.0
Zn/Ca	0.00671	52.9	0.0400	17.9
Sr/Ca	1.30	1.40	1.24	1.87
Ba/Ca	0.00145	26.8	0.00181	31.7
Test weight (µg)	9.8			
Test length (µm)	351			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.36	1.24	4.10	1.76
Al/Ca	0.0280	51.8	0.0524	27.8
Mn/Ca	0.0347	8.83	0.0527	6.11
Zn/Ca	0.0134	40.1	0.0112	46.3
Sr/Ca	1.21	1.15	1.15	1.10
Ba/Ca	0.00101	49.9	0.00147	33.5

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	* <i>f</i>	% 2se
Mg/Ca	3.00	1.49	3.03	1.77
Al/Ca	0.0803	20.6	0.0797	23.3
Mn/Ca	0.0301	8.86	0.0553	7.86
Zn/Ca	0.0345	17.4	0.0821	10.2
Sr/Ca	1.18	1.92	1.13	1.89
Ba/Ca	0.00100	48.6	0.00221	29.4
Test weight (µg)	11.6			
Test length (µm)	360			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	5.47	1.62	5.23	1.40
Al/Ca	0.166	10.4	0.205	8.75
Mn/Ca	0.0816	8.60	0.0487	7.11
Zn/Ca	0.0356	17.6	0.0516	12.3
Sr/Ca	1.25	1.43	1.36	1.38
Ba/Ca	0.00204	28.3	0.00168	32.8

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	2.88	1.56	3.36	1.96
Al/Ca	0.270	7.55	0.437	4.86
Mn/Ca	0.0329	10.5	0.0833	8.66
Zn/Ca	0.0648	13.1	0.0932	20.9
Sr/Ca	1.39	1.60	1.33	2.44
Ba/Ca	0.00143	43.6	0.00313	22.2
Test weight (µg)	x			
Test length (µm)	349			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.02	1.71	2.25	2.72
Al/Ca	0.247	9.85	0.117	29.2
Mn/Ca	0.0443	10.5	0.0507	22.2
Zn/Ca	0.0357	17.6	0.0303	37.4
Sr/Ca	1.11	2.31	1.10	3.10
Ba/Ca	0.00111	55.9	0.000511	203

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.04	2.05	2.53	2.59
Al/Ca	0.151	13.5	0.104	22.0
Mn/Ca	0.0321	10.7	0.0367	12.0
Zn/Ca	0.0279	24.2	0.0309	23.5
Sr/Ca	1.08	2.40	1.15	3.03
Ba/Ca	0.00203	32.3	0.00177	42.6
Test weight (µg)	11.8			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.79	1.79	2.19	2.70
Al/Ca	0.0894	23.6	0.0573	49.9
Mn/Ca	0.0468	11.3	0.0440	13.6
Zn/Ca	0.0536	17.8	0.0472	24.0
Sr/Ca	1.12	1.95	1.02	2.79
Ba/Ca	0.00158	35.8	0.00158	61.0

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	1.84	2.02	1.21	2.22
Al/Ca	0.136	15.7	0.0163	146
Mn/Ca	0.0804	8.99	0.0256	16.3
Zn/Ca	0.0253	22.9	0.0383	19.1
Sr/Ca	1.17	2.04	1.16	2.55
Ba/Ca	0.00191	32.5	0.000966	85.2
Test weight (µg)	11.4			
Test length (µm)	388			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.10	1.33	2.53	1.86
Al/Ca	0.259	5.48	0.129	13.8
Mn/Ca	0.0253	11.8	0.0174	21.3
Zn/Ca	0.0307	20.1	0.0159	53.0
Sr/Ca	1.20	1.51	1.28	2.36
Ba/Ca	0.00261	22.5	0.00182	43.0

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.97	1.52	1.87	3.46
Al/Ca	0.166	10.5	0.0614	65.5
Mn/Ca	0.0248	12.3	0.0232	95.2
Zn/Ca	0.0165	38.6	0.0242	41.2
Sr/Ca	1.22	1.51	1.25	3.23
Ba/Ca	0.00159	36.1	0.000593	152
Test weight (µg)	9.6			
Test length (µm)	323			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.11	1.22	3.30	1.38
Al/Ca	0.0583	21.5	0.0852	13.7
Mn/Ca	0.0109	25.0	0.00641	38.1
Zn/Ca	-0.00203	285	0.00990	54.1
Sr/Ca	1.16	1.43	1.16	1.23
Ba/Ca	0.00270	21.2	0.00246	21.4

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	2.24	1.58	2.18	1.66
Al/Ca	0.0511	25.9	0.139	12.7
Mn/Ca	0.0100	27.9	0.0183	33.5
Zn/Ca	0.00839	72.4	0.0340	18.8
Sr/Ca	1.17	1.68	1.10	1.71
Ba/Ca	0.00101	56.5	0.00477	15.5
Test weight (µg)	11.7			
Test length (µm)	338			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.12	1.50	2.61	1.45
Al/Ca	0.246	6.09	0.183	8.07
Mn/Ca	0.0242	13.2	0.0262	11.6
Zn/Ca	0.0285	22.4	0.0270	25.2
Sr/Ca	1.20	1.62	1.25	1.69
Ba/Ca	0.00239	24.9	0.00190	31.8

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.99	1.48	1.96	3.43
Al/Ca	0.156	9.25	0.0375	54.4
Mn/Ca	0.0245	12.0	0.0129	46.8
Zn/Ca	0.0164	37.3	0.0298	33.8
Sr/Ca	1.22	1.47	1.26	3.58
Ba/Ca	0.00158	34.5	0.000623	143
Test weight (µg)	6.5			
Test length (µm)	356			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.11	1.16	3.40	1.43
Al/Ca	0.0610	20.6	0.0770	15.6
Mn/Ca	0.0111	24.1	0.00570	43.1
Zn/Ca	-0.00133	427	0.0103	53.3
Sr/Ca	1.16	1.35	1.17	1.27
Ba/Ca	0.00297	18.6	0.00197	25.8

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	2.23	1.50	2.16	1.63
Al/Ca	0.0509	26.9	0.155	9.89
Mn/Ca	0.00955	30.2	0.0166	17.7
Zn/Ca	0.00795	80.6	0.0330	20.9
Sr/Ca	1.17	1.73	1.08	1.72
Ba/Ca	0.00100	59.2	0.00500	16.4
Test weight (µg)	4.1			
Test length (µm)	353			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	5.89	1.84	5.55	2.49
Al/Ca	0.335	17.8	0.233	6.59
Mn/Ca	0.0396	31.0	0.0315	20.7
Zn/Ca	0.402	30.9	0.432	31.1
Sr/Ca	2.96	1.75	2.97	1.94
Ba/Ca	0.00322	65.5	0.00332	27.8

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	3.23	1.57	3.03	1.86
Al/Ca	0.113	8.73	0.264	9.95
Mn/Ca	0.0281	23.8	0.0153	50.1
Zn/Ca	0.383	26.7	0.385	31.9
Sr/Ca	2.84	2.15	2.88	1.88
Ba/Ca	0.00126	46.5	0.00182	47.4
Test weight (µg)	7.8			
Test length (µm)	359			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	12.3	1.24	11.8	1.15
Al/Ca	0.109	23.3	0.0832	20.5
Mn/Ca	0.0274	34.5	0.000439	1560
Zn/Ca	0.232	47.1	0.414	23.5
Sr/Ca	2.77	1.28	2.98	1.48
Ba/Ca	0.000882	85.1	0.00115	61.9

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	8.19	1.41	5.96	2.08
Al/Ca	0.0909	48.0	0.0659	37.4
Mn/Ca	0.0142	46.5	0.00599	161
Zn/Ca	0.210	46.1	0.409	36.9
Sr/Ca	2.98	2.37	2.80	3.22
Ba/Ca	0.00127	53.0	0.00213	44.3
Test weight (µg)	10.9			
Test length (µm)	337			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.98	1.36	2.41	1.45
Al/Ca	0.127	12.3	0.110	11.2
Mn/Ca	0.0253	7.49	0.0345	8.60
Zn/Ca	0.0184	8.03	0.0507	10.4
Sr/Ca	1.27	1.42	1.17	1.81
Ba/Ca	0.00248	17.6	0.00198	24.6

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.71	1.82	1.20	1.42
Al/Ca	0.0845	12.7	0.00634	147
Mn/Ca	0.0441	18.3	0.00906	26.6
Zn/Ca	0.0664	29.2	0.00735	51.8
Sr/Ca	1.18	1.64	1.13	1.44
Ba/Ca	0.00273	25.9	0.000945	44.1
Test weight (µg)	7.4			
Test length (µm)	344			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.91	2.35	1.59	2.28
Al/Ca	0.0899	14.1	0.0712	26.0
Mn/Ca	0.227	3.75	0.189	3.43
Zn/Ca	0.0130	5.45	0.0578	7.92
Sr/Ca	1.26	2.09	1.32	2.26
Ba/Ca	0.0187	10.0	0.0191	5.02

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	* <i>f</i>	% 2se
Mg/Ca	1.33	2.03	1.42	2.42
Al/Ca	0.111	17.9	0.0861	20.1
Mn/Ca	0.129	2.80	0.387	2.47
Zn/Ca	0.0846	19.0	0.185	4.42
Sr/Ca	1.29	1.85	1.21	2.05
Ba/Ca	0.0119	4.10	0.00795	7.20
Test weight (µg)	7			
Test length (µm)	323			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.69	3.76	2.61	2.48
Al/Ca	0.103	25.4	0.0254	70.3
Mn/Ca	0.206	5.43	0.122	5.25
Zn/Ca	0.0639	11.6	0.0283	11.2
Sr/Ca	1.35	3.84	1.23	2.43
Ba/Ca	0.0220	7.94	0.0155	6.23

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.64	1.90	1.58	2.16
Al/Ca	0.0557	25.9	0.0459	32.0
Mn/Ca	0.120	3.70	0.0961	4.50
Zn/Ca	0.0968	5.24	0.0471	7.10
Sr/Ca	1.24	1.72	1.31	2.35
Ba/Ca	0.0164	4.49	0.00663	6.55
Test weight (µg)	4.7			
Test length (µm)	259			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>*f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.66	2.49	2.88	2.71
Al/Ca	0.137	78.2	0.174	15.2
Mn/Ca	0.209	4.38	0.211	12.0
Zn/Ca	0.112	15.9	0.0598	15.1
Sr/Ca	1.55	2.93	1.52	3.26
Ba/Ca	0.0228	7.53	0.0203	14.8

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	1.33	3.09	1.92	2.95
Al/Ca	0.111	22.5	0.0612	47.0
Mn/Ca	0.129	6.89	0.197	5.14
Zn/Ca	0.0846	24.1	0.113	11.0
Sr/Ca	1.29	3.97	1.61	2.73
Ba/Ca	0.0119	27.8	0.0444	4.98
Test weight (µg)	5.9			
Test length (µm)	355			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.69	1.65	2.75	1.70
Al/Ca	0.103	4.00	0.174	33.4
Mn/Ca	0.206	5.22	0.211	6.12
Zn/Ca	0.0639	19.3	0.0598	36.7
Sr/Ca	1.35	1.81	1.52	1.74
Ba/Ca	0.0220	5.46	0.0203	6.84

X/Ca (mmol/mol)	* <i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.64	1.53	1.89	1.57
Al/Ca	0.111	6.45	0.103	15.6
Mn/Ca	0.129	4.67	0.0624	5.78
Zn/Ca	0.0846	18.7	0.0283	15.1
Sr/Ca	1.29	1.58	1.51	1.64
Ba/Ca	0.0119	7.74	0.00983	4.86
Test weight (µg)	8.5			
Test length (µm)	332			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	* <i>f-2</i>	% 2se
Mg/Ca	3.91	3.98	2.71	2.23
Al/Ca	0.616	32.6	0.524	6.38
Mn/Ca	0.663	4.78	0.231	3.74
Zn/Ca	0.0696	29.6	0.0242	14.0
Sr/Ca	1.45	4.72	1.47	2.11
Ba/Ca	0.0217	12.4	0.0102	5.81

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	* <i>f</i>	% 2se
Mg/Ca	2.21	2.71	2.25	2.44
Al/Ca	0.176	5.92	0.0462	38.5
Mn/Ca	0.272	3.86	0.751	2.04
Zn/Ca	0.0186	10.6	0.0404	11.2
Sr/Ca	1.53	2.69	1.41	2.75
Ba/Ca	0.00648	5.78	0.00678	10.1
Test weight (µg)	7.2			
Test length (µm)	261			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.99	2.93	3.52	2.19
Al/Ca	0.408	8.11	0.510	6.07
Mn/Ca	0.132	5.31	0.062	9.32
Zn/Ca	0.0528	18.3	0.149	6.64
Sr/Ca	1.36	2.88	1.49	2.72
Ba/Ca	0.0183	5.72	0.0256	29.3

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	2.09	1.76	1.39	2.08
Al/Ca	0.325	5.81	0.145	81.9
Mn/Ca	0.0435	8.80	0.119	3.97
Zn/Ca	0.0331	10.7	0.0869	6.27
Sr/Ca	1.49	1.63	1.36	2.03
Ba/Ca	0.0136	4.22	0.0195	4.48
Test weight (µg)	8.1			
Test length (µm)	321			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	5.29	1.77	4.54	1.71
Al/Ca	0.185	9.19	0.0552	29.0
Mn/Ca	0.411	3.44	0.0957	4.95
Zn/Ca	0.0127	21.1	0.00895	29.7
Sr/Ca	1.45	1.94	1.44	1.97
Ba/Ca	0.0118	9.10	0.00474	7.2

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	4.80	2.96	2.64	2.27
Al/Ca	0.353	7.64	0.0427	36.8
Mn/Ca	0.0788	7.28	0.263	2.64
Zn/Ca	0.00850	42.3	0.0144	19.7
Sr/Ca	1.51	3.06	1.43	2.27
Ba/Ca	0.00631	8.51	0.00462	8.00
Test weight (µg)	7.4			
Test length (µm)	305			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	6.05	2.60	6.47	1.64
Al/Ca	0.0651	36.3	0.0599	23.8
Mn/Ca	0.347	3.82	0.558	2.01
Zn/Ca	0.0377	13.6	0.0581	6.56
Sr/Ca	1.36	3.28	1.34	2.18
Ba/Ca	0.0108	7.15	0.0141	5.37

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	5.75	1.85	3.88	2.03
Al/Ca	0.0906	21.6	0.0122	102
Mn/Ca	0.213	3.19	0.316	2.97
Zn/Ca	0.0531	8.18	0.0190	13.8
Sr/Ca	1.52	2.44	1.48	2.75
Ba/Ca	0.00738	5.92	0.00590	10.7
Test weight (µg)	6.5			
Test length (µm)	257			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	8.67	2.23	8.51	1.83
Al/Ca	0.137	16.2	0.186	8.88
Mn/Ca	0.233	5.73	0.0923	5.47
Zn/Ca	0.00494	23.4	0.0101	10.7
Sr/Ca	1.42	2.95	1.46	2.74
Ba/Ca	0.0101	5.99	0.0106	8.26

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	9.85	2.34	5.17	2.04
Al/Ca	0.196	9.13	0.0841	21.1
Mn/Ca	0.247	3.42	0.819	2.16
Zn/Ca	0.00596	19.3	0.00719	15.7
Sr/Ca	1.49	2.52	1.49	2.29
Ba/Ca	0.0161	11.8	0.0101	5.60
Test weight (µg)	7			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.46	1.60	2.71	2.06
Al/Ca	0.340	4.70	0.340	5.37
Mn/Ca	0.0333	11.2	0.0260	24.9
Zn/Ca	0.0114	23.2	0.00963	27.4
Sr/Ca	1.26	1.63	1.26	1.69
Ba/Ca	0.00505	5.77	0.00675	6.96

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.82	1.52	1.52	1.20
Al/Ca	0.193	7.92	0.0139	72.5
Mn/Ca	0.0126	30.0	0.0164	19.2
Zn/Ca	0.0132	21.0	0.0118	20.0
Sr/Ca	1.27	1.54	1.20	1.18
Ba/Ca	0.00619	5.54	0.00450	5.68
Test weight (µg)	4.6			
Test length (µm)	264			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.75	1.48	2.48	1.57
Al/Ca	0.0645	20.2	-0.0409	33.5
Mn/Ca	0.0464	8.61	0.0399	10.5
Zn/Ca	0.0151	19.1	0.00383	74.6
Sr/Ca	1.30	1.53	1.30	2.02
Ba/Ca	0.00306	8.47	0.00260	11.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.95	1.70	2.86	3.86
Al/Ca	0.0234	53.0	0.0226	57.9
Mn/Ca	0.0529	7.46	0.0396	10.2
Zn/Ca	0.0166	17.6	0.0256	13.7
Sr/Ca	1.31	1.87	1.27	2.07
Ba/Ca	0.00314	8.70	0.00211	11.6
Test weight (µg)	2.9			
Test length (µm)	239			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	0.785	2.91	0.747	2.60
Al/Ca	0.272	9.30	0.260	9.84
Mn/Ca	0.163	7.34	0.104	11.5
Zn/Ca	0.0431	29.5	0.0332	36.4
Sr/Ca	1.10	2.10	1.16	1.95
Ba/Ca	0.00532	23.1	0.00517	58.7

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	0.867	3.13	0.849	3.44
Al/Ca	0.482	8.45	0.119	24.3
Mn/Ca	0.133	13.0	0.157	11.0
Zn/Ca	0.0379	39.3	0.0390	39.8
Sr/Ca	1.16	2.61	1.08	2.76
Ba/Ca	0.00678	11.3	0.00633	19.3
Test weight (µg)	3.2			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	4.08	1.96	3.07	2.18
Al/Ca	0.155	11.2	0.175	11.0
Mn/Ca	0.335	3.79	0.262	3.75
Zn/Ca	0.428	4.75	0.199	5.92
Sr/Ca	1.42	1.76	1.41	1.47
Ba/Ca	0.01538	5.22	0.00829	7.3

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	2.30	1.67	1.39	1.74
Al/Ca	0.0946	16.9	0.0747	18.7
Mn/Ca	0.168	4.71	0.177	4.78
Zn/Ca	0.0603	14.7	0.147	7.36
Sr/Ca	1.45	1.69	1.40	1.50
Ba/Ca	0.00927	5.19	0.00306	9.71
Test weight (µg)	5.4			
Test length (µm)	326			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	4.16	1.32	3.36	2.10
Al/Ca	0.00270	524	0.0159	105
Mn/Ca	0.0985	4.85	0.0686	8.52
Zn/Ca	0.0164	14.3	0.0204	17.7
Sr/Ca	1.35	1.34	1.35	1.96
Ba/Ca	0.00382	7.14	0.00334	11.7

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.15	1.26	1.43	1.62
Al/Ca	0.0454	27.2	0.0401	30.6
Mn/Ca	0.0328	13.6	0.0932	5.12
Zn/Ca	0.00885	26.2	0.00767	29.8
Sr/Ca	1.36	1.39	1.27	1.37
Ba/Ca	0.00230	10.4	0.00340	8.35
Test weight (µg)	5.9			
Test length (µm)	253			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	*f-2	% 2se
Mg/Ca	5.58	1.91	6.03	2.78
Al/Ca	0.0628	7.30	0.219	15.5
Mn/Ca	0.235	3.06	0.365	4.24
Zn/Ca	0.0231	18.0	0.0242	22.8
Sr/Ca	1.48	2.00	1.42	3.02
Ba/Ca	0.0188	4.19	0.0327	5.19

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	3.11	3.50	1.80	2.29
Al/Ca	0.239	53.1	0.0719	26.9
Mn/Ca	0.272	5.67	0.493	2.61
Zn/Ca	0.0194	26.9	0.0485	11.0
Sr/Ca	1.44	3.60	1.41	2.04
Ba/Ca	0.0170	7.28	0.0361	3.98
Test weight (µg)	3.1			
Test length (µm)	264			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	4.07	1.58	3.17	1.22
Al/Ca	0.236	7.21	0.199	7.38
Mn/Ca	0.0430	12.0	0.0170	29.8
Zn/Ca	0.0410	9.46	0.0197	14.7
Sr/Ca	1.26	1.85	1.27	1.25
Ba/Ca	0.00551	8.31	0.00282	12.6

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.16	1.55	1.82	1.77
Al/Ca	0.218	8.62	0.00789	206
Mn/Ca	0.0227	24.4	0.00563	98.0
Zn/Ca	0.0229	16.5	0.00782	39.5
Sr/Ca	1.33	1.59	1.30	1.72
Ba/Ca	0.00346	9.98	0.00168	16.6
Test weight (µg)	6.3			
Test length (µm)	291			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.11	2.19	2.23	2.01
Al/Ca	0.0434	36.4	0.0299	48.2
Mn/Ca	0.185	3.46	0.0750	7.46
Zn/Ca	0.0302	13.9	0.0168	18.1
Sr/Ca	1.36	2.26	1.43	1.83
Ba/Ca	0.00346	10.0	0.00221	13.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.59	2.07	1.31	1.71
Al/Ca	0.0596	27.6	0.0528	32.3
Mn/Ca	0.0555	9.80	0.0620	9.01
Zn/Ca	0.0187	19.1	0.0192	18.3
Sr/Ca	1.36	1.66	1.30	1.49
Ba/Ca	0.00173	16.6	0.00127	21.4
Test weight (µg)	3.9			
Test length (µm)	310			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.11	2.19	2.23	2.01
Al/Ca	0.0434	36.4	0.0299	48.2
Mn/Ca	0.185	3.46	0.0750	7.46
Zn/Ca	0.0302	13.9	0.0168	18.1
Sr/Ca	1.36	2.26	1.43	1.83
Ba/Ca	0.00346	9.95	0.00221	13.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.59	2.07	1.31	1.71
Al/Ca	0.0596	27.6	0.053	32.3
Mn/Ca	0.0555	9.80	0.0620	9.01
Zn/Ca	0.0187	19.1	0.0192	18.3
Sr/Ca	1.36	1.66	1.30	1.49
Ba/Ca	0.00173	16.6	0.00127	21.4
Test weight (µg)	3.9			
Test length (µm)	310			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	4.12	1.49	4.32	1.58
Al/Ca	-0.0136	118	0.00863	199
Mn/Ca	0.166	4.82	0.151	4.05
Zn/Ca	0.0154	22.7	0.0328	12.7
Sr/Ca	1.37	2.00	1.30	1.49
Ba/Ca	0.00500	7.83	0.00589	7.29

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	4.40	2.71	2.49	1.81
Al/Ca	0.173	12.2	-0.00721	214
Mn/Ca	0.118	6.66	0.0819	6.31
Zn/Ca	0.0318	16.3	0.0166	21.0
Sr/Ca	1.30	2.33	1.35	2.10
Ba/Ca	0.00504	10.7	0.00275	11.6
Test weight (µg)	5.7			
Test length (µm)	281			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	23.1	3.46	6.24	1.60
Al/Ca	75.2	4.24	0.117	15.9
Mn/Ca	0.821	5.45	0.0346	30.6
Zn/Ca	0.0598	51.0	0.0204	18.9
Sr/Ca	1.55	3.45	1.37	1.58
Ba/Ca	0.0670	7.12	0.0116	4.84

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	6.93	2.19	3.55	1.50
Al/Ca	0.307	10.3	0.156	11.9
Mn/Ca	0.047	56.4	0.0683	7.72
Zn/Ca	0.0167	34.0	0.0219	17.7
Sr/Ca	1.43	3.31	1.30	1.40
Ba/Ca	0.0185	5.57	0.0206	5.73
Test weight (µg)	2.1			
Test length (µm)	265			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>*f-2</i>	% 2se
Mg/Ca	1.69	1.78	3.27	1.59
Al/Ca	0.249	5.03	0.530	4.56
Mn/Ca	0.0654	12.3	0.0583	10.5
Zn/Ca	0.0211	37.9	0.0360	13.5
Sr/Ca	1.37	1.65	1.47	1.41
Ba/Ca	0.0199	6.44	0.00668	7.10

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	2.46	1.86	2.67	1.33
Al/Ca	0.617	7.54	-1.73	2.85
Mn/Ca	0.0588	8.29	0.0289	16.2
Zn/Ca	0.0139	20.0	0.0268	19.6
Sr/Ca	1.50	1.53	1.46	1.44
Ba/Ca	0.0111	12.2	0.0161	4.28
Test weight (µg)	7.6			
Test length (µm)	290			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.34	1.85	2.70	1.75
Al/Ca	0.254	13.9	0.379	4.58
Mn/Ca	0.208	5.40	0.149	3.69
Zn/Ca	0.0429	15.2	0.0316	12.1
Sr/Ca	1.37	1.78	1.32	1.45
Ba/Ca	0.0227	6.69	0.0147	3.96

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.10	1.85	1.09	1.93
Al/Ca	0.119	7.92	0.0634	25.0
Mn/Ca	0.0907	3.31	0.0379	12.1
Zn/Ca	0.0245	11.4	0.0159	24.8
Sr/Ca	1.34	1.72	1.29	1.66
Ba/Ca	0.00922	13.4	0.00400	10.9
Test weight (µg)	3.2			
Test length (µm)	260			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	* <i>f</i> -2	% 2se
Mg/Ca				
Al/Ca				
Mn/Ca				
Zn/Ca				
Sr/Ca				
Ba/Ca				

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca				
Al/Ca				
Mn/Ca				
Zn/Ca				
Sr/Ca				
Ba/Ca				
Test weight (µg)				
Test length (µm)				
Coiling direction				

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	5.68	1.43	6.17	1.41
Al/Ca	0.0980	16.8	0.249	7.46
Mn/Ca	0.206	2.99	0.0472	22.7
Zn/Ca	0.0191	18.8	0.00505	64.1
Sr/Ca	1.40	1.94	1.46	1.30
Ba/Ca	0.0115	25.7	0.00671	8.63

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	4.98	1.44	5.08	1.42
Al/Ca	0.165	11.2	0.177	9.20
Mn/Ca	0.184	3.49	0.260	2.35
Zn/Ca	0.0253	16.5	0.0241	15.9
Sr/Ca	1.44	1.72	1.39	1.45
Ba/Ca	0.0123	5.41	0.0172	3.74
Test weight (µg)	4.7			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.24	2.28	2.37	1.68
Al/Ca	0.313	9.61	0.203	9.55
Mn/Ca	0.0192	38.0	0.0144	38.6
Zn/Ca	0.0222	27.8	0.0376	20.1
Sr/Ca	1.35	2.08	1.36	1.60
Ba/Ca	0.0222	29.7	0.0193	3.93

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	* <i>f</i>	% 2se
Mg/Ca	1.89	1.90	2.04	1.53
Al/Ca	0.226	9.45	0.100	14.7
Mn/Ca	0.0127	46.3	0.0225	19.5
Zn/Ca	0.0248	20.7	0.0410	9.94
Sr/Ca	1.46	1.68	1.34	1.60
Ba/Ca	0.0140	4.88	0.0316	3.36
Test weight (µg)	4.6			
Test length (µm)	257			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.38	2.70	1.64	2.21
Al/Ca	0.151	10.7	0.0488	47.4
Mn/Ca	0.0378	12.8	0.0166	42.5
Zn/Ca	0.0161	21.4	0.0190	31.2
Sr/Ca	1.27	1.34	1.26	2.02
Ba/Ca	0.0109	6.16	0.00218	19.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.22	2.52	1.49	1.48
Al/Ca	0.194	9.53	0.0208	80.4
Mn/Ca	0.00360	142	0.0195	26.8
Zn/Ca	0.0342	22.9	0.0173	23.2
Sr/Ca	1.34	1.28	1.34	1.36
Ba/Ca	0.00575	7.34	0.00318	10.4
Test weight (µg)	4			
Test length (µm)	288			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.50	1.68	2.09	1.56
Al/Ca	0.0569	28.3	0.303	5.93
Mn/Ca	0.00562	97.7	0.00940	55.3
Zn/Ca	0.0340	12.5	0.0216	18.4
Sr/Ca	1.35	1.54	1.28	1.54
Ba/Ca	0.00725	6.48	0.00636	7.20

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.99	1.52	1.91	1.47
Al/Ca	0.196	8.47	0.417	4.99
Mn/Ca	0.0124	36.3	0.00205	227
Zn/Ca	0.0231	15.9	0.0373	10.7
Sr/Ca	1.32	1.23	1.30	1.38
Ba/Ca	0.00606	6.05	0.0127	4.13
Test weight (µg)	5			
Test length (µm)	280			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.94	1.63	3.55	1.55
Al/Ca	-0.00177	1120	0.0585	34.1
Mn/Ca	0.0555	11.2	0.118	5.52
Zn/Ca	0.0592	9.61	0.0676	8.60
Sr/Ca	1.22	1.54	1.32	1.68
Ba/Ca	0.00394	10.5	0.0120	4.92

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	3.59	1.89	3.72	1.72
Al/Ca	0.0841	26.5	0.0236	83.7
Mn/Ca	0.102	10.9	0.0709	9.11
Zn/Ca	0.0720	9.38	0.112	6.72
Sr/Ca	1.29	1.80	1.21	1.54
Ba/Ca	0.0215	11.8	0.00765	7.31
Test weight (µg)	5.4			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.30	1.48	2.13	2.21
Al/Ca	0.102	16.7	0.135	20.8
Mn/Ca	0.0510	45.8	0.0616	11.5
Zn/Ca	0.0114	31.3	0.0155	33.4
Sr/Ca	1.38	1.34	1.39	2.14
Ba/Ca	0.00590	6.80	0.0104	7.07

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.95	1.66	2.51	1.36
Al/Ca	0.141	15.3	0.196	9.39
Mn/Ca	0.0180	35.6	0.0886	6.35
Zn/Ca	0.0106	42.1	0.0146	25.9
Sr/Ca	1.41	1.70	1.32	1.30
Ba/Ca	0.00542	9.77	0.0149	4.18
Test weight (µg)	4.2			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	5.77	1.36	5.62	1.42
Al/Ca	0.243	3.95	0.251	4.08
Mn/Ca	0.0164	12.1	0.0197	9.48
Zn/Ca	0.0493	7.20	0.047	6.43
Sr/Ca	1.39	1.14	1.38	1.48
Ba/Ca	0.00211	9.96	0.00255	8.23

X/Ca (mmol/mol)	* <i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	5.12	1.46	3.67	2.21
Al/Ca	0.312	4.24	0.0296	22.2
Mn/Ca	0.0156	13.9	0.0193	11.6
Zn/Ca	0.0384	7.11	0.0633	6.37
Sr/Ca	1.46	1.46	1.37	1.80
Ba/Ca	0.00212	11.2	0.00176	12.6
Test weight (µg)	6.7			
Test length (µm)	268			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	4.81	1.76	5.01	2.75
Al/Ca	0.0273	36.5	0.0249	28.9
Mn/Ca	0.0484	8.01	0.0507	4.39
Zn/Ca	0.0472	9.03	0.0663	7.56
Sr/Ca	1.44	2.36	1.35	1.38
Ba/Ca	0.00231	13.4	0.00198	10.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	5.11	2.60	2.85	2.31
Al/Ca	0.0145	61.0	0.0119	72.5
Mn/Ca	0.0447	10.6	0.0291	11.1
Zn/Ca	0.0480	11.4	0.0468	10.0
Sr/Ca	1.32	2.60	1.46	2.38
Ba/Ca	0.00249	16.1	0.00144	18.8
Test weight (µg)	5.7			
Test length (µm)	196			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	5.43	2.05	3.33	1.79
Al/Ca	0.0243	41.0	0.222	4.53
Mn/Ca	0.114	3.11	0.0416	6.79
Zn/Ca	0.140	4.71	0.0789	5.97
Sr/Ca	1.32	2.27	1.32	1.49
Ba/Ca	0.00860	5.73	0.00543	6.97

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.95	1.49	1.97	2.29
Al/Ca	0.126	6.37	0.0041	185
Mn/Ca	0.0243	10.0	0.0499	6.23
Zn/Ca	0.0617	5.97	0.0678	7.76
Sr/Ca	1.33	1.38	1.29	2.35
Ba/Ca	0.00398	8.84	0.00279	11.8
Test weight (µg)	4.6			
Test length (µm)	302			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.20	3.05	2.20	1.91
Al/Ca	0.0738	17.9	0.102	7.45
Mn/Ca	0.0733	6.38	0.0665	3.86
Zn/Ca	0.0727	9.19	0.0655	4.66
Sr/Ca	1.37	3.68	1.32	1.41
Ba/Ca	0.00258	17.7	0.00247	8.41

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.30	1.72	1.18	2.38
Al/Ca	0.185	5.78	0.0259	30.4
Mn/Ca	0.0485	4.70	0.0388	6.68
Zn/Ca	0.0721	4.91	0.110	6.05
Sr/Ca	1.36	1.57	1.25	1.78
Ba/Ca	0.00262	9.22	0.00150	15.5
Test weight (µg)	4.8			
Test length (µm)	247			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>*f-2</i>	% 2se
Mg/Ca	2.68	2.49	2.20	1.81
Al/Ca	0.0154	60.4	0.102	20.2
Mn/Ca	0.0600	6.14	0.0665	5.16
Zn/Ca	0.138	5.94	0.0655	3.49
Sr/Ca	1.42	3.50	1.32	2.05
Ba/Ca	0.00267	12.7	0.00247	11.4

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	3.13	1.84	1.18	2.23
Al/Ca	0.0533	18.1	0.0259	337
Mn/Ca	0.0415	6.96	0.0388	12.9
Zn/Ca	0.0643	6.09	0.110	8.18
Sr/Ca	1.39	1.62	1.25	2.08
Ba/Ca	0.00239	11.1	0.00150	16.1
Test weight (µg)	3.6			
Test length (µm)	243			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	7.86	1.23	6.08	1.35
Al/Ca	0.00706	82.9	0.00907	63.9
Mn/Ca	0.0270	7.29	0.0251	7.65
Zn/Ca	0.0369	6.26	0.0397	5.51
Sr/Ca	1.42	1.24	1.48	0.98
Ba/Ca	0.00270	7.36	0.00187	8.92

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	4.88	1.53	6.87	2.09
Al/Ca	0.00961	63.4	0.0100	92.9
Mn/Ca	0.0295	6.45	0.0470	7.91
Zn/Ca	0.0537	4.99	0.102	6.71
Sr/Ca	1.47	1.21	1.47	2.04
Ba/Ca	0.00161	10.9	0.00281	13.8
Test weight (µg)	4.5			
Test length (µm)	217			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	5.83	6.78	3.50	1.50
Al/Ca	0.181	127	0.0609	11.7
Mn/Ca	0.116	10.5	0.0461	5.40
Zn/Ca	0.0888	17.5	0.0828	5.06
Sr/Ca	1.54	9.75	1.39	1.39
Ba/Ca	0.00364	29.4	0.00178	12.2

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.68	1.65	2.82	1.95
Al/Ca	0.0665	11.6	0.0122	83.8
Mn/Ca	0.0468	5.41	0.0336	10.5
Zn/Ca	0.129	4.03	0.0875	6.94
Sr/Ca	1.44	1.59	1.38	2.03
Ba/Ca	0.00182	11.7	0.00131	21.7
Test weight (µg)	7			
Test length (µm)	238			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	6.00	1.40	6.63	2.06
Al/Ca	0.0225	6.32	0.0257	13.9
Mn/Ca	0.0843	2.94	0.0730	4.25
Zn/Ca	0.0817	3.20	0.120	5.10
Sr/Ca	1.51	1.30	1.46	1.63
Ba/Ca	0.00216	6.93	0.00252	9.31

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	6.61	2.03	6.70	1.76
Al/Ca	0.0998	22.0	0.0348	11.0
Mn/Ca	0.0898	5.40	0.0848	3.72
Zn/Ca	0.168	6.24	0.271	3.13
Sr/Ca	1.44	2.03	1.49	1.78
Ba/Ca	0.00347	13.0	0.00258	10.3
Test weight (µg)	x			
Test length (µm)	206			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	3.47	3.66	2.32	2.81
Al/Ca	0.741	5.48	0.0231	20.6
Mn/Ca	0.0113	51.8	0.00769	43.5
Zn/Ca	0.0384	18.2	0.0362	9.22
Sr/Ca	1.51	5.59	1.47	2.33
Ba/Ca	0.00114	27.0	0.000870	22.1

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	4.48	1.59	2.44	1.73
Al/Ca	0.0334	8.85	0.0267	11.5
Mn/Ca	0.0260	9.29	0.0270	8.74
Zn/Ca	0.0694	4.95	0.0851	4.62
Sr/Ca	1.52	1.63	1.50	1.74
Ba/Ca	0.00132	11.9	0.00140	12.0
Test weight (µg)	5.7			
Test length (µm)	235			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>*f-2</i>	% 2se
Mg/Ca	1.77	1.67	1.99	1.32
Al/Ca	0.0725	8.30	0.668	4.74
Mn/Ca	0.0302	5.62	0.0373	5.50
Zn/Ca	0.0371	4.48	0.0438	4.64
Sr/Ca	1.44	1.52	1.41	1.21
Ba/Ca	0.00141	9.27	0.00488	4.94

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.89	1.55	1.70	1.63
Al/Ca	0.0431	4.94	0.0265	9.91
Mn/Ca	0.0408	7.38	0.0312	6.64
Zn/Ca	0.0617	6.05	0.0483	5.43
Sr/Ca	1.47	1.24	1.44	1.36
Ba/Ca	0.00166	8.93	0.00141	10.1
Test weight (µg)	6.1			
Test length (µm)	243			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	4.39	1.48	4.06	1.70
Al/Ca	0.0201	15.2	0.00679	40.3
Mn/Ca	0.0570	5.72	0.0450	5.78
Zn/Ca	0.0507	4.89	0.0506	5.53
Sr/Ca	1.52	1.29	1.47	1.67
Ba/Ca	0.00516	3.70	0.00474	6.06

X/Ca (mmol/mol)	* <i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	4.67	1.63	3.19	1.93
Al/Ca	0.0147	20.8	0.00936	27.3
Mn/Ca	0.0354	7.27	0.0334	6.70
Zn/Ca	0.0411	6.58	0.0457	5.62
Sr/Ca	1.57	1.62	1.48	1.67
Ba/Ca	0.00960	6.49	0.00325	7.04
Test weight (µg)	2.9			
Test length (µm)	213			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.17	9.37	1.75	1.62
Al/Ca	0.0727	86.6	0.0198	14.8
Mn/Ca	0.102	13.46	0.0373	5.78
Zn/Ca	0.130	14.15	0.0704	4.58
Sr/Ca	1.34	7.69	1.41	1.52
Ba/Ca	0.00225	38.60	0.00198	9.42

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.43	1.27	1.28	1.58
Al/Ca	0.0173	13.1	0.128	6.64
Mn/Ca	0.0201	8.09	0.0322	6.84
Zn/Ca	0.0356	4.91	0.0554	4.77
Sr/Ca	1.44	1.22	1.38	1.32
Ba/Ca	0.00172	7.84	0.00217	9.02
Test weight (µg)	1.2			
Test length (µm)	216			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.32	2.71	3.60	1.84
Al/Ca	0.146	7.08	0.0839	5.64
Mn/Ca	0.0277	13.5	0.0340	8.30
Zn/Ca	0.0309	12.4	0.0380	7.92
Sr/Ca	1.42	3.01	1.45	2.32
Ba/Ca	0.00277	13.9	0.00235	10.9

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.36	2.05	1.86	1.55
Al/Ca	0.544	3.72	0.159	3.32
Mn/Ca	0.0176	11.1	0.0191	10.6
Zn/Ca	0.0315	6.43	0.0256	7.41
Sr/Ca	1.48	1.64	1.36	1.47
Ba/Ca	0.00208	8.88	0.00167	10.5
Test weight (µg)	3.4			
Test length (µm)	235			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	3.20	2.05	3.03	2.79
Al/Ca	0.0588	8.68	0.0579	8.85
Mn/Ca	0.0607	5.43	0.0462	4.84
Zn/Ca	0.115	4.49	0.132	3.90
Sr/Ca	1.43	2.23	1.41	2.03
Ba/Ca	0.00340	8.98	0.00225	7.57

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.29	2.22	1.43	2.02
Al/Ca	0.0405	11.9	0.110	5.57
Mn/Ca	0.0305	8.72	0.0423	5.66
Zn/Ca	0.0935	5.33	0.122	3.96
Sr/Ca	1.44	2.23	1.37	1.73
Ba/Ca	0.00242	14.0	0.00188	23.1
Test weight (µg)	3.1			
Test length (µm)	249			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.03	1.73	1.68	0.986
Al/Ca	0.0880	5.97	0.00928	20.1
Mn/Ca	0.0195	14.0	0.00311	45.1
Zn/Ca	0.0697	5.46	0.0298	4.65
Sr/Ca	1.34	1.70	1.39	0.948
Ba/Ca	0.00347	8.70	0.00135	7.60

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.63	1.28	1.66	1.31
Al/Ca	0.111	4.59	0.0349	7.58
Mn/Ca	0.00781	22.5	0.00762	20.4
Zn/Ca	0.0488	4.31	0.0283	5.57
Sr/Ca	1.41	1.28	1.41	1.28
Ba/Ca	0.00238	7.00	0.00149	8.54
Test weight (µg)	2.7			
Test length (µm)	215			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.96	2.78	4.09	1.83
Al/Ca	0.00236	661	-0.0120	126
Mn/Ca	0.0520	6.39	0.0592	6.03
Zn/Ca	0.0444	7.89	0.0598	7.09
Sr/Ca	1.47	2.30	1.37	2.16
Ba/Ca	0.00392	8.95	0.00381	8.84

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	6.16	1.77	4.97	2.55
Al/Ca	0.00987	188	0.000361	3760
Mn/Ca	0.0789	5.85	0.0784	4.74
Zn/Ca	0.0398	11.99	0.0563	7.56
Sr/Ca	1.51	1.74	1.44	2.18
Ba/Ca	0.00825	7.28	0.0151	5.06
Test weight (µg)	3.1			
Test length (µm)	334			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.61	2.81	1.43	2.05
Al/Ca	0.0133	170	-0.00564	279
Mn/Ca	0.0989	6.53	0.0897	5.38
Zn/Ca	0.0170	57.3	0.0165	19.1
Sr/Ca	1.52	2.49	1.48	2.27
Ba/Ca	0.00204	21.7	0.00204	14.4

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.27	1.77	1.24	2.45
Al/Ca	0.0137	122	-0.0128	133
Mn/Ca	0.0943	3.86	0.0933	5.08
Zn/Ca	0.00700	16.9	0.0181	19.5
Sr/Ca	1.45	1.36	1.37	2.47
Ba/Ca	0.00177	13.1	0.00209	16.0
Test weight (µg)	7			
Test length (µm)	243			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	* <i>f</i> -2	% 2se
Mg/Ca	8.09	1.43	10.2	3.00
Al/Ca	-0.00991	194	0.0420	53.9
Mn/Ca	0.424	1.69	0.468	8.25
Zn/Ca	0.0283	9.06	0.0417	11.3
Sr/Ca	1.48	1.40	1.63	4.08
Ba/Ca	0.00293	11.8	0.00439	21.8

X/Ca (mmol/mol)	* <i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	5.67	1.69	6.36	1.85
Al/Ca	0.00377	361	0.00957	231
Mn/Ca	0.358	2.02	0.397	2.03
Zn/Ca	0.0427	8.30	0.0285	11.9
Sr/Ca	1.44	1.87	1.42	2.60
Ba/Ca	0.00267	10.8	0.00383	9.15
Test weight (µg)	7.4			
Test length (µm)	326			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	*f-2	% 2se
Mg/Ca	1.24	1.43	1.54	2.18
Al/Ca	0.0606	79.8	0.217	11.1
Mn/Ca	0.0404	3.65	0.156	3.11
Zn/Ca	0.00797	31.8	0.0176	17.2
Sr/Ca	1.48	1.39	1.36	2.27
Ba/Ca	0.00404	4.71	0.0145	5.11

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.49	1.99	1.30	2.36
Al/Ca	0.0194	27.8	0.0461	37.6
Mn/Ca	0.111	9.50	0.0811	5.33
Zn/Ca	0.00767	37.9	0.0125	24.8
Sr/Ca	1.36	2.22	1.35	2.32
Ba/Ca	0.00914	9.68	0.0104	6.15
Test weight (µg)	3.8			
Test length (µm)	232			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.63	2.14	2.68	1.53
Al/Ca	0.0691	27.0	0.0846	17.8
Mn/Ca	0.137	4.11	0.101	4.59
Zn/Ca	0.0200	21.2	0.0295	11.0
Sr/Ca	1.38	2.36	1.34	1.71
Ba/Ca	0.00476	11.6	0.00341	9.18

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	1.98	1.75	1.93	2.13
Al/Ca	0.362	5.45	0.0683	30.2
Mn/Ca	0.0981	4.62	0.249	2.51
Zn/Ca	0.0186	17.7	0.0223	15.4
Sr/Ca	1.40	1.80	1.38	2.38
Ba/Ca	0.00448	8.49	0.00340	11.7
Test weight (µg)	6.9			
Test length (µm)	331			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.03	2.14	2.49	2.06
Al/Ca	0.0257	71.4	0.0202	78.7
Mn/Ca	0.0891	5.21	0.0452	7.83
Zn/Ca	0.00863	36.5	0.0100	28.3
Sr/Ca	1.35	3.25	1.32	2.27
Ba/Ca	0.00271	12.4	0.00200	13.0

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.15	1.82	2.42	1.91
Al/Ca	0.0296	58.5	0.0301	50.2
Mn/Ca	0.122	3.63	0.147	3.09
Zn/Ca	0.0204	16.8	0.0305	11.3
Sr/Ca	1.37	2.18	1.34	2.12
Ba/Ca	0.00317	11.5	0.00560	7.30
Test weight (µg)	3.6			
Test length (µm)	275			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	4.54	1.80	3.32	2.16
Al/Ca	0.128	13.2	0.213	11.3
Mn/Ca	0.233	2.42	0.138	5.04
Zn/Ca	0.0489	21.4	0.0120	34.9
Sr/Ca	1.39	2.16	1.36	2.28
Ba/Ca	0.00743	6.68	0.00626	9.04

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	2.93	4.92	1.87	2.97
Al/Ca	0.326	17.8	0.0912	27.6
Mn/Ca	0.137	10.2	0.171	4.75
Zn/Ca	0.00447	191	0.0190	23.7
Sr/Ca	1.33	5.95	1.33	3.43
Ba/Ca	0.00480	25.7	0.00652	10.1
Test weight (µg)	9			
Test length (µm)	293			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	2.06	1.91	1.62	2.67
Al/Ca	0.333	6.03	0.0522	40.0
Mn/Ca	0.0719	5.91	0.0204	21.2
Zn/Ca	0.0143	21.8	0.0161	24.9
Sr/Ca	1.35	1.62	1.39	2.29
Ba/Ca	0.00876	6.40	0.00279	15.0

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	2.02	2.17	1.90	1.24
Al/Ca	2.12	3.49	0.894	2.77
Mn/Ca	0.0415	8.57	0.0899	3.29
Zn/Ca	0.00784	38.2	0.0171	14.6
Sr/Ca	1.51	2.31	1.37	1.17
Ba/Ca	0.00746	6.26	0.01305	3.62
Test weight (µg)	6.2			
Test length (µm)	276			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.26	1.83	3.27	1.86
Al/Ca	0.0441	38.9	0.648	4.58
Mn/Ca	0.296	2.80	0.182	2.81
Zn/Ca	0.0975	6.57	0.0697	6.26
Sr/Ca	1.36	1.98	1.39	1.42
Ba/Ca	0.00490	8.51	0.00375	8.91

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.87	2.08	2.54	2.21
Al/Ca	0.0606	71.0	-0.0126	134
Mn/Ca	0.112	4.86	0.0686	5.72
Zn/Ca	0.0607	7.78	0.0401	10.6
Sr/Ca	1.38	2.23	1.35	2.18
Ba/Ca	0.00202	13.4	0.00232	13.2
Test weight (µg)	5.2			
Test length (µm)	281			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	6.83	2.43	6.56	2.26
Al/Ca	0.0453	46.4	0.0927	24.6
Mn/Ca	0.211	3.97	0.132	4.49
Zn/Ca	0.0789	9.06	0.0568	9.90
Sr/Ca	1.34	2.47	1.36	2.13
Ba/Ca	0.00909	8.28	0.0109	6.65

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	7.14	2.34	2.12	4.43
Al/Ca	-0.0140	144	0.00891	328
Mn/Ca	0.127	4.34	0.309	5.74
Zn/Ca	0.0409	14.0	0.0675	13.1
Sr/Ca	1.38	2.30	1.37	3.50
Ba/Ca	0.00631	10.3	0.0154	18.8
Test weight (µg)	5.2			
Test length (µm)	312			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	5.01	2.12	4.09	1.73
Al/Ca	0.0323	128	0.0818	22.3
Mn/Ca	0.351	4.37	0.208	2.81
Zn/Ca	0.0397	24.4	0.0784	6.74
Sr/Ca	1.46	3.09	1.46	1.97
Ba/Ca	0.00728	12.2	0.0039	10.3

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.98	1.87	1.59	2.24
Al/Ca	0.0546	30.1	-0.0140	126
Mn/Ca	0.192	2.96	0.117	4.39
Zn/Ca	0.0649	7.90	0.0576	9.40
Sr/Ca	1.46	1.85	1.41	1.92
Ba/Ca	0.00530	7.81	0.00298	12.3
Test weight (µg)	2.6			
Test length (µm)	229			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.96	1.46	3.74	1.61
Al/Ca	1.73	28.8	0.0367	49.3
Mn/Ca	0.817	1.94	0.579	2.06
Zn/Ca	0.154	4.87	0.157	4.79
Sr/Ca	1.49	1.62	1.51	1.74
Ba/Ca	0.00825	6.17	0.0051	8.31

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	2.71	2.41	1.80	2.07
Al/Ca	0.0598	4.31	0.00434	389
Mn/Ca	0.343	2.75	0.145	3.58
Zn/Ca	0.122	17.7	0.0680	7.79
Sr/Ca	1.53	2.56	1.39	2.04
Ba/Ca	0.00723	11.7	0.00288	12.5
Test weight (µg)	1.1			
Test length (µm)	228			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	<i>f</i> -2	% 2se
Mg/Ca	6.74	1.96	6.40	1.83
Al/Ca	-0.0176	630	0.00861	166
Mn/Ca	0.431	4.67	0.317	2.47
Zn/Ca	0.0175	11.2	0.0171	15.7
Sr/Ca	1.46	2.59	1.44	1.78
Ba/Ca	0.00628	12.6	0.00589	7.20

X/Ca (mmol/mol)	* <i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	7.16	1.66	5.89	1.79
Al/Ca	-0.00366	88.8	-0.0144	84.1
Mn/Ca	0.298	2.69	0.266	2.09
Zn/Ca	0.0496	18.7	0.0246	10.8
Sr/Ca	1.46	2.06	1.33	1.35
Ba/Ca	0.00558	7.01	0.00461	7.13
Test weight (µg)	4.6			
Test length (µm)	268			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	<i>f</i> -2	% 2se
Mg/Ca	2.06	2.19	2.07	2.20
Al/Ca	0.0170	106	0.00108	1730
Mn/Ca	0.116	4.25	0.110	4.36
Zn/Ca	0.00813	35.7	0.0147	23.4
Sr/Ca	1.35	1.67	1.31	2.32
Ba/Ca	0.00418	8.88	0.00262	13.8

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	2.50	2.31	1.86	2.22
Al/Ca	-0.0210	92.3	-0.0179	101
Mn/Ca	0.170	3.15	0.143	3.27
Zn/Ca	0.0143	24.0	0.0129	23.6
Sr/Ca	1.30	1.88	1.22	1.93
Ba/Ca	0.00481	9.33	0.00526	8.51
Test weight (µg)	6.7			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	0.663	2.62	0.563	1.39
Al/Ca	0.0241	21.8	0.0572	7.48
Mn/Ca	0.00242	50.3	0.00357	27.4
Zn/Ca	0.00214	122	0.00351	57.9
Sr/Ca	0.884	2.95	0.908	1.39
Ba/Ca	0.000847	31.9	0.000734	26.8

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.935	1.01	0.595	1.87
Al/Ca	0.0836	6.97	0.0480	12.2
Mn/Ca	0.00743	18.7	0.00601	24.7
Zn/Ca	0.00613	43.2	0.00187	158
Sr/Ca	0.947	0.919	0.865	1.51
Ba/Ca	0.00114	24.0	0.00102	28.7
Test weight (µg)	40.3			
Test length (µm)	521			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	0.820	4.93	0.541	5.78
Al/Ca	0.368	13.0	0.103	9.23
Mn/Ca	0.0115	18.4	0.00400	49.1
Zn/Ca	0.0262	18.9	0.0159	27.1
Sr/Ca	0.855	5.10	0.866	4.29
Ba/Ca	0.00129	40.8	0.000234	161

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.825	1.76	0.643	1.49
Al/Ca	0.0703	7.21	0.227	3.61
Mn/Ca	0.0136	8.83	0.0173	8.78
Zn/Ca	0.0169	15.0	0.0383	10.3
Sr/Ca	0.849	0.956	0.878	1.35
Ba/Ca	0.000595	36.7	0.00170	17.9
Test weight (µg)	29.5			
Test length (µm)	452			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.53	2.13	2.52	1.62
Al/Ca	0.295	3.71	0.276	3.85
Mn/Ca	0.0507	3.85	0.0340	4.80
Zn/Ca	0.224	4.06	0.108	4.76
Sr/Ca	0.957	2.59	0.957	1.99
Ba/Ca	0.00568	9.34	0.00462	7.50

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.67	1.82	1.32	2.46
Al/Ca	0.217	7.72	0.0213	40.3
Mn/Ca	0.0265	9.12	0.0255	8.34
Zn/Ca	0.102	7.16	0.103	7.44
Sr/Ca	1.00	1.74	0.960	3.35
Ba/Ca	0.00523	13.0	0.00444	12.2
Test weight (µg)	7			
Test length (µm)	344			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	4.12	2.26	3.60	1.80
Al/Ca	0.0617	18.4	0.132	11.0
Mn/Ca	0.0533	6.44	0.0398	4.52
Zn/Ca	0.095	10.1	0.117	5.65
Sr/Ca	0.998	3.12	0.975	2.56
Ba/Ca	0.00997	16.9	0.0105	5.45

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.90	3.38	1.37	2.64
Al/Ca	0.147	37.8	0.0524	17.7
Mn/Ca	0.0304	10.7	0.0304	7.63
Zn/Ca	0.0929	13.2	0.0740	8.59
Sr/Ca	0.944	3.78	0.919	3.29
Ba/Ca	0.00682	13.8	0.00426	13.7
Test weight (µg)	9.6			
Test length (µm)	351			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	0.118	3.14	0.106	2.82
Al/Ca	0.0651	4.49	0.0338	4.24
Mn/Ca	0.00203	6.81	0.00144	7.15
Zn/Ca	0.00289	10.8	0.00236	10.0
Sr/Ca	0.0560	2.22	0.0533	2.04
Ba/Ca	0.000603	12.5	0.000534	5.68

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.114	2.12	0.0664	2.57
Al/Ca	0.0898	3.16	0.0150	7.91
Mn/Ca	0.00108	12.2	0.000659	24.3
Zn/Ca	0.00224	14.6	0.00166	23.5
Sr/Ca	0.0566	2.36	0.0558	2.75
Ba/Ca	0.000746	4.82	0.00027	10.8
Test weight (µg)	10			
Test length (µm)	363			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	0.106	2.60	0.0851	1.65
Al/Ca	0.169	3.20	0.0112	5.89
Mn/Ca	0.00284	4.79	0.00254	5.02
Zn/Ca	0.00222	18.3	0.00169	14.2
Sr/Ca	0.0523	2.51	0.0504	1.83
Ba/Ca	0.000880	5.32	0.000359	6.27

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.0883	2.16	0.0825	2.28
Al/Ca	0.00891	11.4	0.0812	3.76
Mn/Ca	0.00660	3.18	0.00199	7.35
Zn/Ca	0.00225	16.5	0.00255	13.8
Sr/Ca	0.0511	3.05	0.0526	2.74
Ba/Ca	0.000277	9.87	0.000366	9.76
Test weight (µg)	20.4			
Test length (µm)	441			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	0.623	4.96	1.82	1.74
Al/Ca	0.623	9.86	0.335	4.61
Mn/Ca	0.0293	26.7	0.0114	20.3
Zn/Ca	0.0422	32.8	0.0125	30.5
Sr/Ca	1.48	5.05	1.50	1.43
Ba/Ca	0.00283	39.8	0.00166	21.8

X/Ca (mmol/mol)	* <i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.46	2.26	1.54	1.54
Al/Ca	2.87	4.63	0.0428	32.2
Mn/Ca	0.0296	8.94	0.0422	6.70
Zn/Ca	0.0680	7.45	0.0401	12.7
Sr/Ca	1.53	1.86	1.40	1.33
Ba/Ca	0.00601	8.40	0.00196	21.8
Test weight (µg)	4.3			
Test length (µm)	313			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	0.0428	2.28	1.18	3.48
Al/Ca	0.108	12.0	0.216	9.36
Mn/Ca	0.0458	6.40	0.0116	30.2
Zn/Ca	0.0756	8.30	0.0339	18.5
Sr/Ca	1.44	2.39	1.42	3.73
Ba/Ca	0.0186	8.83	0.0120	8.84

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	1.34	2.09	0.798	2.26
Al/Ca	0.850	4.19	0.0753	13.5
Mn/Ca	0.0485	6.22	0.0124	16.5
Zn/Ca	0.0429	8.73	0.0076	36.8
Sr/Ca	1.54	1.86	1.43	1.50
Ba/Ca	0.0175	5.13	0.00306	10.9
Test weight (µg)	12.7			
Test length (µm)	353			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.10	1.07	2.46	0.217
Al/Ca	0.202	7.22	0.216	6.27
Mn/Ca	0.0316	8.14	0.0116	15.2
Zn/Ca	0.0378	11.4	0.0339	15.3
Sr/Ca	1.44	0.917	1.42	0.901
Ba/Ca	0.00188	22.0	0.0120	14.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.94	2.11	3.29	2.91
Al/Ca	0.152	7.65	0.0190	78.1
Mn/Ca	0.0239	10.8	0.0354	7.26
Zn/Ca	0.0269	12.7	0.0374	11.3
Sr/Ca	1.42	0.774	1.46	1.37
Ba/Ca	0.00248	12.8	0.00420	9.8
Test weight (µg)	9.9			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.97	1.95	2.54	1.70
Al/Ca	0.365	6.91	0.202	10.1
Mn/Ca	0.0774	6.81	0.0571	6.65
Zn/Ca	0.167	7.20	0.0927	8.24
Sr/Ca	1.36	1.77	1.35	1.67
Ba/Ca	0.00446	15.4	0.00349	18.3

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.74	1.69	1.58	1.62
Al/Ca	0.368	4.62	0.156	13.5
Mn/Ca	0.0391	7.44	0.0489	7.45
Zn/Ca	0.109	5.89	0.169	5.60
Sr/Ca	1.42	1.16	1.50	1.34
Ba/Ca	0.00319	12.7	0.00527	13.7
Test weight (µg)	5.2			
Test length (µm)	385			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca				
Al/Ca				
Mn/Ca				
Zn/Ca				
Sr/Ca				
Ba/Ca				

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca				
Al/Ca				
Mn/Ca				
Zn/Ca				
Sr/Ca				
Ba/Ca				
Test weight (µg)				
Test length (µm)				
Coiling direction				

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>*f-2</i>	% 2se
Mg/Ca	2.38	3.55	1.91	3.49
Al/Ca	-0.0102	33.0	0.0717	34.5
Mn/Ca	0.0888	4.66	0.0861	4.94
Zn/Ca	0.225	4.84	0.387	6.45
Sr/Ca	1.31	2.70	1.35	2.35
Ba/Ca	0.00381	14.1	0.00697	10.0

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.00	3.36	1.62	3.79
Al/Ca	0.0781	234	0.001	1800
Mn/Ca	0.146	5.64	0.0706	7.34
Zn/Ca	0.444	5.27	0.255	6.53
Sr/Ca	1.29	2.57	1.37	3.50
Ba/Ca	0.00682	16.4	0.00316	21.3
Test weight (µg)	4.2			
Test length (µm)	n/a			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.48	2.73	1.36	1.93
Al/Ca	0.102	26.0	0.0916	23.2
Mn/Ca	0.0102	40.9	0.0063	47.6
Zn/Ca	0.0246	41.3	0.0201	25.9
Sr/Ca	1.24	2.37	1.23	1.42
Ba/Ca	0.00803	11.6	0.00398	12.3

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.03	1.92	1.29	1.57
Al/Ca	0.324	5.83	0.0173	83.7
Mn/Ca	0.0214	13.9	0.0207	11.4
Zn/Ca	0.0624	9.81	0.0233	16.3
Sr/Ca	1.31	1.47	1.26	1.04
Ba/Ca	0.00880	7.02	0.00316	13.0
Test weight (µg)	7.6			
Test length (µm)	n/a			
Coiling direction				

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.85	1.58	3.15	1.92
Al/Ca	0.794	3.99	0.311	7.03
Mn/Ca	0.0794	4.22	0.0892	3.97
Zn/Ca	0.0425	12.3	0.0209	21.1
Sr/Ca	1.33	1.30	1.38	1.05
Ba/Ca	0.0188	4.05	0.0116	5.69

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	3.06	1.85	6.50	4.00
Al/Ca	2.00	5.15	0.141	37.2
Mn/Ca	0.0424	6.93	0.0619	8.60
Zn/Ca	0.0383	12.4	0.0801	23.0
Sr/Ca	1.48	2.16	1.52	3.23
Ba/Ca	0.0172	5.11	0.0307	6.27
Test weight (µg)	7.9			
Test length (µm)	343			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	2.29	1.45	1.64	1.47
Al/Ca	0.233	7.57	0.708	2.84
Mn/Ca	0.0692	8.25	0.0274	9.26
Zn/Ca	0.114	7.78	0.0478	9.20
Sr/Ca	1.33	1.61	1.42	1.46
Ba/Ca	0.00982	5.05	0.00767	11.7

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	1.82	1.93	1.49	1.21
Al/Ca	0.224	7.63	0.405	4.41
Mn/Ca	0.0351	4.98	0.0278	8.18
Zn/Ca	0.0656	5.96	0.0633	6.74
Sr/Ca	1.39	1.63	1.39	1.21
Ba/Ca	0.0100	17.9	0.00721	5.52
Test weight (µg)	8			
Test length (µm)	n/a			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	4.28	1.75	4.14	2.14
Al/Ca	2.520	1.91	0.798	2.92
Mn/Ca	0.0612	5.96	0.0449	5.96
Zn/Ca	0.064	8.79	0.0449	8.90
Sr/Ca	1.44	2.34	1.38	1.44
Ba/Ca	0.00970	8.44	0.00655	7.27

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.92	1.61	2.25	1.32
Al/Ca	0.767	3.00	0.829	3.00
Mn/Ca	0.0323	7.87	0.0270	9.82
Zn/Ca	0.0400	10.8	0.0393	12.7
Sr/Ca	1.46	1.44	1.28	1.57
Ba/Ca	0.00694	6.48	0.00676	6.55
Test weight (µg)	10.3			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.45	1.35	2.36	1.69
Al/Ca	-0.0430	101	0.00287	588
Mn/Ca	0.0627	7.59	0.0632	5.30
Zn/Ca	0.227	4.55	0.224	4.01
Sr/Ca	1.28	1.36	1.33	2.37
Ba/Ca	0.00339	17.7	0.00332	14.3

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.73	2.08	1.27	2.46
Al/Ca	0.0174	49.3	0.0185	104
Mn/Ca	0.0422	6.87	0.0281	11.7
Zn/Ca	0.147	4.81	0.108	7.54
Sr/Ca	1.32	2.24	1.28	1.82
Ba/Ca	0.00246	15.6	0.00157	25.9
Test weight (µg)	3.6			
Test length (µm)	281			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.67	1.19	2.60	1.32
Al/Ca	0.153	4.60	0.279	6.61
Mn/Ca	0.121	4.32	0.108	2.85
Zn/Ca	0.196	3.17	0.236	3.15
Sr/Ca	1.37	1.34	1.36	1.58
Ba/Ca	0.00729	6.69	0.0122	5.04

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.00	2.08	1.35	2.03
Al/Ca	0.441	13.9	0.0698	30.2
Mn/Ca	0.0631	9.84	0.0537	6.72
Zn/Ca	0.187	5.47	0.155	5.90
Sr/Ca	1.42	2.21	1.38	1.77
Ba/Ca	0.00554	9.29	0.00599	16.9
Test weight (µg)	6.5			
Test length (µm)	273			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.99	2.38	2.14	2.18
Al/Ca	0.0702	35.7	0.792	3.72
Mn/Ca	0.0794	6.04	0.0424	12.1
Zn/Ca	0.0518	13.4	0.0191	29.0
Sr/Ca	1.38	3.26	1.32	2.63
Ba/Ca	0.00694	11.9	0.00323	16.5

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.32	1.49	1.45	1.67
Al/Ca	0.296	6.24	0.0950	17.5
Mn/Ca	0.0555	5.55	0.0269	11.5
Zn/Ca	0.0245	17.6	0.0322	13.8
Sr/Ca	1.33	1.09	1.31	1.56
Ba/Ca	0.00559	7.71	0.00171	22.0
Test weight (µg)	11.1			
Test length (µm)	321			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	* <i>f-2</i>	% 2se
Mg/Ca	4.93	3.40	5.38	3.47
Al/Ca	0.613	10.0	0.144	24.7
Mn/Ca	0.0916	7.96	0.0767	7.00
Zn/Ca	0.0569	18.5	0.0775	12.3
Sr/Ca	1.33	4.60	1.23	3.57
Ba/Ca	0.00823	13.9	0.0174	14.4

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.57	2.36	3.70	1.46
Al/Ca	0.104	15.0	0.0818	22.0
Mn/Ca	0.0395	7.38	0.0465	6.5
Zn/Ca	0.0320	13.2	0.0298	13.3
Sr/Ca	1.45	1.62	1.30	1.59
Ba/Ca	0.00524	8.70	0.00425	9.10
Test weight (µg)	8.2			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.57	3.62	2.20	2.52
Al/Ca	0.106	9.03	0.146	6.01
Mn/Ca	0.0604	5.70	0.0231	6.52
Zn/Ca	0.0507	8.94	0.0389	6.39
Sr/Ca	1.42	3.33	1.48	1.35
Ba/Ca	0.00642	8.23	0.0067	4.41

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.21	1.68	1.08	2.12
Al/Ca	0.575	3.26	0.171	4.87
Mn/Ca	0.0273	5.47	0.0518	4.48
Zn/Ca	0.0221	7.75	0.0225	9.95
Sr/Ca	1.45	1.38	1.39	1.85
Ba/Ca	0.00408	5.84	0.00249	8.18
Test weight (µg)	26.9			
Test length (µm)	311			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.24	2.10	2.65	2.96
Al/Ca	0.535	3.74	0.647	8.90
Mn/Ca	0.0309	7.27	0.0303	9.53
Zn/Ca	0.0864	4.83	0.122	3.89
Sr/Ca	1.38	2.61	1.47	1.38
Ba/Ca	0.00217	9.83	0.00269	7.87

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.69	2.84	1.57	2.24
Al/Ca	0.187	5.81	0.181	7.22
Mn/Ca	0.0212	8.34	0.0410	6.74
Zn/Ca	0.0387	7.27	0.188	3.85
Sr/Ca	1.46	1.88	1.45	2.15
Ba/Ca	0.00167	12.3	0.00168	14.1
Test weight (µg)	13			
Test length (µm)	303			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.96	1.76	1.90	1.96
Al/Ca	0.0552	19.4	0.0314	33.5
Mn/Ca	-0.00330	89.1	0.00281	88.8
Zn/Ca	0.00885	44.8	0.0136	26.0
Sr/Ca	1.35	1.83	1.31	1.55
Ba/Ca	0.00321	18.4	0.00742	9.50

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.30	1.59	1.46	1.41
Al/Ca	0.244	4.51	0.0129	51.4
Mn/Ca	0.00131	128	0.00295	56.1
Zn/Ca	0.0175	15.0	0.0171	16.2
Sr/Ca	1.37	1.00	1.37	1.09
Ba/Ca	0.00835	9.86	0.0044	8.77
Test weight (µg)	7.4			
Test length (µm)	259			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.85	3.69	1.19	1.09
Al/Ca	2.84	2.24	0.0671	10.1
Mn/Ca	0.0119	47.6	0.000602	310
Zn/Ca	0.00495	44.6	0.00331	64.6
Sr/Ca	1.33	1.20	1.36	0.820
Ba/Ca	0.00281	14.6	0.000597	41.8

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.05	3.77	1.10	3.94
Al/Ca	0.735	15.9	0.235	6.07
Mn/Ca	0.00405	257	0.00139	177
Zn/Ca	0.00510	39.1	0.00738	46.7
Sr/Ca	1.39	1.10	1.34	1.88
Ba/Ca	0.000975	25.5	0.000677	65.9
Test weight (µg)	21.2			
Test length (µm)	369			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.70	2.97	1.96	2.85
Al/Ca	1.89	16.4	0.699	4.38
Mn/Ca	0.00680	1170	0.00225	70.7
Zn/Ca	0.0617	36.1	0.0417	8.23
Sr/Ca	1.31	2.56	1.34	1.28
Ba/Ca	0.00717	54.3	0.00590	10.9

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	1.22	2.33	1.05	1.91
Al/Ca	0.151	2.57	0.187	7.28
Mn/Ca	-0.000354	35.1	0.00354	72.1
Zn/Ca	0.0285	8.30	0.0256	17.0
Sr/Ca	1.31	1.64	1.28	1.75
Ba/Ca	0.00118	13.1	0.00183	26.0
Test weight (µg)	5.6			
Test length (µm)	252			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	* <i>f-2</i>	% 2se
Mg/Ca	0.987	3.03	1.98	2.23
Al/Ca	0.0519	26.4	0.600	2.65
Mn/Ca	0.00183	119	0.00552	17.0
Zn/Ca	0.00789	42.5	0.0164	12.0
Sr/Ca	0.960	2.76	0.976	1.42
Ba/Ca	0.000711	58.2	0.00217	10.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	0.879	3.64	0.780	4.00
Al/Ca	0.0638	25.3	0.0318	30.9
Mn/Ca	0.00258	78.5	0.00441	70.2
Zn/Ca	0.0131	25.2	0.0328	9.82
Sr/Ca	0.968	3.76	0.930	2.68
Ba/Ca	0.00122	43.4	0.00145	22.3
Test weight (µg)	7.8			
Test length (µm)	275			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.21	1.64	2.82	2.40
Al/Ca	0.0181	24.7	0.00404	147
Mn/Ca	0.00218	32.2	0.000785	115
Zn/Ca	0.00246	35.1	0.00879	15.3
Sr/Ca	1.09	1.07	1.09	1.28
Ba/Ca	0.000886	15.9	0.00082	22.6

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.41	2.28	1.02	1.66
Al/Ca	0.0930	13.7	0.0641	12.1
Mn/Ca	0.00307	57.5	0.00305	36.1
Zn/Ca	0.00686	32.1	0.00973	17.6
Sr/Ca	1.13	2.58	1.05	1.52
Ba/Ca	0.00267	15.9	0.000990	24.0
Test weight (µg)	19.1			
Test length (µm)	353			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	4.83	1.85	4.28	2.88
Al/Ca	0.176	7.27	0.427	4.76
Mn/Ca	0.0100	21.0	0.00758	29.2
Zn/Ca	0.0510	9.04	0.0606	6.89
Sr/Ca	1.11	1.65	1.11	1.80
Ba/Ca	0.00536	9.10	0.00491	10.2

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.21	1.64	1.69	1.74
Al/Ca	0.298	3.38	0.0375	21.4
Mn/Ca	0.00171	109.1	0.00343	55.6
Zn/Ca	0.0138	15.8	0.0349	9.00
Sr/Ca	1.03	1.33	1.05	1.77
Ba/Ca	0.00184	14.9	0.00250	14.6
Test weight (µg)	6.8			
Test length (µm)	299			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.16	1.61	1.01	2.47
Al/Ca	0.0145	44.3	0.0313	20.9
Mn/Ca	0.00308	68.9	0.000769	188
Zn/Ca	0.0125	13.3	0.00697	24.7
Sr/Ca	1.09	0.959	1.12	1.02
Ba/Ca	0.00116	19.2	0.00103	20.9

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.01	2.11	0.71	1.82
Al/Ca	0.0146	45.9	0.0396	37.0
Mn/Ca	0.00219	46.9	0.00565	34.2
Zn/Ca	0.0143	14.7	0.0284	9.50
Sr/Ca	1.10	1.10	1.09	1.42
Ba/Ca	0.00123	19.8	0.00146	19.6
Test weight (µg)	9.9			
Test length (µm)	343			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.38	1.70	2.46	2.08
Al/Ca	0.0937	10.5	0.0771	10.8
Mn/Ca	0.0229	9.61	0.0159	11.3
Zn/Ca	0.0360	9.71	0.0568	5.82
Sr/Ca	1.28	1.13	1.29	0.970
Ba/Ca	0.00359	11.6	0.00286	11.4

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.31	2.45	1.19	1.47
Al/Ca	0.247	4.77	0.276	4.78
Mn/Ca	0.0102	16.0	0.00900	18.5
Zn/Ca	0.0773	4.69	0.0245	10.2
Sr/Ca	1.31	1.05	1.34	1.04
Ba/Ca	0.00262	14.8	0.00106	25.8
Test weight (µg)	13.9			
Test length (µm)	323			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	1.82	1.76	0.866	1.24
Al/Ca	1.74	3.24	0.105	8.24
Mn/Ca	0.00685	31.9	0.00262	66.2
Zn/Ca	0.00683	41.0	0.00772	29.7
Sr/Ca	1.33	1.96	1.31	0.921
Ba/Ca	0.00294	12.9	0.00058	44.5

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	0.868	1.39	0.907	1.87
Al/Ca	0.0370	44.0	0.118	11.8
Mn/Ca	0.000352	532	-0.00317	99.6
Zn/Ca	0.00269	85.2	0.0156	28.0
Sr/Ca	1.30	1.05	1.28	1.57
Ba/Ca	0.00145	20.7	0.000808	60.0
Test weight (µg)	23.3			
Test length (µm)	368			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.52	1.26	1.32	1.21
Al/Ca	0.0493	8.19	0.0889	9.29
Mn/Ca	0.00950	15.8	0.00571	29.1
Zn/Ca	0.0141	8.21	0.0204	12.7
Sr/Ca	1.29	1.02	1.32	1.16
Ba/Ca	0.00311	11.8	0.00252	13.1

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.14	1.23	1.17	1.93
Al/Ca	0.124	18.7	0.0797	15.4
Mn/Ca	0.0119	20.9	0.0139	19.6
Zn/Ca	0.0411	18.9	0.0323	14.7
Sr/Ca	1.33	1.21	1.46	1.74
Ba/Ca	0.00279	11.0	0.00197	21.6
Test weight (µg)	6.1			
Test length (µm)	283			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	0.724	2.08	0.962	1.52
Al/Ca	0.0317	31.7	0.0579	8.10
Mn/Ca	0.00332	52.2	0.00070	120
Zn/Ca	0.0605	6.68	0.0176	9.39
Sr/Ca	0.435	2.13	0.438	1.27
Ba/Ca	0.000939	30.0	0.000680	21.1

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.899	1.70	0.731	1.37
Al/Ca	0.0204	21.5	0.0233	17.6
Mn/Ca	0.00353	182	0.00159	51.9
Zn/Ca	0.0166	9.79	0.0535	4.19
Sr/Ca	0.434	1.25	0.419	1.25
Ba/Ca	0.000472	26.5	0.000747	18.0
Test weight (µg)	7.4			
Test length (µm)	269			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	1.17	2.62	1.08	1.66
Al/Ca	0.608	4.71	0.249	7.90
Mn/Ca	0.00835	20.8	0.00439	18.2
Zn/Ca	0.0297	6.59	0.0304	9.61
Sr/Ca	0.428	1.83	0.426	1.63
Ba/Ca	0.00361	5.44	0.00194	8.2

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	0.822	1.23	0.482	1.18
Al/Ca	0.0474	10.1	0.127	4.18
Mn/Ca	0.00237	41.2	0.00216	38.5
Zn/Ca	0.0200	8.85	0.0141	10.1
Sr/Ca	0.435	1.38	0.429	1.08
Ba/Ca	0.00185	9.74	0.00135	12.2
Test weight (µg)	6.7			
Test length (µm)	278			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3*</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.77	2.92	2.69	3.05
Al/Ca	0.0113	11.1	0.0260	69.8
Mn/Ca	0.00705	131	0.00937	154
Zn/Ca	0.0117	35.0	0.0149	98.0
Sr/Ca	1.30	3.08	1.30	1.29
Ba/Ca	0.00200	16.4	0.00282	9.49

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.64	2.66	2.87	2.30
Al/Ca	0.0698	30.0	0.0319	254
Mn/Ca	0.0170	104	0.0188	62.7
Zn/Ca	0.0220	221	0.0193	61.4
Sr/Ca	1.27	1.64	1.28	1.53
Ba/Ca	0.00483	10.6	0.00460	17.5
Test weight (µg)	22.4			
Test length (µm)	412			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.27	1.78	1.04	1.90
Al/Ca	-0.000260	3336	-0.0140	82.5
Mn/Ca	-0.00224	101	-0.00264	106
Zn/Ca	-0.000782	195	0.00103	195
Sr/Ca	1.34	1.23	1.34	1.35
Ba/Ca	0.00123	13.4	0.000866	21.0

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.26	1.90	0.875	1.83
Al/Ca	-0.00261	364	0.00604	151
Mn/Ca	0.000148	1672	-0.000863	269
Zn/Ca	0.00769	41	0.00506	34.5
Sr/Ca	1.38	1.33	1.41	1.28
Ba/Ca	0.00147	13.7	0.000873	17.4
Test weight (µg)	22.0			
Test length (µm)	432			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.26	1.58	1.17	1.92
Al/Ca	0.0382	32.3	0.0146	81.4
Mn/Ca	-0.00127	201	-0.00232	117
Zn/Ca	0.00138	132	0.00254	78.8
Sr/Ca	1.42	1.47	1.38	1.80
Ba/Ca	0.00185	10.9	0.00235	16.9

X/Ca (mmol/mol)	<i>f-1*</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.03	1.65	1.243	2.12
Al/Ca	-0.896	1.85	0.0358	28.7
Mn/Ca	0.00771	42.4	0.000532	548
Zn/Ca	0.00477	47.1	0.00620	37.6
Sr/Ca	1.45	1.46	1.44	1.51
Ba/Ca	0.00365	8.42	0.00144	13.5
Test weight (µg)	21.2			
Test length (µm)	404			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3*	% 2se	f-2*	% 2se
Mg/Ca	2.21	1.58	2.25	1.64
Al/Ca	-0.0180	67.6	0.0179	54.6
Mn/Ca	0.0118	27.2	0.00994	25.6
Zn/Ca	0.0106	23.4	0.00595	31.8
Sr/Ca	1.41	1.77	1.41	1.42
Ba/Ca	0.00550	6.85	0.00529	5.33

X/Ca (mmol/mol)	f-1*	% 2se	f*	% 2se
Mg/Ca	2.02	1.90	2.64	1.57
Al/Ca	-0.0114	101	0.00372	292
Mn/Ca	0.00857	38.3	0.00977	31.4
Zn/Ca	0.00280	84.3	0.00890	26.0
Sr/Ca	1.42	1.72	1.34	1.68
Ba/Ca	0.00521	7.36	0.00416	7.49
Test weight (µg)	21.6			
Test length (µm)	436			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.10	5.13	1.25	2.95
Al/Ca	0.0222	23.2	-0.00100	732
Mn/Ca	0.000221	44.3	-0.00224	79.1
Zn/Ca	0.00255	145	0.000792	171
Sr/Ca	1.38	3.67	1.34	1.69
Ba/Ca	0.00235	18.1	0.000838	17.8

X/Ca (mmol/mol)	f-1	% 2se	f*	% 2se
Mg/Ca	1.07	1.60	1.68	2.98
Al/Ca	0.0605	30.2	0.0752	22.0
Mn/Ca	0.00788	713	0.0136	29.0
Zn/Ca	0.00187	49.4	0.000829	353
Sr/Ca	1.37	1.43	1.39	3.06
Ba/Ca	0.00170	7.34	0.00220	19.7
Test weight (µg)	25.4			
Test length (µm)	499			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	<i>f</i> -2	% 2se
Mg/Ca	2.10	1.62	1.25	1.44
Al/Ca	0.0222	53.8	-0.00100	26.9
Mn/Ca	0.000221	28.4	-0.00224	49.0
Zn/Ca	0.00255	18.2	0.000792	13.7
Sr/Ca	1.38	1.33	1.34	1.45
Ba/Ca	0.00235	6.46	0.000838	8.27

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	1.07	1.81	1.68	1.27
Al/Ca	0.0605	30.1	0.0752	15.2
Mn/Ca	0.00788	717	0.0136	32.2
Zn/Ca	0.00187	33.7	0.000829	13.8
Sr/Ca	1.37	1.59	1.39	1.12
Ba/Ca	0.00170	13.9	0.00220	7.81
Test weight (µg)	9.9			
Test length (µm)	359			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.26	1.81	1.82	2.38
Al/Ca	0.00601	104	0.00968	67.3
Mn/Ca	0.000729	214	-0.00299	56.8
Zn/Ca	0.00337	43.0	0.002884	52.6
Sr/Ca	1.23	1.61	1.31	1.66
Ba/Ca	0.00162	9.57	0.000716	16.8

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.00	1.62	1.40	1.58
Al/Ca	0.0120	59.1	0.00887	76.5
Mn/Ca	-0.000096	1987	0.000777	225
Zn/Ca	0.000495	321	0.00379	37.7
Sr/Ca	1.31	1.52	1.29	1.30
Ba/Ca	0.00106	13.6	0.00139	10.1
Test weight (µg)	23.1			
Test length (µm)	438			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3*</i>	% 2se	<i>f-2*</i>	% 2se
Mg/Ca	1.68	1.49	1.59	3.88
Al/Ca	0.0201	27.7	0.25273	10.7
Mn/Ca	0.00198	75.7	0.00284	119
Zn/Ca	0.00539	23.7	0.003797	85.4
Sr/Ca	1.33	1.10	1.45	3.04
Ba/Ca	0.00294	5.47	0.002243	17.3

X/Ca (mmol/mol)	<i>f-1*</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.81	1.93	1.34	2.69
Al/Ca	0.113	6.96	0.0387	18.4
Mn/Ca	0.00217	80.1	-0.0009	188
Zn/Ca	0.000201	766	0.003536	38.3
Sr/Ca	1.56	1.51	1.51	1.35
Ba/Ca	0.00290	7.19	0.00240	7.16
Test weight (µg)	36.4			
Test length (µm)	478			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.86	1.24	1.95	1.48
Al/Ca	0.0570	11.0	0.0649	10.9
Mn/Ca	0.00182	96.4	0.00456	33.7
Zn/Ca	0.00495	29.4	0.00353	32.2
Sr/Ca	1.28	1.07	1.31	1.07
Ba/Ca	0.00170	9.21	0.00115	10.4

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.83	1.92	1.32	1.57
Al/Ca	0.0141	49.5	0.0157	35.1
Mn/Ca	0.00186	100	0.0017	83.9
Zn/Ca	0.00358	41.2	0.00443	26.5
Sr/Ca	1.37	1.42	1.32	1.36
Ba/Ca	0.00153	12.9	0.00131	9.64
Test weight (µg)	22.1			
Test length (µm)	418			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.29	2.25	0.840	2.19
Al/Ca	0.0479	21.5	0.00447	153
Mn/Ca	-0.00193	132	0.0000171	11999
Zn/Ca	0.000171	1024	0.00118	118
Sr/Ca	1.39	1.93	1.37	2.06
Ba/Ca	0.00131	17.5	0.00079	17.6

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	0.883	3.72	1.00	2.22
Al/Ca	-0.0036	229	-0.00467	140
Mn/Ca	-0.00100	221	-0.00155	128
Zn/Ca	0.000409	408	0.000130	1082
Sr/Ca	1.35	2.92	1.34	1.71
Ba/Ca	0.00102	20.8	0.00107	15.0
Test weight (µg)	30.5			
Test length (µm)	430			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3*</i>	% 2se	<i>f-2*</i>	% 2se
Mg/Ca	2.46	3.29	3.22	2.13
Al/Ca	0.0118	70.5	0.0129	51
Mn/Ca	0.0158	15.5	0.0170	11
Zn/Ca	0.00594	34.5	0.0197	10
Sr/Ca	1.36	2.74	1.33	1.86
Ba/Ca	0.00272	10.7	0.00328	7.1

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.81	2.38	1.18	2.78
Al/Ca	0.00738	121	0.0207	33.1
Mn/Ca	0.00649	43.1	0.00808	23.9
Zn/Ca	0.00741	33.5	0.00649	26.1
Sr/Ca	1.48	2.23	1.36	2.08
Ba/Ca	0.00182	12.7	0.00226	9.56
Test weight (µg)	12.6			
Test length (µm)	368			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.61	2.00	1.52	2.60
Al/Ca	-0.000399	1663	0.0293	21.1
Mn/Ca	0.00193	102	0.000352	445
Zn/Ca	0.00264	53.4	0.00264	51.4
Sr/Ca	1.38	1.53	1.40	1.77
Ba/Ca	0.00147	11.2	0.00131	11.9

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.81	1.50	1.28	1.96
Al/Ca	0.00589	117	0.00286	254
Mn/Ca	0.00180	112	0.00084	236
Zn/Ca	0.00328	46.5	0.00287	52.4
Sr/Ca	1.38	1.43	1.37	1.86
Ba/Ca	0.00144	11.1	0.00134	13.0
Test weight (µg)	10.4			
Test length (µm)	366			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3*</i>	% 2se	<i>f-2*</i>	% 2se
Mg/Ca	2.90	2.32	2.91	2.66
Al/Ca	0.0104	59.8	0.00763	71.8
Mn/Ca	0.0138	15.1	0.0116	14.9
Zn/Ca	0.00777	20.4	0.00408	29.7
Sr/Ca	1.50	1.78	1.46	1.39
Ba/Ca	0.00192	9.88	0.00135	10.7

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.82	1.55	3.05	3.01
Al/Ca	0.00926	68.5	0.00157	423
Mn/Ca	0.00635	30.9	0.00628	35.0
Zn/Ca	0.00279	54.1	0.00299	49.7
Sr/Ca	1.55	1.74	1.51	1.61
Ba/Ca	0.00145	11.3	0.00119	14.0
Test weight (µg)	8.8			
Test length (µm)	302			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3*</i>	% 2se	<i>f-2*</i>	% 2se
Mg/Ca	3.36	2.97	3.16	3.02
Al/Ca	0.0714	16.0	0.0332	26.2
Mn/Ca	0.00993	35.2	0.00734	30.9
Zn/Ca	0.0142	22.4	0.0139	14.1
Sr/Ca	1.46	3.35	1.46	2.14
Ba/Ca	0.00360	12.4	0.00263	9.71

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f*</i>	% 2se
Mg/Ca	2.31	2.50	2.57	3.96
Al/Ca	0.00948	67.2	2.30	6.27
Mn/Ca	0.00254	70.3	0.0097	23.0
Zn/Ca	0.00604	24.2	0.0213	10.6
Sr/Ca	1.45	1.64	1.37	1.53
Ba/Ca	0.00212	8.27	0.00350	7.56
Test weight (µg)	12.6			
Test length (µm)	395			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.01	2.27	1.81	1.70
Al/Ca	0.0154	43.5	0.0175	31.3
Mn/Ca	0.00406	44.1	0.000403	412
Zn/Ca	0.00339	39.6	0.000256	431
Sr/Ca	1.59	1.60	1.44	1.42
Ba/Ca	0.00083	15.2	0.00090	13.6

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.79	2.47	1.88	2.91
Al/Ca	0.0131	46.5	0.0278	22.3
Mn/Ca	0.00218	72.5	0.00156	108
Zn/Ca	0.00121	93.8	0.00179	69.9
Sr/Ca	1.61	1.54	1.64	1.71
Ba/Ca	0.00080	14.7	0.00069	16.6
Test weight (µg)	16.0			
Test length (µm)	364			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3*	% 2se	f-2	% 2se
Mg/Ca	4.62	1.62	2.89	2.48
Al/Ca	0.0244	30.6	0.0577	13.9
Mn/Ca	0.0274	7.74	0.00546	36.2
Zn/Ca	0.0322	8.39	0.00966	19.2
Sr/Ca	1.32	2.60	1.40	1.54
Ba/Ca	0.00398	6.94	0.00142	12.2

X/Ca (mmol/mol)	f-1*	% 2se	f	% 2se
Mg/Ca	3.80	1.84	1.50	1.95
Al/Ca	0.0186	41.0	0.0215	32.6
Mn/Ca	0.00742	27.9	0.00247	79.5
Zn/Ca	0.00853	22.8	0.00767	23.2
Sr/Ca	1.39	1.83	1.34	1.68
Ba/Ca	0.00171	11.7	0.00139	14.0
Test weight (µg)	10.6			
Test length (µm)	370			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3*</i>	% 2se	<i>f-2*</i>	% 2se
Mg/Ca	4.60	5.08	4.68	3.41
Al/Ca	0.0542	27.4	3.49	5.13
Mn/Ca	0.0170	24.6	0.0145	35.9
Zn/Ca	0.0217	20.9	0.0226	22.2
Sr/Ca	1.19	3.10	1.23	1.86
Ba/Ca	0.00492	12.6	0.00965	8.16

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	3.37	2.51	1.72	3.30
Al/Ca	0.0325	29.3	0.00538	126
Mn/Ca	0.00347	78.6	0.00404	50.0
Zn/Ca	0.0103	26.8	0.00687	24.8
Sr/Ca	1.22	2.16	1.23	1.45
Ba/Ca	0.00223	13.6	0.00160	10.6
Test weight (µg)	6.1			
Test length (µm)	322			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3*	% 2se	f-2	% 2se
Mg/Ca	4.52	2.42	2.28	2.50
Al/Ca	0.145	8.44	0.0399	15.6
Mn/Ca	0.0103	28.0	0.00289	57.6
Zn/Ca	0.00989	24.4	0.00399	31.7
Sr/Ca	1.37	1.64	1.41	1.38
Ba/Ca	0.00494	8.69	0.00179	8.53

X/Ca (mmol/mol)	f-1*	% 2se	f	% 2se
Mg/Ca	2.24	2.67	1.19	2.29
Al/Ca	0.0821	10.5	0.0374	22.7
Mn/Ca	0.000378	577	0.000417	561
Zn/Ca	0.00373	45.7	0.00174	99.0
Sr/Ca	1.40	1.60	1.37	2.01
Ba/Ca	0.00224	10.3	0.00116	15.8
Test weight (µg)	10.1			
Test length (µm)	358			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.54	2.57	2.54	1.96
Al/Ca	0.0335	32.0	0.0135	48.2
Mn/Ca	0.00534	43.2	0.00323	58.6
Zn/Ca	0.00483	42.4	0.00890	19.4
Sr/Ca	1.42	1.74	1.38	1.61
Ba/Ca	0.00280	10.7	0.00299	8.20

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.61	2.33	1.27	1.80
Al/Ca	0.0687	13.7	0.0515	16.1
Mn/Ca	0.00256	92.9	0.00436	49.4
Zn/Ca	0.00948	25.02	0.00567	35.2
Sr/Ca	1.38	2.39	1.32	1.54
Ba/Ca	0.00421	8.19	0.00218	9.28
Test weight (µg)	12.2			
Test length (µm)	443			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	1.78	3.10	2.89	2.01
Al/Ca	0.00189	383	0.0208	50.2
Mn/Ca	0.00446	46.0	0.0103	26.2
Zn/Ca	0.00817	25.4	0.0246	14.8
Sr/Ca	1.30	1.42	1.35	2.26
Ba/Ca	0.00224	30.4	0.00330	10.3

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	3.22	1.62	1.54	2.07
Al/Ca	0.0108	60.5	0.0317	26.1
Mn/Ca	0.00868	22.2	0.00434	54.4
Zn/Ca	0.0212	10.8	0.00679	31.8
Sr/Ca	1.39	1.66	1.36	1.79
Ba/Ca	0.00266	7.94	0.00156	14.0
Test weight (µg)	11.3			
Test length (µm)	381			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.60	1.71	1.40	1.89
Al/Ca	0.0203	28.7	0.00894	40.1
Mn/Ca	0.00380	28.4	0.00142	60.3
Zn/Ca	0.00702	15.6	0.00268	29.0
Sr/Ca	1.30	1.09	1.29	1.14
Ba/Ca	0.00169	5.40	0.00075	6.96

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.15	1.38	1.25	1.45
Al/Ca	0.0131	35.1	0.0334	15.7
Mn/Ca	0.00125	85.8	0.00220	51.4
Zn/Ca	0.00618	17.6	0.00936	13.3
Sr/Ca	1.35	1.20	1.28	1.24
Ba/Ca	0.00114	6.38	0.00122	6.92
Test weight (µg)	20			
Test length (µm)	326			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	1.83	2.47	1.72	2.40
Al/Ca	0.0226	22.8	0.0458	17.5
Mn/Ca	0.0155	8.52	0.00410	23.9
Zn/Ca	0.0432	6.01	0.0141	10.1
Sr/Ca	1.29	1.96	1.24	1.33
Ba/Ca	0.00260	5.84	0.00236	6.90

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.62	1.42	1.31	2.01
Al/Ca	0.0345	14.7	0.0313	21.3
Mn/Ca	0.00441	25.1	0.00668	22.5
Zn/Ca	0.00919	14.3	0.0285	9.73
Sr/Ca	1.30	1.02	1.32	1.76
Ba/Ca	0.00245	5.17	0.00185	9.21
Test weight (µg)	13.8			
Test length (µm)	345			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>*f-2</i>	% 2se
Mg/Ca	1.27	1.92	1.61	3.18
Al/Ca	0.00621	69.8	0.391	4.43
Mn/Ca	0.00336	30.2	0.00428	47.4
Zn/Ca	0.00473	23.9	0.00489	46.3
Sr/Ca	1.30	1.17	1.40	3.96
Ba/Ca	0.00131	7.37	0.0235	4.88

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.17	1.96	0.98	1.65
Al/Ca	0.0950	8.10	0.0361	14.2
Mn/Ca	0.00312	47.0	0.00252	42.9
Zn/Ca	0.00290	42.3	0.0112	10.9
Sr/Ca	1.32	1.38	1.40	1.30
Ba/Ca	0.00162	6.84	0.000954	7.13
Test weight (µg)	17			
Test length (µm)	368			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.76	1.92	2.41	2.26
Al/Ca	0.00777	59.3	-0.00175	292
Mn/Ca	0.0134	8.91	0.00556	23.7
Zn/Ca	0.00631	19.6	0.00567	32.7
Sr/Ca	1.25	1.46	1.25	1.84
Ba/Ca	0.00339	4.75	0.00234	7.45

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	2.42	2.50	2.01	1.93
Al/Ca	0.0411	18.7	0.0232	35.6
Mn/Ca	0.00817	20.2	0.00339	34.0
Zn/Ca	0.0155	14.1	0.0104	13.5
Sr/Ca	1.25	1.83	1.29	1.29
Ba/Ca	0.00343	52.1	0.00165	7.28
Test weight (µg)	17.2			
Test length (µm)	344			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>*f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.57	1.58	1.07	3.81
Al/Ca	0.00497	29.8	0.0206	52.3
Mn/Ca	0.00727	14.2	0.00250	70.8
Zn/Ca	0.0438	10.2	0.0149	19.8
Sr/Ca	1.22	1.35	1.14	2.43
Ba/Ca	0.00528	4.36	0.00251	11.2

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.69	1.76	1.11	1.83
Al/Ca	0.0322	120	0.000917	775
Mn/Ca	0.00843	16.4	0.00347	36.9
Zn/Ca	0.0161	7.14	0.0158	9.68
Sr/Ca	1.18	1.35	1.21	1.46
Ba/Ca	0.00699	15.9	0.00230	5.85
Test weight (µg)	28.9			
Test length (µm)	426			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.29	4.20	2.20	3.43
Al/Ca	0.0182	61.8	0.0271	33.6
Mn/Ca	0.0217	13.3	0.0127	14.2
Zn/Ca	0.0179	24.9	0.0152	14.7
Sr/Ca	1.20	5.50	1.20	1.93
Ba/Ca	0.00372	16.3	0.00266	9.17

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	2.08	1.86	1.17	2.19
Al/Ca	0.0199	29.6	0.0139	57.4
Mn/Ca	0.00986	11.9	0.00694	23.7
Zn/Ca	0.0152	9.26	0.0114	15.8
Sr/Ca	1.25	1.50	1.19	1.37
Ba/Ca	0.00247	5.06	0.00153	8.74
Test weight (µg)	8.8			
Test length (µm)	342			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.98	5.96	3.40	2.66
Al/Ca	0.211	44.2	0.0888	26.4
Mn/Ca	0.0269	12.4	0.0146	10.4
Zn/Ca	0.0466	11.0	0.131	22.1
Sr/Ca	1.28	5.51	1.32	2.84
Ba/Ca	0.0111	7.57	0.00799	6.13

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	3.02	1.52	2.50	1.59
Al/Ca	0.0237	25.4	0.0284	22.1
Mn/Ca	0.0106	12.6	0.00743	17.9
Zn/Ca	0.0607	4.74	0.0396	7.88
Sr/Ca	1.28	1.43	1.29	1.49
Ba/Ca	0.00247	3.90	0.00402	4.48
Test weight (µg)	6.9			
Test length (µm)	312			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca				
Al/Ca				
Mn/Ca				
Zn/Ca				
Sr/Ca				
Ba/Ca				

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca				
Al/Ca				
Mn/Ca				
Zn/Ca				
Sr/Ca				
Ba/Ca				
Test weight (µg)				
Test length (µm)				
Coiling direction				

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.65	2.30	1.37	2.60
Al/Ca	0.0289	32.0	0.0310	29.6
Mn/Ca	0.00573	20.6	0.00815	13.2
Zn/Ca	0.0110	16.2	0.0189	9.01
Sr/Ca	1.37	1.82	1.40	1.44
Ba/Ca	0.00205	8.16	0.00257	5.70

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.17	2.00	1.06	1.86
Al/Ca	0.0259	42.7	0.00670	-155
Mn/Ca	0.00531	28.4	0.00416	37.1
Zn/Ca	0.0107	18.1	0.0155	14.9
Sr/Ca	1.43	1.51	1.38	1.51
Ba/Ca	0.00151	9.53	0.00171	8.50
Test weight (µg)	8.5			
Test length (µm)	322			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.38	1.42	1.41	1.36
Al/Ca	0.0271	27.8	0.0341	22.9
Mn/Ca	0.00334	29.9	0.00156	69.5
Zn/Ca	0.00356	35.5	0.00490	27.1
Sr/Ca	1.27	1.24	1.31	1.32
Ba/Ca	0.00350	10.7	0.00243	8.84

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.50	1.43	1.14	1.66
Al/Ca	-0.000304	4460	0.00798	121
Mn/Ca	0.00316	54.0	0.00284	45.7
Zn/Ca	0.00641	35.2	0.00602	28.3
Sr/Ca	1.37	1.27	1.28	1.32
Ba/Ca	0.00226	7.86	0.00144	8.45
Test weight (µg)	25.8			
Test length (µm)	416			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	3.05	1.86	1.45	3.64
Al/Ca	0.0107	81.8	0.00538	208
Mn/Ca	0.0132	10.4	0.00227	64.1
Zn/Ca	0.0149	13.3	0.00270	65.4
Sr/Ca	1.33	1.68	1.43	2.74
Ba/Ca	0.00447	5.6	0.00157	11.5

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	2.86	3.76	2.64	2.07
Al/Ca	0.0190	57.6	0.0182	51.1
Mn/Ca	0.000932	156	0.00285	43.5
Zn/Ca	0.00155	104	0.0113	21.5
Sr/Ca	1.46	1.46	1.32	1.23
Ba/Ca	0.00167	9.19	0.00162	7.26
Test weight (µg)	21.8			
Test length (µm)	363			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	1.54	1.58	1.42	1.54
Al/Ca	-0.0230	28.3	-0.000478	1520
Mn/Ca	0.00377	26.2	0.00311	31.9
Zn/Ca	0.0104	13.2	0.0180	9.74
Sr/Ca	1.25	1.10	1.24	1.17
Ba/Ca	0.00172	6.53	0.00186	6.87

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.29	1.54	1.31	1.83
Al/Ca	0.0526	18.6	-0.000656	1540
Mn/Ca	0.00111	124	0.00207	70.9
Zn/Ca	0.0167	11.7	0.0149	14.9
Sr/Ca	1.31	1.10	1.24	1.29
Ba/Ca	0.00196	6.94	0.00138	9.68
Test weight (µg)	13.5			
Test length (µm)	355			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.15	1.60	1.13	1.73
Al/Ca	0.0529	116	0.0248	37.1
Mn/Ca	0.00229	95.4	0.00312	38.9
Zn/Ca	0.00209	432	0.00319	45.8
Sr/Ca	1.36	1.31	1.26	1.16
Ba/Ca	0.00194	11.0	0.00273	11.6

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.08	2.25	1.46	2.76
Al/Ca	0.00651	26.9	0.0108	116
Mn/Ca	0.00113	92.0	0.00445	40.0
Zn/Ca	0.000275	104	0.0104	21.7
Sr/Ca	1.26	2.04	1.31	1.48
Ba/Ca	0.000862	19.0	0.00254	7.78
Test weight (µg)	24			
Test length (µm)	440			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.78	2.06	1.32	2.14
Al/Ca	0.00636	46.6	0.0624	16.3
Mn/Ca	0.00521	18.3	0.00226	53.3
Zn/Ca	0.00528	36.3	0.00484	32.0
Sr/Ca	1.49	1.36	1.29	1.24
Ba/Ca	0.00297	9.16	0.00193	9.44

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.02	1.36	1.54	1.76
Al/Ca	0.0165	153	0.0225	63.5
Mn/Ca	0.00535	23.2	0.00402	50.1
Zn/Ca	0.00618	29.2	0.0233	13.2
Sr/Ca	1.34	1.29	1.38	1.64
Ba/Ca	0.00263	5.90	0.00336	25.7
Test weight (µg)	27.2			
Test length (µm)	416			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.79	6.44	1.84	3.02
Al/Ca	0.676	22.8	0.106	14.6
Mn/Ca	0.0203	75.6	0.00202	81.9
Zn/Ca	0.0178	26.7	0.00837	35.5
Sr/Ca	1.48	4.23	1.31	2.37
Ba/Ca	0.00394	17.0	0.00116	16.8

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	2.42	5.00	1.27	2.61
Al/Ca	0.614	21.0	0.0864	22.2
Mn/Ca	0.00733	113	0.00183	141
Zn/Ca	0.0242	31.9	0.0328	14.8
Sr/Ca	1.28	3.24	1.33	2.07
Ba/Ca	0.00455	18.8	0.00251	10.7
Test weight (µg)	12.2			
Test length (µm)	341			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	2.24	2.76	1.30	2.23
Al/Ca	0.0239	45.1	0.00911	88.9
Mn/Ca	0.00831	18.9	0.000151	703
Zn/Ca	0.0456	8.89	0.00353	36.5
Sr/Ca	1.25	1.58	1.28	1.43
Ba/Ca	0.00381	6.69	0.00150	7.80

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.13	2.44	1.13	1.40
Al/Ca	0.0201	64.9	0.0222	53.4
Mn/Ca	0.000990	183	0.00256	62.1
Zn/Ca	0.0150	16.2	0.0133	16.9
Sr/Ca	1.35	1.41	1.34	1.15
Ba/Ca	0.00143	10.5	0.00114	11.0
Test weight (µg)	22.6			
Test length (µm)	357			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	3.26	2.58	3.60	2.55
Al/Ca	0.0100	37.3	0.0253	55.9
Mn/Ca	0.00727	9.83	0.0192	12.1
Zn/Ca	0.00790	23.87	0.0353	11.6
Sr/Ca	1.46	1.94	1.41	2.56
Ba/Ca	0.00218	7.16	0.00258	10.23

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	2.32	1.73	2.16	2.83
Al/Ca	0.0379	143.2	0.0235	57.6
Mn/Ca	0.0216	27.4	0.0119	16.2
Zn/Ca	0.0107	31.5	0.00384	58.9
Sr/Ca	1.38	1.65	1.38	1.56
Ba/Ca	0.00475	12.0	0.00165	12.0
Test weight (µg)	8			
Test length (µm)	347			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.00	1.89	2.10	1.49
Al/Ca	0.0586	20.9	0.0237	37.2
Mn/Ca	0.00476	34.5	0.00463	25.6
Zn/Ca	0.0202	14.6	0.0213	13.5
Sr/Ca	1.35	1.66	1.42	1.33
Ba/Ca	0.00395	6.48	0.00228	7.14

X/Ca (mmol/mol)	<i>*f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	1.91	1.82	1.57	1.50
Al/Ca	0.256	8.36	0.0393	27.4
Mn/Ca	0.00802	32.6	0.00673	25.1
Zn/Ca	0.0531	9.53	0.0612	8.47
Sr/Ca	1.43	1.77	1.38	1.40
Ba/Ca	0.00305	9.20	0.00180	9.22
Test weight (µg)	8.1			
Test length (µm)	332			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.29	2.23	1.28	1.81
Al/Ca	0.0104	29.1	0.0377	9.46
Mn/Ca	0.00322	34.6	0.00680	17.0
Zn/Ca	0.0118	11.5	0.0265	7.50
Sr/Ca	1.24	1.37	1.22	1.13
Ba/Ca	0.00345	6.85	0.00302	7.35

X/Ca (mmol/mol)	* <i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.08	1.74	0.89	1.57
Al/Ca	0.0207	20.2	0.0320	13.5
Mn/Ca	0.000797	195	0.00424	37.3
Zn/Ca	0.0138	11.5	0.0681	4.88
Sr/Ca	1.26	1.02	1.22	1.20
Ba/Ca	0.00205	12.2	0.00140	12.1
Test weight (µg)	17.7			
Test length (µm)	413			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.96	1.80	1.71	1.34
Al/Ca	0.00548	43.3	0.00985	29.9
Mn/Ca	0.00462	19.7	0.00225	42.2
Zn/Ca	0.00560	18.1	0.00513	17.4
Sr/Ca	1.29	1.46	1.29	1.10
Ba/Ca	0.00221	7.56	0.00193	7.32

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.27	1.29	1.19	1.46
Al/Ca	0.00231	146	0.00477	74.4
Mn/Ca	0.00229	60.4	0.00373	37.4
Zn/Ca	0.00311	35.9	0.0133	13.3
Sr/Ca	1.28	1.08	1.29	1.39
Ba/Ca	0.00204	8.78	0.00150	12.8
Test weight (µg)	28			
Test length (µm)	497			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.04	1.99	1.49	2.04
Al/Ca	0.0347	11.9	0.0209	16.8
Mn/Ca	0.00767	95.3	0.00335	39.8
Zn/Ca	0.0263	31.3	0.0149	11.1
Sr/Ca	1.30	2.26	1.26	1.46
Ba/Ca	0.00425	22.4	0.00231	8.30

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.88	1.70	1.03	1.79
Al/Ca	0.0477	12.2	0.00972	46.8
Mn/Ca	0.00180	21.1	0.00268	66.4
Zn/Ca	0.00426	8.54	0.0128	15.7
Sr/Ca	1.34	1.50	1.26	1.42
Ba/Ca	0.00399	6.79	0.000915	18.4
Test weight (µg)	42			
Test length (µm)	629			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	0.955	2.81	1.04	2.46
Al/Ca	0.0347	30.7	0.00659	39.6
Mn/Ca	0.00215	71.1	-0.000241	412
Zn/Ca	0.00495	67.7	0.00847	12.8
Sr/Ca	1.24	3.00	1.23	1.27
Ba/Ca	0.00148	19.5	0.000756	14.0

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.11	2.81	1.04	2.19
Al/Ca	0.0146	23.2	0.0119	27.2
Mn/Ca	0.00254	50.8	0.000912	141
Zn/Ca	0.00448	23.3	0.0155	9.56
Sr/Ca	1.27	1.33	1.26	1.32
Ba/Ca	0.000691	17.2	0.00119	11.1
Test weight (µg)	32.6			
Test length (µm)	433			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	1.90	2.47	1.28	2.77
Al/Ca	0.0214	16.0	0.0165	15.5
Mn/Ca	0.00471	44.3	0.00227	41.1
Zn/Ca	0.0284	7.71	0.0260	6.60
Sr/Ca	1.14	1.71	1.19	1.32
Ba/Ca	0.00260	9.31	0.00172	8.81

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.72	2.16	1.19	2.22
Al/Ca	0.0265	11.1	0.0546	7.17
Mn/Ca	0.00320	17.9	0.00122	92.5
Zn/Ca	0.0258	6.18	0.0207	7.81
Sr/Ca	1.24	1.30	1.16	1.18
Ba/Ca	0.00379	7.16	0.00109	12.9
Test weight (µg)	34.5			
Test length (µm)	554			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.81	1.53	1.89	1.62
Al/Ca	0.00581	37.8	0.0115	18.2
Mn/Ca	0.00261	30.6	0.00345	23.3
Zn/Ca	0.0176	7.94	0.0193	6.85
Sr/Ca	1.15	1.64	1.16	1.43
Ba/Ca	0.00140	8.49	0.00132	8.73

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.59	1.43	1.50	1.42
Al/Ca	0.0110	32.5	0.0436	10.2
Mn/Ca	0.000685	205	0.00309	37.6
Zn/Ca	0.0250	7.60	0.0308	6.11
Sr/Ca	1.18	1.32	1.15	1.36
Ba/Ca	0.00138	11.0	0.00173	8.83
Test weight (µg)	14.1			
Test length (µm)	342			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	<i>f</i> -2	% 2se
Mg/Ca	2.17	2.37	2.08	1.49
Al/Ca	0.0317	9.59	0.0141	20.5
Mn/Ca	0.00381	28.1	0.00135	76.6
Zn/Ca	0.00575	19.9	0.0169	7.33
Sr/Ca	1.49	1.77	1.48	1.00
Ba/Ca	0.00147	13.5	0.00118	10.6

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	* <i>f</i>	% 2se
Mg/Ca	1.85	1.01	1.70	1.80
Al/Ca	0.0339	10.3	0.103	6.66
Mn/Ca	0.00156	79.0	0.00149	98.3
Zn/Ca	0.0118	10.8	0.0185	9.72
Sr/Ca	1.55	0.799	1.60	1.43
Ba/Ca	0.00403	7.37	0.00117	12.6
Test weight (µg)	18.3			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	* <i>f</i> -2	% 2se
Mg/Ca	1.16	2.30	1.71	3.19
Al/Ca	0.0639	6.76	0.0907	8.15
Mn/Ca	0.00233	60.9	-0.000200	746
Zn/Ca	0.0119	14.2	0.0222	13.4
Sr/Ca	1.36	1.87	1.36	1.93
Ba/Ca	0.00202	13.3	0.00270	10.1

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	1.53	2.43	1.04	1.32
Al/Ca	0.0297	13.5	0.0157	24.1
Mn/Ca	-0.000875	164	0.00577	26.4
Zn/Ca	0.0151	10.9	0.0204	8.99
Sr/Ca	1.40	1.31	1.36	1.16
Ba/Ca	0.00163	11.5	0.00217	8.92
Test weight (µg)	28.6			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	2.53	2.14	1.91	1.55
Al/Ca	0.0174	16.8	0.0226	17.1
Mn/Ca	0.00757	15.2	0.00373	28.3
Zn/Ca	0.00715	13.3	0.00590	19.4
Sr/Ca	1.30	1.55	1.29	1.34
Ba/Ca	0.00305	7.66	0.00212	7.89

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.46	1.61	0.86	1.72
Al/Ca	0.0140	24.9	0.0295	11.8
Mn/Ca	0.00132	109	0.00188	65.9
Zn/Ca	0.00437	22.1	0.00424	26.3
Sr/Ca	1.33	1.35	1.31	1.37
Ba/Ca	0.00164	10.9	0.00154	16.6
Test weight (µg)	27.2			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	<i>f</i> -2	% 2se
Mg/Ca	1.26	4.97	1.26	2.88
Al/Ca	0.00828	85.8	0.0234	15.9
Mn/Ca	0.000747	407	0.000926	114
Zn/Ca	0.00656	38.0	0.00857	14.4
Sr/Ca	1.36	4.81	1.39	1.67
Ba/Ca	0.00104	39.8	0.000695	17.0

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	1.07	2.12	1.26	1.88
Al/Ca	0.0123	24.9	0.00323	93.7
Mn/Ca	-0.000501	241	0.00240	54.0
Zn/Ca	0.00152	46.9	0.0185	7.54
Sr/Ca	1.39	1.50	1.40	1.16
Ba/Ca	0.00129	29.2	0.000954	13.2
Test weight (µg)	29.3			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -3	% 2se	<i>f</i> -2	% 2se
Mg/Ca	1.54	3.20	0.723	2.26
Al/Ca	0.0110	22.9	0.0115	22.8
Mn/Ca	0.0172	7.83	0.00418	25.2
Zn/Ca	0.138	6.93	0.0201	8.39
Sr/Ca	1.27	1.81	1.24	1.26
Ba/Ca	0.00292	7.39	0.000820	13.7

X/Ca (mmol/mol)	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	0.648	1.83	0.689	1.56
Al/Ca	0.0175	16.6	0.0345	9.73
Mn/Ca	0.00385	32.3	0.00363	35.5
Zn/Ca	0.00832	15.4	0.0567	5.28
Sr/Ca	1.26	1.11	1.27	1.16
Ba/Ca	0.000969	12.0	0.00109	12.2
Test weight (µg)	10.7			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	2.10	3.40	1.48	1.90
Al/Ca	0.0163	33.1	0.0105	28.7
Mn/Ca	0.0232	10.6	0.00188	72.2
Zn/Ca	0.0425	9.71	0.0359	7.70
Sr/Ca	1.48	2.17	1.32	1.56
Ba/Ca	0.00251	18.6	0.00152	9.78

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	1.98	2.13	1.24	1.78
Al/Ca	0.0320	10.6	0.0167	19.8
Mn/Ca	0.0117	11.2	0.00349	37.7
Zn/Ca	0.0587	6.19	0.0767	4.93
Sr/Ca	1.30	2.58	1.29	1.43
Ba/Ca	0.00372	6.90	0.00129	10.6
Test weight (µg)	17.9			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.08	1.80	1.09	4.10
Al/Ca	0.00563	34.4	0.0352	14.9
Mn/Ca	0.00134	66.6	-0.0000774	1650
Zn/Ca	0.00459	14.9	0.0128	15.0
Sr/Ca	1.34	1.09	1.36	2.64
Ba/Ca	0.00153	7.47	0.00134	14.2

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.26	3.64	1.08	2.77
Al/Ca	0.0448	14.7	0.00276	84.5
Mn/Ca	0.000933	156	0.000574	160
Zn/Ca	0.0134	41.9	0.00326	24.9
Sr/Ca	1.31	2.68	1.33	1.36
Ba/Ca	0.00220	41.1	0.00238	10.2
Test weight (µg)	20.3			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	3.22	2.93	2.86	4.42
Al/Ca	0.511	10.5	0.0371	25.0
Mn/Ca	0.0190	53.8	0.00596	14.2
Zn/Ca	0.0271	27.3	0.0111	17.2
Sr/Ca	1.39	2.17	1.49	1.39
Ba/Ca	0.00464	12.3	0.00220	22.8

X/Ca (mmol/mol)	f-1	% 2se	*f	% 2se
Mg/Ca	2.41	1.78	2.13	6.43
Al/Ca	0.102	7.39	0.645	53.5
Mn/Ca	0.00692	10.4	0.0506	93.0
Zn/Ca	0.0142	7.68	0.0288	22.7
Sr/Ca	1.48	1.42	1.41	2.74
Ba/Ca	0.00205	19.9	0.00504	23.3
Test weight (µg)	12.8			
Test length (µm)	382			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.19	2.95	0.934	2.11
Al/Ca	0.0720	6.85	0.0162	10.8
Mn/Ca	0.00476	18.2	0.00285	25.2
Zn/Ca	0.00403	21.3	0.00601	11.3
Sr/Ca	1.38	1.11	1.36	0.935
Ba/Ca	0.00123	7.21	0.00120	6.94

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	0.840	3.71	0.805	2.29
Al/Ca	0.0409	14.4	0.0293	11.2
Mn/Ca	0.00297	63.0	0.00597	16.0
Zn/Ca	0.00526	32.3	0.0156	9.81
Sr/Ca	1.41	2.06	1.41	1.48
Ba/Ca	0.00245	52.0	0.00230	8.46
Test weight (µg)	20.6			
Test length (µm)	430			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	2.20	2.27	1.20	3.42
Al/Ca	0.119	6.36	0.0342	24.2
Mn/Ca	0.0538	5.20	0.00447	48.1
Zn/Ca	0.0253	8.32	0.0255	136
Sr/Ca	1.49	2.08	1.31	2.42
Ba/Ca	0.00763	5.01	0.00170	14.3

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.93	5.18	1.80	2.65
Al/Ca	0.0796	10.8	0.0460	11.8
Mn/Ca	0.0130	33.5	0.0116	12.0
Zn/Ca	0.0121	36.9	0.0214	10.1
Sr/Ca	1.51	2.96	1.36	1.48
Ba/Ca	0.00267	13.1	0.00300	7.18
Test weight (µg)	22.9			
Test length (µm)	n/a			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	4.92	3.68	4.80	2.85
Al/Ca	-0.166	26.1	0.0545	9.07
Mn/Ca	0.0130	12.8	0.0148	10.1
Zn/Ca	0.0170	14.2	0.0246	10.6
Sr/Ca	1.62	2.96	1.53	1.72
Ba/Ca	0.00235	11.5	0.00239	10.1

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	3.30	1.92	1.73	2.33
Al/Ca	0.0233	2.98	0.0180	26.7
Mn/Ca	0.0135	10.9	0.0115	14.2
Zn/Ca	0.0179	11.6	0.00889	18.0
Sr/Ca	1.52	1.46	1.49	1.99
Ba/Ca	0.00261	7.58	0.00183	19.3
Test weight (µg)	7.3			
Test length (µm)	338			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

Note: The background count of Al/Ca (—) was higher than the signal from the test chamber and therefore produced negative values which do not appear on the log scale graphs.

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.19	2.69	1.00	3.47
Al/Ca	0.160	13.6	0.0760	10.3
Mn/Ca	0.00424	15.4	0.00168	91.1
Zn/Ca	0.0239	12.8	0.0162	16.4
Sr/Ca	1.56	1.94	1.40	2.02
Ba/Ca	0.00304	9.65	0.00253	11.6

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	* <i>f</i>	% 2se
Mg/Ca	1.22	6.24	1.00	3.51
Al/Ca	0.0491	15.9	0.223	6.65
Mn/Ca	0.00848	60.3	0.00963	23.5
Zn/Ca	0.0175	94.1	0.0399	11.7
Sr/Ca	1.53	4.67	1.45	2.42
Ba/Ca	0.00322	51.1	0.00258	13.6
Test weight (µg)	24.5			
Test length (µm)	456			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	2.84	2.34	1.89	3.45
Al/Ca	0.0711	20.5	0.149	6.90
Mn/Ca	0.0312	6.6	0.0215	7.36
Zn/Ca	0.0286	9.36	0.0336	13.1
Sr/Ca	1.42	1.96	1.44	2.08
Ba/Ca	0.00579	6.90	0.00467	21.4

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.08	2.47	1.88	2.87
Al/Ca	0.111	6.64	0.0448	15.0
Mn/Ca	0.0143	12.1	0.0106	11.1
Zn/Ca	0.0192	16.3	0.0174	12.4
Sr/Ca	1.43	1.64	1.43	1.79
Ba/Ca	0.00255	10.4	0.00273	8.96
Test weight (µg)	13.1			
Test length (µm)	370			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.48	2.42	1.44	1.80
Al/Ca	0.0302	15.5	0.0424	11.8
Mn/Ca	0.0209	6.55	0.0134	8.88
Zn/Ca	0.0310	6.28	0.0281	7.30
Sr/Ca	1.41	1.70	1.35	1.82
Ba/Ca	0.00321	7.36	0.00222	8.08

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.24	2.21	0.957	4.02
Al/Ca	0.0337	16.4	0.0357	31.3
Mn/Ca	0.0119	13.8	0.0181	36.6
Zn/Ca	0.0174	12.2	0.0275	17.9
Sr/Ca	1.39	2.22	1.32	2.68
Ba/Ca	0.00206	9.80	0.00266	12.8
Test weight (µg)	12.1			
Test length (µm)	415			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	3.10	1.80	0.934	2.38
Al/Ca	0.0310	16.1	0.0305	19.5
Mn/Ca	0.0246	6.39	0.00360	38.3
Zn/Ca	0.0469	5.47	0.00630	22.2
Sr/Ca	1.34	1.52	1.26	1.68
Ba/Ca	0.0123	4.17	0.00156	13.9

X/Ca (mmol/mol)	*f-1	% 2se	f	% 2se
Mg/Ca	1.16	3.25	1.06	1.85
Al/Ca	0.0388	19.6	0.0477	15.0
Mn/Ca	0.0317	131	0.0192	10.0
Zn/Ca	0.0162	18.0	0.0144	14.0
Sr/Ca	1.38	2.37	1.30	1.52
Ba/Ca	0.00326	10.6	0.00156	11.5
Test weight (µg)	21			
Test length (µm)	421			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.33	1.32	2.119	1.26
Al/Ca	-0.000463	23.3	0.00609	62.7
Mn/Ca	0.0121	17.6	0.00706	15.6
Zn/Ca	0.0103	10.9	0.0145	9.31
Sr/Ca	1.31	1.39	1.34	1.16
Ba/Ca	0.0019	8.45	0.00177	11.3

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.06	1.28	1.56	2.47
Al/Ca	0.0254	814	0.0210	40.7
Mn/Ca	0.00619	12.4	0.00498	47.5
Zn/Ca	0.0116	11.1	0.0077	26.7
Sr/Ca	1.35	1.07	1.32	2.31
Ba/Ca	0.00141	7.75	0.00118	19.1
Test weight (µg)	14.9			
Test length (µm)	326			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	1.95	1.18	1.832	1.64
Al/Ca	0.0353	12.0	0.0185	25.6
Mn/Ca	0.00953	13.5	0.00196	59.3
Zn/Ca	0.0168	9.70	0.0231	8.04
Sr/Ca	1.34	1.19	1.27	1.51
Ba/Ca	0.00544	9.50	0.00152	9.82

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.80	2.37	1.39	1.32
Al/Ca	0.2148	6.08	0.135	4.72
Mn/Ca	0.00241	68.6	0.00794	15.6
Zn/Ca	0.00867	18.7	0.0162	8.85
Sr/Ca	1.38	2.09	1.32	1.34
Ba/Ca	0.00409	7.04	0.00507	4.70
Test weight (µg)	10.6			
Test length (µm)	365			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.84	2.35	2.513	3.03
Al/Ca	0.0433	11.6	0.0181	24.7
Mn/Ca	0.0372	5.94	0.0252	6.11
Zn/Ca	0.00955	13.3	0.0279	7.55
Sr/Ca	1.54	1.55	1.50	1.87
Ba/Ca	0.00401	6.29	0.00283	7.24

X/Ca (mmol/mol)	* <i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.68	3.13	1.18	1.93
Al/Ca	0.0241	30.5	0.0173	33.1
Mn/Ca	0.0225	8.29	0.0153	9.64
Zn/Ca	0.0472	9.04	0.0277	7.83
Sr/Ca	1.59	3.19	1.49	1.96
Ba/Ca	0.00366	9.03	0.00182	9.52
Test weight (µg)	17.5			
Test length (µm)	363			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.52	1.99	1.42	2.43
Al/Ca	0.00837	23.1	0.0225	18.0
Mn/Ca	0.00913	11.3	0.0115	10.9
Zn/Ca	0.00486	15.3	0.0205	9.03
Sr/Ca	1.22	1.43	1.26	1.20
Ba/Ca	0.00391	7.13	0.00204	7.51

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.57	2.36	1.14	1.57
Al/Ca	0.0220	60.1	0.0125	35.8
Mn/Ca	0.0123	18.9	0.0175	8.63
Zn/Ca	0.0101	26.3	0.0126	10.8
Sr/Ca	1.28	1.55	1.25	1.22
Ba/Ca	0.00242	7.49	0.00120	9.66
Test weight (µg)	20.5			
Test length (µm)	439			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.25	7.81	2.28	3.87
Al/Ca	0.149	18.2	0.121	7.50
Mn/Ca	0.00731	112	0.0105	22.1
Zn/Ca	0.0138	72.3	0.00492	33.4
Sr/Ca	1.41	4.47	1.43	2.33
Ba/Ca	0.00208	22.9	0.00141	13.6

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.19	4.92	0.93	1.75
Al/Ca	0.198	23.0	0.0376	15.7
Mn/Ca	0.00324	64.6	0.0166	12.1
Zn/Ca	0.00478	47.2	0.0136	12.7
Sr/Ca	1.43	4.21	1.41	1.73
Ba/Ca	0.00197	25.1	0.00155	10.5
Test weight (µg)	25.6			
Test length (µm)	457			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.25	1.99	0.723	1.79
Al/Ca	0.00253	165	0.00874	47.1
Mn/Ca	0.00645	16.9	0.00356	35.3
Zn/Ca	0.00343	26.8	0.00251	37.3
Sr/Ca	1.35	1.20	1.34	1.45
Ba/Ca	0.00130	7.73	0.00089	11.2

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	0.821	2.23	0.871	2.18
Al/Ca	0.00909	44.9	-0.00184	230
Mn/Ca	0.00709	16.9	0.00850	14.5
Zn/Ca	0.00705	15.6	0.00406	31.6
Sr/Ca	1.32	1.19	1.36	1.28
Ba/Ca	0.00175	8.00	0.00113	10.9
Test weight (µg)	24.7			
Test length (µm)	403			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.34	2.90	0.771	2.02
Al/Ca	0.0739	10.8	0.00482	127
Mn/Ca	0.0211	10.3	0.00114	127
Zn/Ca	0.00809	24.4	0.00315	42.0
Sr/Ca	1.38	1.71	1.38	1.69
Ba/Ca	0.00412	7.44	0.00105	13.9

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	0.964	1.96	0.853	1.42
Al/Ca	0.0345	14.3	0.0163	34.9
Mn/Ca	0.00254	43.7	0.00171	63.1
Zn/Ca	0.00282	37.1	0.00410	23.9
Sr/Ca	1.40	1.20	1.41	1.05
Ba/Ca	0.00212	6.15	0.00121	8.60
Test weight (µg)	30.4			
Test length (µm)	448			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.48	2.82	0.924	2.81
Al/Ca	0.00442	111	-0.00371	145
Mn/Ca	0.00267	42.5	0.000527	264
Zn/Ca	0.00213	49.4	0.00256	56.3
Sr/Ca	1.58	1.45	1.45	1.93
Ba/Ca	0.00144	9.06	0.00124	12.0

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.27	2.25	1.21	1.33
Al/Ca	0.0782	10.2	0.0329	14.3
Mn/Ca	0.00150	84.9	0.00902	12.1
Zn/Ca	0.00362	35.3	0.00721	14.1
Sr/Ca	1.56	1.92	1.53	0.933
Ba/Ca	0.00214	10.5	0.00304	8.23
Test weight (µg)	38.5			
Test length (µm)	498			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	3.29	2.38	2.580	2.23
Al/Ca	0.0268	21.9	0.00652	69.9
Mn/Ca	0.0210	6.54	0.0138	9.34
Zn/Ca	0.0226	8.20	0.0128	10.6
Sr/Ca	1.35	1.53	1.33	1.17
Ba/Ca	0.00798	11.1	0.00384	6.35

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.13	2.16	1.18	2.08
Al/Ca	0.0134	35.9	0.0964	9.56
Mn/Ca	0.00602	20.4	0.00432	39.4
Zn/Ca	0.00910	14.0	0.00811	23.3
Sr/Ca	1.34	1.33	1.33	1.80
Ba/Ca	0.00269	6.48	0.00236	9.35
Test weight (µg)	21			
Test length (µm)	450			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	2.38	2.25	1.81	2.38
Al/Ca	0.0834	9.63	0.0253	18.7
Mn/Ca	0.0144	12.6	0.0131	9.46
Zn/Ca	0.0319	8.48	0.0156	10.2
Sr/Ca	1.51	1.69	1.48	1.25
Ba/Ca	0.00290	8.85	0.00159	7.57

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.99	2.14	1.28	2.01
Al/Ca	0.0448	17.3	0.0456	17.2
Mn/Ca	0.00888	19.3	0.00589	32.8
Zn/Ca	0.0157	15.6	0.0183	13.5
Sr/Ca	1.57	1.87	1.43	1.82
Ba/Ca	0.00189	12.4	0.00143	13.6
Test weight (µm)	12.7			
Test length (µm)	379			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	2.52	1.47	2.26	2.25
Al/Ca	0.00340	9.92	0.0156	26.4
Mn/Ca	0.00202	43.3	0.00280	37.4
Zn/Ca	0.00468	17.1	0.00255	32.0
Sr/Ca	1.31	1.09	1.28	1.20
Ba/Ca	0.00116	8.74	0.00109	9.03

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	1.76	2.24	1.23	1.49
Al/Ca	0.0400	110	0.00665	53.6
Mn/Ca	0.00219	50.6	0.00263	36.9
Zn/Ca	0.00525	18.6	0.00782	12.8
Sr/Ca	1.36	1.03	1.30	1.04
Ba/Ca	0.000957	8.56	0.000882	10.5
Test weight (µg)	19.6			
Test length (µm)	414			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	f-2	% 2se
Mg/Ca	3.51	1.33	2.71	1.45
Al/Ca	0.0651	9.94	-0.00225	157
Mn/Ca	0.0102	18.0	0.00999	16.8
Zn/Ca	0.0236	8.30	0.0256	6.87
Sr/Ca	1.45	1.35	1.38	1.15
Ba/Ca	0.00370	5.89	0.00329	5.01

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	3.13	1.98	2.44	2.04
Al/Ca	0.0292	24.5	0.0498	17.6
Mn/Ca	0.00170	91.0	0.00249	67.2
Zn/Ca	0.00685	22.8	0.0124	16.4
Sr/Ca	1.49	1.87	1.45	2.18
Ba/Ca	0.00312	7.40	0.00205	24.2
Test weight (µg)	25.6			
Test length (µm)	465			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-3	% 2se	*f-2	% 2se
Mg/Ca	4.55	2.41	5.78	2.65
Al/Ca	0.0220	13.9	0.0276	17.1
Mn/Ca	0.0306	9.73	0.0427	6.41
Zn/Ca	0.0203	12.2	0.0226	9.69
Sr/Ca	1.46	2.01	1.48	1.53
Ba/Ca	0.00540	8.01	0.00585	8.25

X/Ca (mmol/mol)	*f-1	% 2se	*f	% 2se
Mg/Ca	4.11	4.51	2.88	2.29
Al/Ca	0.0506	26.8	0.0524	22.0
Mn/Ca	0.0173	8.38	0.0145	12.9
Zn/Ca	0.0210	11.9	0.0138	17.6
Sr/Ca	1.46	1.51	1.40	2.30
Ba/Ca	0.00362	11.9	0.00219	11.4
Test weight (µg)	9.2			
Test length (µm)	384			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	3.07	1.14	2.16	1.79
Al/Ca	0.0538	10.5	0.00349	122
Mn/Ca	0.00848	17.0	0.00289	39.8
Zn/Ca	0.0159	11.6	0.00559	24.8
Sr/Ca	1.28	1.26	1.24	1.53
Ba/Ca	0.00475	4.71	0.00260	6.84

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.46	2.29	1.96	2.14
Al/Ca	0.0170	28.9	0.00706	68.6
Mn/Ca	0.00777	16.3	0.0118	12.1
Zn/Ca	0.00544	28.2	0.0118	14.4
Sr/Ca	1.24	1.58	1.26	1.33
Ba/Ca	0.00292	6.40	0.00311	6.84
Test weight (µg)	22.2			
Test length (µm)	392			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-3</i>	% 2se	<i>f-2</i>	% 2se
Mg/Ca	1.30	1.71	1.32	1.70
Al/Ca	0.0126	29.1	0.00483	64.3
Mn/Ca	0.00533	19.8	0.000847	105
Zn/Ca	0.00935	10.2	0.00185	35.5
Sr/Ca	1.41	0.987	1.39	1.00
Ba/Ca	0.000867	9.63	0.000690	9.83

X/Ca (mmol/mol)	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.18	2.14	1.12	2.19
Al/Ca	0.000801	436	0.0139	26.7
Mn/Ca	0.00185	53.2	0.0105	10.3
Zn/Ca	0.00429	25.8	0.0131	9.60
Sr/Ca	1.52	1.39	1.33	1.04
Ba/Ca	0.000530	13.3	0.00101	9.40
Test weight (µg)	18.1			
Test length (µm)	360			
Coiling direction	Clockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-3	% 2se	f-2	% 2se
Mg/Ca	1.77	1.33	2.69	1.05
Al/Ca	0.0113	14.4	0.0260	7.25
Mn/Ca	0.00705	10.3	0.00937	6.61
Zn/Ca	0.0117	7.35	0.01488	5.69
Sr/Ca	1.30	1.17	1.30	1.14
Ba/Ca	0.00200	4.98	0.00282	4.52

X/Ca (mmol/mol)	f-1	% 2se	f	% 2se
Mg/Ca	2.64	2.10	2.87	1.64
Al/Ca	0.0698	49.2	0.0319	35.4
Mn/Ca	0.0170	8.18	0.0188	16.1
Zn/Ca	0.0220	9.33	0.0193	10.6
Sr/Ca	1.27	1.80	1.28	1.35
Ba/Ca	0.00483	7.06	0.00460	7.24
Test weight (µg)	15.9			
Test length (µm)	407			
Coiling direction	Anticlockwise			

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.35	14.0	1.25	2.33	2.49	1.69
Al/Ca	0.0243	13.6	0.0482	5.37	0.0687	20.1
Mn/Ca	0.0108	10.4	0.00805	6.13	0.0521	6.29
Zn/Ca	0.0231	5.55	0.0191	3.40	0.212	4.28
Sr/Ca	1.37	1.89	1.40	1.23	1.97	1.43
Ba/Ca	0.00119	3.71	0.00115	5.21	0.00420	3.59
Test weight (µg)	19.9					
Test length (µm)	339					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.52	2.54	0.989	2.30	2.43	1.53
Al/Ca	0.108	9.29	0.0364	22.9	0.0193	28.7
Mn/Ca	0.0273	5.59	0.00803	16.7	0.0259	4.22
Zn/Ca	0.0216	6.17	0.0152	6.52	0.0525	4.23
Sr/Ca	1.31	0.924	1.33	1.25	1.40	1.22
Ba/Ca	0.0156	22.3	0.00232	8.05	0.00676	3.76
Test weight (µg)	16.1					
Test length (µm)	293					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.13	1.69	1.22	1.45	2.18	1.62
Al/Ca	0.0552	13.7	0.00431	148	0.0161	20.0
Mn/Ca	0.0654	11.9	0.00273	23.3	0.0388	4.03
Zn/Ca	0.00805	7.86	0.00255	23.7	0.0191	4.87
Sr/Ca	1.37	0.791	1.37	1.40	1.45	1.43
Ba/Ca	0.00163	7.18	0.000742	6.58	0.00417	4.03
Test weight (µg)	26.9					
Test length (µm)	n/a					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.66	2.61	1.06	3.54	2.03	2.57
Al/Ca	0.101	6.27	0.00851	48.1	0.0267	27.2
Mn/Ca	0.0298	4.28	0.0102	9.68	0.0219	4.75
Zn/Ca	0.0141	29.9	0.00359	16.9	0.0637	3.66
Sr/Ca	1.31	1.59	1.24	1.09	1.43	2.00
Ba/Ca	0.0114	5.29	0.00228	8.58	0.00760	6.79
Test weight (µg)	16.7					
Test length (µm)	290					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.79	2.12	0.70	1.44	1.30	2.73
Al/Ca	0.0473	10.5	0.00777	41.3	-0.00146	-213
Mn/Ca	0.00377	18.2	0.00142	43.1	0.00939	9.34
Zn/Ca	0.00316	16.9	0.00275	17.5	0.00994	7.86
Sr/Ca	1.49	1.73	1.51	0.852	1.52	1.09
Ba/Ca	0.00345	14.8	0.000412	7.85	0.00152	6.51
Test weight (µm)	30.2					
Test length (µm)	330					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -2	% 2se	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca						
Al/Ca						
Mn/Ca						
Zn/Ca						
Sr/Ca						
Ba/Ca						
Test weight (µg)						
Test length (µm)						
Number of chambers						

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	3.27	1.65	3.75	1.59	3.33	2.95
Al/Ca	0.276	7.14	0.07	8.51	0.03	28.4
Mn/Ca	0.158	4.64	0.0662	43.8	0.0278	11.3
Zn/Ca	0.0384	15.3	0.0432	5.46	0.0559	6.86
Sr/Ca	1.37	2.20	1.41	1.71	1.47	2.68
Ba/Ca	0.157	2.21	0.155	2.21	0.111	3.54
Test weight (µg)	19.6					
Test length (µm)	304					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.73	1.77	1.51	2.47	2.11	2.47
Al/Ca	0.0847	8.28	0.0417	20.0	0.0550	12.1
Mn/Ca	0.0168	7.06	0.00864	8.39	0.0128	11.0
Zn/Ca	0.0232	16.3	0.0137	32.9	0.0635	4.99
Sr/Ca	1.29	1.48	1.27	1.41	1.52	2.18
Ba/Ca	0.00384	4.56	0.00293	6.27	0.00491	9.81
Test weight (µg)	36.5					
Test length (µm)	293					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

Key

Mg/Ca

Al/Ca

Mn/Ca

Zn/Ca

Sr/Ca

Ba/Ca

integrated data

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.03	1.32	0.952	1.81	1.98	2.16
Al/Ca	0.0163	35.0	0.00859	40.3	0.0126	69.7
Mn/Ca	0.00210	27.8	0.0315	19.3	0.0247	4.75
Zn/Ca	0.00470	17.5	0.00484	35.0	0.0135	7.16
Sr/Ca	1.36	0.842	1.42	1.10	1.43	0.823
Ba/Ca	0.00198	11.2	0.00118	5.30	0.00757	4.63
Test weight (µg)	24.7					
Test length (µm)	319					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.22	2.05	0.909	1.66	3.74	1.81
Al/Ca	0.0214	28.1	0.0372	22.1	0.0276	37.9
Mn/Ca	0.00300	24.2	0.00220	29.9	0.0166	91.0
Zn/Ca	0.0268	5.93	0.00440	13.8	0.0609	4.85
Sr/Ca	1.24	1.17	1.25	0.97	1.51	3.36
Ba/Ca	0.00134	5.57	0.000577	6.51	0.00273	11.7
Test weight (µg)	19.3					
Test length (µm)	328					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	0.623	1.57	0.567	3.49	0.692	4.86
Al/Ca	0.0406	16.3	0.154	32.8	0.0566	23.6
Mn/Ca	0.00560	11.5	0.00734	94.9	0.00263	55.4
Zn/Ca	0.00989	11.5	0.0165	35.0	0.0767	23.8
Sr/Ca	1.38	0.778	1.44	1.16	1.43	1.99
Ba/Ca	0.00211	4.99	0.00141	6.47	0.00119	63.2
Test weight (µg)	17.3					
Test length (µm)	343					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.97	1.92	2.19	1.81	2.29	1.52
Al/Ca	0.100	14.3	0.17	21.9	1.05	115
Mn/Ca	0.0689	4.47	0.0251	4.13	0.0979	15.4
Zn/Ca	0.0299	4.83	0.0232	5.62	0.196	3.76
Sr/Ca	1.42	0.86	1.49	1.17	1.64	1.45
Ba/Ca	0.00303	16.0	0.00412	10.8	0.00677	3.38
Test weight (µg)	21.6					
Test length (µm)	375					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.07	2.01	1.155	5.00	2.34	1.96
Al/Ca	0.124	5.15	-0.00062	699	0.0262	33.2
Mn/Ca	0.0228	6.00	0.00238	32.1	0.0134	12.1
Zn/Ca	0.00548	23.4	0.00433	16.2	0.0674	4.12
Sr/Ca	1.20	1.28	1.33	1.14	1.51	2.15
Ba/Ca	0.00336	8.77	0.000566	7.47	0.00264	54.4
Test weight (µg)	26.9					
Test length (µm)	335					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.49	2.03	1.122	1.53	1.57	2.84
Al/Ca	0.244	20.6	-0.00015	2920	0.0067	91.9
Mn/Ca	0.0252	4.80	0.00271	28.6	0.0062	20.8
Zn/Ca	0.11381	2.53	0.00448	15.3	0.0628	4.96
Sr/Ca	1.36	1.29	1.32	1.13	1.45	1.93
Ba/Ca	1.43269	104	0.000591	7.37	0.00135	8.17
Test weight (µg)	16.9					
Test length (µm)	306					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.81	1.93	1.694	2.55	1.44	3.03
Al/Ca	0.266	11.8	0.136	23.0	0.283	76.9
Mn/Ca	0.0900	34.7	0.0641	19.4	0.0389	27.1
Zn/Ca	0.0396	8.21	0.0486	26.9	0.0661	17.6
Sr/Ca	1.23	2.31	1.27	1.92	1.32	1.29
Ba/Ca	0.0169	7.98	0.00219	15.6	0.00184	34.8
Test weight (µm)	16					
Test length (µm)	276					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.27	1.91	0.948	1.52	2.33	2.23
Al/Ca	0.032	39.2	0.004	111	0.230	9.62
Mn/Ca	0.0071	12.8	0.0055	17.3	0.0875	4.09
Zn/Ca	0.0138	7.21	0.0021	30.4	0.0811	4.38
Sr/Ca	1.16	1.61	1.29	1.34	1.56	1.19
Ba/Ca	0.0015	8.65	0.00081	6.31	0.07832	5.38
Test weight (µg)	22.8					
Test length (µm)	308					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

J. Marr
G. inflata-P71

A221

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.81	1.67	1.483	1.95	2.03	2.14
Al/Ca	0.235	4.50	0.084	10.9	0.068	10.9
Mn/Ca	0.0808	8.78	0.0495	4.51	0.0477	3.99
Zn/Ca	0.0278	4.71	0.0195	6.12	0.0353	5.35
Sr/Ca	1.39	1.54	1.45	1.27	1.43	1.69
Ba/Ca	0.0025	5.67	0.00169	4.80	0.00150	6.42
Test weight (µg)	33.6					
Test length (µm)	366					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.789	3.46	0.617	1.97	1.10	3.09
Al/Ca	0.0194	53.6	0.0218	23.2	0.00605	158
Mn/Ca	0.00783	41.0	0.00697	11.9	0.0174	27.8
Zn/Ca	0.00452	21.7	0.00297	22.7	0.0268	14.2
Sr/Ca	1.19	1.12	1.34	1.58	1.30	2.77
Ba/Ca	0.00252	7.35	0.00117	6.77	0.00783	155
Test weight (µg)	33.6					
Test length (µm)	366					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.65	2.78	1.69	3.21	2.07	3.87
Al/Ca	0.122	4.81	0.0746	8.27	0.0449	12.2
Mn/Ca	0.0179	28.2	0.00910	11.8	0.00830	12.1
Zn/Ca	0.0262	8.06	0.0307	8.27	0.0266	6.87
Sr/Ca	1.21	1.23	1.26	1.35	1.43	4.34
Ba/Ca	0.00203	11.0	0.00179	5.68	0.00194	6.52
Test weight (µg)	14.8					
Test length (µm)	310					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	2.08	14.0	1.89	2.33	2.18	1.69
Al/Ca	0.0423	13.6	0.0741	5.37	0.0988	20.1
Mn/Ca	0.00744	10.4	0.0124	6.13	0.0160	6.29
Zn/Ca	0.0435	5.55	0.0602	3.40	0.154	4.28
Sr/Ca	1.28	1.89	1.38	1.23	1.50	1.43
Ba/Ca	0.00780	3.71	0.00694	5.21	0.00446	3.59
Test weight (µg)	29.3					
Test length (µm)	361					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	2.04	1.78	1.86	2.85	2.68	2.52
Al/Ca	0.0647	44.2	0.0145	27.7	0.353	14.2
Mn/Ca	0.0521	8.25	0.0266	6.56	0.121	8.18
Zn/Ca	0.0385	4.50	0.0364	3.81	0.124	8.94
Sr/Ca	1.50	1.28	1.54	1.16	1.50	1.49
Ba/Ca	0.00310	8.92	0.00348	3.75	0.00458	5.30
Test weight (µg)	21.4					
Test length (µm)	336					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.33	2.26	1.08	1.72	1.17	1.83
Al/Ca	0.0846	19.9	0.0609	96.4	-0.00234	214
Mn/Ca	0.0343	7.43	0.00740	27.6	0.00750	13.0
Zn/Ca	0.0164	7.05	0.0108	16.2	0.0242	7.17
Sr/Ca	1.22	0.960	1.29	1.05	1.45	1.40
Ba/Ca	0.0107	4.76	0.00515	10.9	0.00151	6.02
Test weight (µg)	23.9					
Test length (µm)	327					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.02	2.42	0.923	1.69	1.80	2.31
Al/Ca	0.0290	99.1	0.00708	59.9	0.0337	10.5
Mn/Ca	0.0105	11.0	0.00417	14.8	0.0583	7.09
Zn/Ca	0.00980	10.6	0.00512	13.7	0.0861	3.04
Sr/Ca	1.15	0.92	1.24	1.08	1.36	2.22
Ba/Ca	0.00146	6.97	0.000963	6.44	0.00269	4.31
Test weight (µg)	36.8					
Test length (µm)	324					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.10	1.35	2.01	2.46	1.95	1.27
Al/Ca	0.0560	9.8	0.0503	39.4	0.0751	17.9
Mn/Ca	0.0102	6.3	0.0504	10.4	0.0717	3.21
Zn/Ca	0.00491	16.5	0.0339	12.5	0.0632	5.64
Sr/Ca	1.26	1.25	1.39	1.53	1.41	1.26
Ba/Ca	0.000625	8.42	0.00175	43.1	0.00200	11.4
Test weight (µg)	33.4					
Test length (µm)	369					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

Key

Mg/Ca

Al/Ca

Mn/Ca

Zn/Ca

Sr/Ca

Ba/Ca

integrated data

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.77	4.65	0.73	6.40	1.92	8.52
Al/Ca	0.0146	27.4	0.0605	23.7	0.0103	20.4
Mn/Ca	0.0271	10.2	0.00966	19.4	0.128	6.85
Zn/Ca	0.00485	26.3	0.00714	28.7	0.0201	14.7
Sr/Ca	1.30	3.72	1.26	5.13	1.51	5.26
Ba/Ca	0.00215	9.27	0.00115	8.49	0.0210	12.1
Test weight (µg)	19.3					
Test length (µm)	332					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2*	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.27	4.58	1.65	4.49	1.60	10.3
Al/Ca	0.0668	12.1	0.0690	6.35	0.00896	93.0
Mn/Ca	0.0872	4.99	0.0429	8.78	0.0383	13.7
Zn/Ca	0.129	5.03	0.0774	10.2	0.0734	13.2
Sr/Ca	1.44	4.75	1.29	3.43	1.42	14.3
Ba/Ca	0.0188	4.62	0.00444	7.13	0.00280	10.8
Test weight (µg)	25.2					
Test length (µm)	396					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2*	% 2se	f-1*	% 2se	f*	% 2se
Mg/Ca	1.00	5.46	1.02	6.45	1.49	4.67
Al/Ca	0.0105	25.5	0.00784	27.5	0.00317	70.7
Mn/Ca	0.0210	11.9	0.0203	12.0	0.0497	7.26
Zn/Ca	0.00745	25.3	0.00691	23.4	0.00994	20.3
Sr/Ca	1.28	3.73	1.27	3.87	1.38	4.29
Ba/Ca	0.0479	9.50	0.0299	10.6	0.0420	8.68
Test weight (µg)	12.8					
Test length (µm)	312					
Number of chambers	3.00					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.741	5.55	0.946	8.46	1.21	7.45
Al/Ca	0.0381	41.6	0.02004	25.6	0.000405	22.6
Mn/Ca	0.00977	23.9	0.00765	35.0	0.0153	11.5
Zn/Ca	0.00829	25.5	0.00561	45.1	0.0300	13.4
Sr/Ca	1.16	4.86	1.31	6.54	1.44	5.30
Ba/Ca	0.000843	10.7	0.000973	9.30	0.00920	7.92
Test weight (µg)	15.2					
Test length (µm)	347					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.02	5.63	0.666	5.67	1.48	9.93
Al/Ca	0.0102	31.6	0.0132	21.5	0.00553	42.9
Mn/Ca	0.0272	11.4	0.00510	54.8	0.111	14.2
Zn/Ca	0.00357	41.4	0.000475	285	0.0110	49.5
Sr/Ca	1.22	4.39	1.35	4.76	1.85	9.45
Ba/Ca	0.00187	6.46	0.000757	8.49	0.0111	11.3
Test weight (µg)	7.8					
Test length (µm)	267					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f*	% 2se
Mg/Ca	0.468	5.02	0.459	3.87	1.45	14.2
Al/Ca	0.0150	17.4	0.00508	144	0.0381	50.0
Mn/Ca	0.00676	30.6	0.00857	24.2	0.0692	7.65
Zn/Ca	0.00196	60.7	0.00238	46.5	0.0170	26.2
Sr/Ca	1.37	4.47	1.45	3.42	2.60	7.28
Ba/Ca	0.00155	5.60	0.00267	6.93	0.0136	8.47
Test weight (µg)	16.2					
Test length (µm)	321					
Number of chambers	3.00					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.588	4.83	0.545	5.49	1.21	6.86
Al/Ca	0.0169	20.1	0.00747	42.5	0.000405	815
Mn/Ca	0.00295	75.6	0.000913	213	0.0153	18.1
Zn/Ca	0.00267	53.1	0.00188	69.5	0.0300	15.9
Sr/Ca	1.30	4.54	1.34	4.16	1.44	3.48
Ba/Ca	0.00259	4.40	0.00230	4.56	0.00920	7.77
Test weight (µg)	13.1					
Test length (µm)	365					
Number of chambers	3.75					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2*	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.514	7.95	0.427	8.58	1.48	10.3
Al/Ca	0.512	13.8	0.0100	45.2	0.00553	61.7
Mn/Ca	0.0122	19.8	0.00651	43.0	0.111	9.85
Zn/Ca	0.00429	55.0	0.00309	0.02	0.0110	22.8
Sr/Ca	1.44	6.28	1.58	7.62	1.85	12.2
Ba/Ca	0.00483	36.3	0.000937	9.47	0.0111	12.3
Test weight (µg)	13.1					
Test length (µm)	365					
Number of chambers	3.75					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-2*</i>	% 2se	<i>f-1*</i>	% 2se	<i>f*</i>	% 2se
Mg/Ca	0.754	5.38	0.445	9.49	1.45	6.48
Al/Ca	0.732	4.06	0.0917	45.4	0.0381	15.5
Mn/Ca	0.0441	23.4	0.00714	45.4	0.0692	10.1
Zn/Ca	0.163	51.4	0.00391	68.0	0.0170	14.7
Sr/Ca	1.41	7.06	1.63	8.11	2.60	6.11
Ba/Ca	0.00627	4.13	0.00181	10.0	0.0136	6.96
Test weight (µg)	13.5					
Test length (µm)	292					
Number of chambers	3.25					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f *	% 2se
Mg/Ca	1.55	5.44	1.02	4.39	2.50	5.12
Al/Ca	0.0107	22.7	0.00867	34.7	0.00695	42.1
Mn/Ca	0.0177	12.1	0.00334	56.6	0.0705	5.18
Zn/Ca	0.00479	24.6	0.00133	81.0	0.0182	11.6
Sr/Ca	1.29	3.03	1.21	3.07	1.52	5.57
Ba/Ca	0.00219	6.21	0.00104	10.4	0.00657	6.80
Test weight (µg)	14.2					
Test length (µm)	283					
Number of chambers	3.25					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2*	% 2se	f-1	% 2se	f*	% 2se
Mg/Ca	0.804	5.28	0.663	4.07	0.914	7.01
Al/Ca	0.180	13.4	0.00823	35.1	0.00728	46.2
Mn/Ca	0.0097	18.0	0.0206	13.3	0.0712	9.08
Zn/Ca	0.0320	183	0.000471	218	0.00437	41.1
Sr/Ca	1.28	3.15	1.34	2.59	1.42	4.77
Ba/Ca	0.00900	6.99	0.00693	5.86	0.0422	10.5
Test weight (µg)	15.1					
Test length (µm)	323					
Number of chambers	3.50					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.604	3.89	0.636	3.90	1.47	7.64
Al/Ca	0.00646	37.5	0.0133	51.7	0.0168	45.7
Mn/Ca	0.00293	46.8	0.00599	27.7	0.0580	11.6
Zn/Ca	0.00215	43.5	0.00159	61.6	0.0173	21.8
Sr/Ca	1.23	3.82	1.28	2.72	1.58	5.74
Ba/Ca	0.000736	5.18	0.00112	4.84	0.00474	9.32
Test weight (µg)	13.1					
Test length (µm)	271					
Number of chambers	3.00					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.639	2.23	0.670	2.34	1.18	3.80
Al/Ca	0.00234	101	0.000318	689	0.0311	29.1
Mn/Ca	0.00792	21.1	0.0106	16.7	0.148	10.8
Zn/Ca	0.00164	39.8	0.00136	51.2	0.0209	15.5
Sr/Ca	1.31	1.99	1.31	2.20	1.34	3.17
Ba/Ca	0.00120	6.94	0.00145	7.21	0.0145	28.7
Test weight (µg)	12.9					
Test length (µm)	312					
Number of chambers	3.50					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-2*</i>	% 2se	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	0.744	5.05	0.785	2.90	1.22	4.17
Al/Ca	0.169	6.49	0.00668	52.7	0.000587	459
Mn/Ca	0.00473	83.2	0.00774	20.4	0.0169	13.2
Zn/Ca	0.000783	197	0.00285	29.6	0.00163	50.5
Sr/Ca	1.18	4.71	1.38	2.43	1.36	2.65
Ba/Ca	0.00132	15.2	0.00106	8.68	0.00112	10.6
Test weight (µg)	15.1					
Test length (µm)	318					
Number of chambers	3.25					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.744	2.92	0.785	2.60	1.22	4.46
Al/Ca	0.169	45.7	0.00668	35.3	0.000587	27.5
Mn/Ca	0.00473	17.5	0.00774	30.1	0.0169	5.50
Zn/Ca	0.000783	14.7	0.00285	20.6	0.00163	11.8
Sr/Ca	1.18	2.61	1.38	2.40	1.36	3.17
Ba/Ca	0.00132	7.85	0.00106	7.15	0.00112	6.96
Test weight (µg)	15.1					
Test length (µm)	318					
Number of chambers	3.25					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.670	2.12	0.698	2.16	1.33	1.67
Al/Ca	0.0126	18.3	0.00479	42.9	0.00375	49.9
Mn/Ca	0.00809	17.5	0.00399	34.1	0.128	2.50
Zn/Ca	0.00197	28.8	0.00211	27.1	0.0112	8.69
Sr/Ca	1.41	2.12	1.38	1.90	1.48	1.28
Ba/Ca	0.000729	9.20	0.000673	9.58	0.0103	3.69
Test weight (µg)	16.2					
Test length (µm)	318					
Number of chambers	3.25					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.628	1.69	0.700	2.29	0.747	2.64
Al/Ca	0.0251	10.0	0.00725	31.5	0.0122	48.1
Mn/Ca	0.00355	37.4	0.0174	9.33	0.0261	7.91
Zn/Ca	0.00179	29.1	0.0120	9.24	0.0286	9.72
Sr/Ca	1.40	1.36	1.45	1.63	1.47	2.21
Ba/Ca	0.00195	6.02	0.0110	12.1	0.0132	4.49
Test weight (µg)	11.7					
Test length (µm)	417					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.10	2.68	0.633	2.53	0.789	4.57
Al/Ca	0.0668	8.45	0.0141	31.2	0.0639	94.7
Mn/Ca	0.0407	7.90	0.00505	30.2	0.0466	12.2
Zn/Ca	0.00990	13.1	0.00176	35.8	0.0244	22.6
Sr/Ca	1.17	1.62	1.23	2.03	0.583	3.02
Ba/Ca	0.00343	7.20	0.00296	6.39	0.00522	9.00
Test weight (µg)	11.9					
Test length (µm)	354					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-2*</i>	% 2se	<i>f-1</i>	% 2se	<i>f*</i>	% 2se
Mg/Ca	1.14	2.39	0.899	2.25	2.06	2.52
Al/Ca	0.0190	12.0	0.00327	59.7	0.0315	63.8
Mn/Ca	0.0193	7.55	0.00950	14.7	0.0658	4.78
Zn/Ca	0.0203	10.0	0.00390	18.2	0.0419	6.43
Sr/Ca	1.29	1.53	1.33	2.12	1.63	2.62
Ba/Ca	0.0172	6.28	0.00271	7.55	0.0359	5.31
Test weight (µg)	15.6					
Test length (µm)	333					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2*	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.810	6.09	0.703	2.09	1.25	2.64
Al/Ca	0.123	6.89	0.0534	9.34	0.00597	42.1
Mn/Ca	0.00993	25.6	0.00849	18.3	0.0446	5.69
Zn/Ca	0.00317	39.2	0.0187	127	0.0168	9.24
Sr/Ca	1.27	5.75	1.22	1.93	1.29	2.08
Ba/Ca	0.00326	54.2	0.00198	19.9	0.00912	4.88
Test weight (µg)	10.7					
Test length (µm)	303					
Number of chambers	3.3					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.885	3.18	0.605	2.48	1.70	1.73
Al/Ca	0.00700	25.7	0.0103	24.0	0.0154	16.1
Mn/Ca	0.00485	23.7	0.00288	84.4	0.0167	9.39
Zn/Ca	0.0138	9.44	0.00265	26.3	0.0433	4.84
Sr/Ca	1.29	1.68	1.20	2.20	1.63	1.42
Ba/Ca	0.00103	7.21	0.000642	10.9	0.00436	4.10
Test weight (µg)	14.4					
Test length (µm)	325					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.798	1.90	0.788	3.13	1.09	3.04
Al/Ca	0.00894	19.8	0.0322	8.78	0.00506	55.3
Mn/Ca	0.0119	11.5	0.00755	17.2	0.0284	9.47
Zn/Ca	0.00125	36.7	0.00171	33.3	0.00606	19.5
Sr/Ca	1.27	1.45	1.29	2.26	1.48	2.40
Ba/Ca	0.00401	4.36	0.00444	5.54	0.00705	5.94
Test weight (µg)	15.0					
Test length (µm)	337					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -2*	% 2se	<i>f</i> -1*	% 2se	<i>f</i> *	% 2se
Mg/Ca	1.22	1.92	1.35	3.01	1.84	1.60
Al/Ca	0.0162	24.1	0.0161	13.1	0.0126	16.0
Mn/Ca	0.00782	16.0	0.0141	10.6	0.0329	5.14
Zn/Ca	0.00340	15.6	0.00483	14.4	0.0128	8.65
Sr/Ca	1.26	1.22	1.32	1.71	1.40	1.58
Ba/Ca	0.0634	2.02	0.0788	5.94	0.0961	3.17
Test weight (µg)	14.5					
Test length (µm)	330					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1*	% 2se	f	% 2se
Mg/Ca	0.931	1.92	0.778	2.23	1.66	2.20
Al/Ca	0.00964	16.7	0.000153	2.01	0.0624	10.7
Mn/Ca	0.0184	7.52	0.00664	18.5	0.118	7.94
Zn/Ca	0.00339	15.0	0.00367	15.8	0.0500	5.23
Sr/Ca	1.29	1.28	1.29	1.71	1.44	2.20
Ba/Ca	0.0103	4.65	0.00207	5.18	0.0170	3.45
Test weight (µg)	11.7					
Test length (µm)	360					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.93	2.61	1.20	3.03	1.78	4.01
Al/Ca	0.0777	10.3	0.00789	87.2	0.0214	43.0
Mn/Ca	0.0229	8.29	0.0112	12.6	0.0406	5.80
Zn/Ca	0.0147	9.59	0.0104	11.2	0.0469	6.88
Sr/Ca	1.22	1.58	1.27	2.56	1.34	2.91
Ba/Ca	0.00127	8.14	0.000767	10.9	0.00242	7.80
Test weight (μg)	11.9					
Test length (μm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	0.826	4.94	0.651	2.98	1.71	1.71
Al/Ca	0.271	7.93	-0.0210	38.1	-0.00154	652
Mn/Ca	0.00572	46.3	0.00360	40.1	0.0532	11.4
Zn/Ca	0.0158	17.6	0.00913	12.8	0.0805	5.47
Sr/Ca	1.22	3.79	1.34	2.63	1.46	1.96
Ba/Ca	0.000647	23.8	0.000790	11.2	0.00276	5.93
Test weight (µg)	13.7					
Test length (µm)	327					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.956	1.54	0.832	5.41	1.64	5.95
Al/Ca	0.0567	16.1	0.0300	59.8	0.0188	47.2
Mn/Ca	0.0100	20.2	0.00491	65.5	0.0411	8.60
Zn/Ca	0.0102	11.2	0.00402	51.4	0.0326	7.61
Sr/Ca	1.23	1.42	1.26	4.34	1.72	1.84
Ba/Ca	0.00103	7.73	0.000531	31.6	0.00275	6.29
Test weight (µg)	22.9					
Test length (µm)	415					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.13	1.29	2.05	2.17	1.54	1.29
Al/Ca	0.00734	106	-0.00903	82.2	0.0178	34.5
Mn/Ca	0.0845	2.64	0.0717	6.22	0.0754	3.28
Zn/Ca	0.0842	3.35	0.128	4.14	0.152	2.50
Sr/Ca	1.50	1.37	1.65	2.59	1.63	1.32
Ba/Ca	0.00331	7.93	0.00328	7.19	0.00264	35.8
Test weight (µg)	20.8					
Test length (µm)	384					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.96	2.59	0.91	2.68	1.80	2.15
Al/Ca	0.04972	10.1	-0.00215	22.2	0.0038	62.8
Mn/Ca	0.0042	4.25	0.0098	12.7	0.0381	3.43
Zn/Ca	0.0066	6.56	0.003	17.7	0.017	6.69
Sr/Ca	1.20	2.58	1.25	2.75	1.47	1.68
Ba/Ca	0.00061	8.20	0.00083	19.0	0.00220	7.61
Test weight (µg)	30.4					
Test length (µm)	390					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.958	1.41	0.908	1.99	1.80	1.31
Al/Ca	0.04972	16.6	-0.00215	332	0.00375	201
Mn/Ca	0.00415	36.4	0.00981	13.7	0.0381	4.78
Zn/Ca	0.00657	16.5	0.00257	31.5	0.0167	7.10
Sr/Ca	1.20	1.30	1.25	2.06	1.47	1.21
Ba/Ca	0.000612	10.8	0.000832	10.4	0.00220	5.46
Test weight (µg)	30.4					
Test length (µm)	390					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.18	2.05	1.51	3.36	1.79	1.77
Al/Ca	0.0527	14.8	0.0412	8.60	0.0928	7.22
Mn/Ca	0.0756	6.07	0.0307	6.16	0.0669	2.88
Zn/Ca	0.0749	6.35	0.0366	5.38	0.0758	3.42
Sr/Ca	1.58	3.09	1.32	1.67	1.44	1.48
Ba/Ca	0.00288	9.42	0.00197	6.42	0.00305	4.41
Test weight (µg)	14.2					
Test length (µm)	356					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.86	2.14	1.50	2.67	1.23	1.87
Al/Ca	0.326	4.88	0.144	8.17	0.107	4.45
Mn/Ca	0.108	5.11	0.0758	4.99	0.0925	2.65
Zn/Ca	0.0914	4.08	0.0783	6.29	0.0591	7.17
Sr/Ca	1.62	1.86	1.89	2.69	2.09	1.28
Ba/Ca	0.00478	6.04	0.00413	7.01	0.00569	3.61
Test weight (µg)	11.1					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.04	1.51	2.08	2.13	1.99	1.63
Al/Ca	0.0759	8.71	0.0544	20.5	0.0285	11.1
Mn/Ca	0.0591	3.27	0.0739	7.18	0.0792	2.88
Zn/Ca	0.0539	3.81	0.0777	4.24	0.113	3.04
Sr/Ca	1.33	1.65	1.37	2.86	1.41	1.44
Ba/Ca	0.0120	3.75	0.00332	5.81	0.00356	4.46
Test weight (µg)	13.9					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	0.762	2.54	0.563	2.28	1.08	2.96
Al/Ca	0.0758	7.91	0.0331	10.6	0.0040	76.3
Mn/Ca	0.0226	10.7	0.0102	18.5	0.0268	9.06
Zn/Ca	0.0233	10.5	0.0125	8.54	0.047	6.06
Sr/Ca	1.31	2.49	1.29	1.53	1.38	1.88
Ba/Ca	0.00375	6.99	0.00119	9.06	0.00216	9.83
Test weight (µg)	13.9					
Test length (µm)	373					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.50	2.90	1.08	2.92	1.89	1.87
Al/Ca	0.158	4.81	0.0159	17.3	0.0168	16.5
Mn/Ca	0.0520	7.09	0.0303	5.62	0.0952	2.97
Zn/Ca	0.0326	5.44	0.0171	7.21	0.113	3.27
Sr/Ca	1.29	2.01	1.24	1.69	1.53	1.78
Ba/Ca	0.0490	8.96	0.0215	8.13	0.0759	4.35
Test weight (μm)	9.3					
Test length (μm)	317					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.56	2.31	1.56	1.81	1.35	2.17
Al/Ca	0.0519	17.8	0.0597	8.85	0.0246	21.1
Mn/Ca	0.0655	4.80	0.0454	6.48	0.0378	5.89
Zn/Ca	0.0605	4.54	0.0552	5.05	0.0343	5.91
Sr/Ca	1.41	2.77	1.30	1.76	1.25	1.90
Ba/Ca	0.00492	4.59	0.00203	6.68	0.00146	7.82
Test weight (µg)	10.9					
Test length (µm)	324					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.12	1.75	0.918	2.35	1.47	1.90
Al/Ca	0.0375	9.47	0.0231	13.2	0.0174	18.6
Mn/Ca	0.0165	9.94	0.00951	16.9	0.0549	3.75
Zn/Ca	0.0143	8.41	0.00651	13.9	0.0806	4.31
Sr/Ca	1.18	1.56	1.20	2.30	1.27	2.14
Ba/Ca	0.000774	8.29	0.000544	10.8	0.00159	6.56
Test weight (µg)	17.1					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f</i> -2	% 2se	<i>f</i> -1	% 2se	<i>f</i>	% 2se
Mg/Ca	0.817	1.95	1.38	1.79	1.28	2.62
Al/Ca	0.00597	37.7	0.00530	42.4	0.00753	39.7
Mn/Ca	0.00232	52.0	0.0337	5.03	0.0213	8.29
Zn/Ca	0.00342	15.5	0.0232	5.34	0.0236	7.91
Sr/Ca	1.24	1.48	1.41	1.46	1.339	2.99
Ba/Ca	0.000416	8.88	0.00197	6.40	0.000796	12.0
Test weight (µg)	12.8					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.55	2.73	1.23	2.92	1.68	1.83
Al/Ca	0.0832	5.59	0.0309	9.50	0.0125	22.0
Mn/Ca	0.0184	8.62	0.0163	9.86	0.0281	6.20
Zn/Ca	0.0336	10.4	0.0170	7.87	0.0359	5.29
Sr/Ca	1.18	1.60	1.16	1.54	1.29	1.60
Ba/Ca	0.00308	18.8	0.00161	8.37	0.00220	6.75
Test weight (µg)	11.6					
Test length (µm)	318					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.84	1.47	1.45	2.68	1.67	1.74
Al/Ca	0.164	4.45	0.0334	8.93	0.00955	33.6
Mn/Ca	0.0493	5.30	0.0394	5.03	0.0861	3.00
Zn/Ca	0.0330	5.72	0.0241	6.05	0.0570	4.74
Sr/Ca	1.22	1.66	1.19	1.68	1.46	2.06
Ba/Ca	0.0555	4.51	0.0295	5.19	0.0275	2.61
Test weight (µg)	19.4					
Test length (µm)	409					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.782	8.91	1.86	4.51	2.03	4.53
Al/Ca	0.0231	132	0.00746	29.1	0.0208	13.4
Mn/Ca	0.00548	45.2	0.118	9.19	0.229	5.85
Zn/Ca	0.00203	79.7	0.00565	25.4	0.0116	22.5
Sr/Ca	1.30	6.34	1.36	3.98	1.42	3.12
Ba/Ca	0.000712	8.91	0.00549	8.20	0.00966	5.62
Test weight (µg)	8.5					
Test length (µm)	n/a					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.866	3.03	1.41	5.17	1.92	5.62
Al/Ca	0.0597	8.39	0.00853	41.6	0.0055	44.3
Mn/Ca	0.01127	14.1	0.032	11.0	0.060	7.12
Zn/Ca	0.00352	28.5	0.00036	418	0.0031	36.3
Sr/Ca	1.23	3.33	1.37	2.54	1.46	2.49
Ba/Ca	0.001719	5.81	0.00401	10.1	0.00914	6.71
Test weight (µg)	26.8					
Test length (µm)	n/a					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-2</i>	% 2se	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	1.216	12.1	0.940	5.73	0.865	7.99
Al/Ca	0.0385	135	0.0395	64.7	0.0115	203
Mn/Ca	0.0751	12.0	0.0604	11.2	0.0826	34.5
Zn/Ca	0.00308	70.6	0.00200	66.5	0.0155	45.3
Sr/Ca	1.41	13.7	1.29	4.06	1.45	9.87
Ba/Ca	0.0102	13.2	0.00538	8.03	0.00896	10.3
Test weight (µg)	12.3					
Test length (µm)	n/a					
Number of chambers	3.3					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.16	8.48	1.43	4.86	1.51	5.39
Al/Ca	0.0908	9.90	0.00650	28.9	0.0600	66.6
Mn/Ca	0.0472	21.2	0.0566	9.83	0.111	26.7
Zn/Ca	0.00251	49.1	0.00245	29.9	0.00810	22.5
Sr/Ca	1.37	9.40	1.27	3.41	1.41	5.49
Ba/Ca	0.0119	17.5	0.0125	13.5	0.0123	9.77
Test weight (µg)	9					
Test length (µm)	316					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>*f-2</i>	% 2se	<i>*f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	1.74	4.69	1.54	7.98	1.33	4.65
Al/Ca	0.0313	15.9	0.0348	23.9	0.0363	83.1
Mn/Ca	0.188	3.53	0.181	4.63	0.244	3.6
Zn/Ca	0.00546	18.9	0.0303	6.90	0.0309	9.41
Sr/Ca	1.48	3.94	1.69	8.25	1.66	3.36
Ba/Ca	0.0191	11.2	0.0117	6.28	0.00826	3.69
Test weight (µg)	19.8					
Test length (µm)	356					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.07	10.4	0.625	5.57	1.44	22.0
Al/Ca	0.509	6.95	0.0125	26.1	0.0813	66.1
Mn/Ca	0.00965	25.9	0.0106	21.0	0.0667	11.2
Zn/Ca	0.00167	68.2	0.000403	219	0.0317	42.8
Sr/Ca	1.25	5.79	1.25	3.66	1.69	29.9
Ba/Ca	0.00141	8.14	0.000854	8.29	0.00472	28.7
Test weight (µg)	10.2					
Test length (µm)	310					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.65	5.34	1.28	6.40	1.81	5.41
Al/Ca	0.202	31.0	0.0450	8.94	0.111	13.9
Mn/Ca	0.145	7.06	0.0799	9.16	0.159	7.25
Zn/Ca	0.00823	19.6	0.00737	20.9	0.00439	37.8
Sr/Ca	1.37	5.79	1.34	5.29	1.31	2.79
Ba/Ca	0.0422	9.64	0.0196	12.17	0.0265	8.35
Test weight (μm)	15.4					
Test length (μm)	333					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.53	6.81	0.96	8.53	1.24	8.68
Al/Ca	1.01	7.52	0.0715	75.8	0.0218	24.9
Mn/Ca	0.0247	17.8	0.00746	39.9	0.0273	15.3
Zn/Ca	0.00865	23.0	0.00423	42.0	0.0329	13.9
Sr/Ca	1.24	3.33	1.25	8.75	1.28	6.48
Ba/Ca	0.0196	6.89	0.00361	15.7	0.0130	15.0
Test weight (µg)	9.3					
Test length (µm)	268					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.44	6.27	1.75	7.72	4.59	7.83
Al/Ca	0.0186	15.5	0.00397	68.4	0.00863	44.4
Mn/Ca	0.0511	10.3	0.0851	12.3	0.167	7.05
Zn/Ca	0.00511	33.1	0.00246	62.1	0.00646	35.1
Sr/Ca	1.33	5.10	1.43	7.11	1.81	10.7
Ba/Ca	0.00131	8.41	0.00216	12.1	0.00505	11.6
Test weight (µg)	12.1					
Test length (µm)	292					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	0.904	12.5	1.66	6.41	2.34	14.2
Al/Ca	0.196	56.2	0.0183	15.5	0.0244	60.2
Mn/Ca	0.0238	18.5	0.276	18.8	0.360	8.61
Zn/Ca	0.0249	151	0.0132	13.1	0.0653	18.0
Sr/Ca	1.29	11.0	1.44	3.70	2.19	17.8
Ba/Ca	0.00173	17.5	0.00717	5.47	0.0278	17.4
Test weight (µg)	25.7					
Test length (µm)	433					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	1.21	7.33	1.07	8.41	1.71	10.1
Al/Ca	0.225	20.0	0.0741	10.2	0.0276	24.8
Mn/Ca	0.0813	7.83	0.104	6.76	0.109	8.94
Zn/Ca	0.0143	32.7	0.0438	15.6	0.0343	18.2
Sr/Ca	1.27	8.67	1.26	5.39	1.63	13.9
Ba/Ca	0.00788	8.71	0.00554	9.57	0.0131	12.2
Test weight (µg)	15.5					
Test length (µm)	n/a					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	0.775	6.88	0.856	5.28	2.02	6.74
Al/Ca	0.134	16.9	0.00546	42.5	-0.000632	-416
Mn/Ca	0.00733	40.7	0.0313	8.40	0.187	9.29
Zn/Ca	0.00380	44.5	0.00263	40.0	0.00644	39.2
Sr/Ca	1.27	5.86	1.28	2.81	1.74	10.7
Ba/Ca	0.00509	8.23	0.0104	7.14	0.0300	9.09
Test weight (µg)	25.5					
Test length (µm)	397					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.955	13.0	1.306	7.00	1.07	14.8
Al/Ca	0.515	46.2	0.0782	46.4	0.208	31.2
Mn/Ca	0.603	43.8	0.119	5.74	0.0338	43.7
Zn/Ca	0.0372	32.2	0.00689	41.9	0.00534	108
Sr/Ca	1.58	17.5	1.25	5.92	1.41	19.7
Ba/Ca	0.0671	23.4	0.00992	6.71	0.00340	70.1
Test weight (µg)	23.5					
Test length (µm)	339					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.922	10.2	0.922	15.7	1.10	14.7
Al/Ca	0.00215	171	0.00215	-392	-0.00129	86.6
Mn/Ca	0.0207	14.6	0.0207	22.2	0.0224	26.0
Zn/Ca	0.00195	91.4	0.00195	-530	-0.000428	153
Sr/Ca	1.34	9.80	1.34	28.1	2.01	23.7
Ba/Ca	0.00100	12.1	0.00100	20.9	0.00136	32.1
Test weight (µg)	9.9					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.23	6.12	1.23	5.68	0.731	12.0
Al/Ca	0.0638	6.76	0.0638	111	0.00320	21.2
Mn/Ca	0.0320	6.95	0.0634	12.7	0.0230	11.3
Zn/Ca	0.00339	37.1	0.00339	92.9	0.00164	38.7
Sr/Ca	1.35	4.23	1.35	4.44	1.36	26.3
Ba/Ca	0.00220	6.72	0.00220	6.84	0.00104	19.3
Test weight (µg)	23.3					
Test length (µm)	349					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.68	8.48	0.638	7.79	2.51	17.2
Al/Ca	0.222	12.7	0.000804	615	0.0269	38.8
Mn/Ca	0.142	8.05	0.0262	19.6	0.390	13.6
Zn/Ca	0.00426	41.1	0.00116	202	0.0122	29.1
Sr/Ca	1.33	4.74	1.32	5.96	2.89	30.1
Ba/Ca	0.0133	11.6	0.00138	9.56	0.0779	24.5
Test weight (μg)	9.3					
Test length (μm)	280					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	3.65	29.9	1.94	7.89	3.60	14.4
Al/Ca	0.0311	36.2	0.00943	48.8	0.0504	131
Mn/Ca	0.0343	27.9	0.00954	27.6	0.0855	10.2
Zn/Ca	0.00564	82.5	0.00446	40.8	0.0109	32.9
Sr/Ca	1.82	43.6	1.33	4.37	1.78	17.3
Ba/Ca	0.0105	29.7	0.00266	8.26	0.0160	16.5
Test weight (µg)	17					
Test length (µm)	372					
Number of chambers	3.8					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>f-2</i>	% 2se	<i>f-1</i>	% 2se	<i>f</i>	% 2se
Mg/Ca	2.07	10.5	0.982	6.28	1.17	13.6
Al/Ca	0.0534	17.2	0.0726	12.0	0.0823	32.8
Mn/Ca	0.172	6.85	0.0616	8.55	0.0969	10.1
Zn/Ca	0.00986	35.6	0.00309	58.6	0.0152	33.6
Sr/Ca	1.84	13.2	1.40	8.95	1.62	12.9
Ba/Ca	0.0121	15.2	0.00272	9.85	0.00586	12.7
Test weight (µg)	9					
Test length (µm)	290					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.87	1.66	1.83	1.77	2.07	2.78
Al/Ca	0.113	7.90	0.0274	17.9	0.118	31.1
Mn/Ca	0.0625	2.58	0.0560	3.42	0.0872	4.57
Zn/Ca	0.0248	6.35	0.0184	6.02	0.0760	7.04
Sr/Ca	1.31	1.43	1.34	1.46	1.38	2.42
Ba/Ca	0.0113	3.27	0.0136	3.29	0.0279	17.5
Test weight (µg)	12					
Test length (µm)	285					
Number of chambers	3.3					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.03	1.84	1.53	1.86	1.66	2.25
Al/Ca	0.133	27.5	0.0445	14.6	0.107	56.5
Mn/Ca	0.112	9.80	0.0835	2.43	0.0723	4.59
Zn/Ca	0.0187	6.87	0.0322	4.98	0.0244	8.93
Sr/Ca	1.46	1.45	1.45	1.36	1.50	2.06
Ba/Ca	0.00861	5.30	0.00670	3.30	0.0151	3.74
Test weight (µg)	13.7					
Test length (µm)	299					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.10	3.51	1.43	4.32	1.64	3.66
Al/Ca	0.232	67.9	0.0492	50.6	0.00859	76.6
Mn/Ca	0.0906	9.49	0.0517	5.08	0.0874	5.57
Zn/Ca	0.0842	7.32	0.0701	6.09	0.0856	7.84
Sr/Ca	1.25	1.24	1.23	1.50	1.33	2.44
Ba/Ca	0.0260	8.30	0.0280	7.55	0.0105	9.54
Test weight (µg)	12.6					
Test length (µm)	286					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.72	1.89	1.79	2.82	2.38	2.27
Al/Ca	0.176	10.6	0.0181	38.9	0.0180	48.1
Mn/Ca	0.0435	20.3	0.0427	8.06	0.0623	3.83
Zn/Ca	0.0140	8.54	0.0187	13.0	0.0252	6.63
Sr/Ca	1.20	2.02	1.18	1.49	1.36	1.54
Ba/Ca	0.00642	25.0	0.00553	6.40	0.0116	3.97
Test weight (µg)	14.8					
Test length (µm)	340					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.82	2.28	0.89	3.78	1.30	3.01
Al/Ca	0.346	3.37	0.0233	23.5	0.00298	183
Mn/Ca	0.0296	8.15	0.0135	10.3	0.0316	4.41
Zn/Ca	0.0133	14.8	0.0172	76.7	0.0149	7.08
Sr/Ca	1.22	2.22	1.22	1.07	1.38	1.20
Ba/Ca	0.0115	28.9	0.00409	10.5	0.0122	4.68
Test weight (µg)	15.2					
Test length (µm)	340					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	5.78	1.74	1.51	1.65	1.64	1.29
Al/Ca	14.1	2.49	0.168	4.78	0.171	7.40
Mn/Ca	0.0670	50.9	0.0334	18.0	0.0453	4.29
Zn/Ca	0.0458	69.7	0.00738	11.1	0.0177	7.16
Sr/Ca	1.24	2.25	1.27	1.26	1.58	1.21
Ba/Ca	0.0231	10.0	0.00232	8.32	0.00543	4.28
Test weight (µg)	5.45					
Test length (µm)	414					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.88	2.02	2.13	2.96	2.30	2.21
Al/Ca	0.185	6.01	0.387	90.9	0.0712	10.3
Mn/Ca	0.0610	4.26	0.0771	8.41	0.124	1.85
Zn/Ca	0.198	4.36	0.270	5.57	0.358	2.13
Sr/Ca	1.24	1.30	1.30	3.41	1.44	1.65
Ba/Ca	0.00442	4.88	0.00889	7.18	0.00987	3.41
Test weight (µg)	9.2					
Test length (µm)	275					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	1.70	3.03	1.19	4.26	1.37	2.62
Al/Ca	2.31	31.0	1.46	4.68	0.125	143
Mn/Ca	0.0128	18.7	0.00868	11.3	0.0116	7.22
Zn/Ca	0.00628	26.0	0.00746	10.8	0.00425	14.5
Sr/Ca	1.28	3.13	1.40	1.01	1.45	1.46
Ba/Ca	0.00562	12.2	0.00352	4.34	0.00330	8.63
Test weight (µg)	26.6					
Test length (µm)	351					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.80	2.14	1.90	2.66	2.24	2.17
Al/Ca	0.0419	18.9	0.0217	26.4	0.0257	29.6
Mn/Ca	0.0482	3.70	0.0658	9.01	0.0726	6.16
Zn/Ca	0.0371	5.53	0.0586	4.10	0.120	4.18
Sr/Ca	1.28	1.01	1.30	1.73	1.39	1.92
Ba/Ca	0.00621	3.19	0.00352	3.75	0.0110	3.76
Test weight (µg)	13.7					
Test length (µm)	312					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.16	2.71	1.01	3.86	1.15	3.64
Al/Ca	0.235	4.01	0.0465	10.9	0.00602	95.4
Mn/Ca	0.0217	4.92	0.0171	7.34	0.0488	5.54
Zn/Ca	0.0534	6.03	0.0323	7.50	0.0805	5.75
Sr/Ca	1.38	1.02	1.34	1.26	1.35	2.21
Ba/Ca	0.0157	5.93	0.0176	5.97	0.00880	8.82
Test weight (µg)	13.3					
Test length (µm)	281					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.39	1.94	0.957	2.88	1.16	2.30
Al/Ca	0.0241	25.7	0.0498	16.9	0.00857	65.4
Mn/Ca	0.0392	4.42	0.0294	7.12	0.0412	5.23
Zn/Ca	0.0927	3.85	0.0691	9.56	0.0697	6.36
Sr/Ca	1.36	1.33	1.30	1.34	1.47	1.49
Ba/Ca	0.0108	3.50	0.00423	5.70	0.00312	4.64
Test weight (µg)	18.5					
Test length (µm)	364					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	2.09	1.86	1.82	2.38	2.03	2.92
Al/Ca	0.201	5.32	0.224	6.82	0.0300	52.5
Mn/Ca	0.0433	5.09	0.0416	2.91	0.0654	3.19
Zn/Ca	0.0202	8.51	0.0305	9.44	0.0261	7.07
Sr/Ca	1.37	1.38	1.48	1.70	1.65	2.34
Ba/Ca	0.00488	7.30	0.00690	5.49	0.00836	7.53
Test weight (µg)	17.3					
Test length (µm)	345					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.49	2.07	1.07	2.47	1.72	2.37
Al/Ca	0.369	8.08	0.201	8.92	0.0695	80.6
Mn/Ca	0.0481	6.21	0.0244	13.4	0.0413	6.32
Zn/Ca	0.0300	7.07	0.0219	32.0	0.0453	31.0
Sr/Ca	1.11	1.33	1.08	2.72	1.15	2.41
Ba/Ca	0.0763	4.30	0.0257	4.85	0.0791	3.45
Test weight (µg)	21.3					
Test length (µm)	414					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.09	2.12	1.47	1.27	1.51	1.58
Al/Ca	0.293	6.87	0.0428	16.1	0.0613	65.1
Mn/Ca	0.0604	4.06	0.0532	2.43	0.0679	2.95
Zn/Ca	0.0575	4.86	0.0346	5.22	0.0702	10.0
Sr/Ca	1.29	1.99	1.43	1.06	1.47	1.60
Ba/Ca	0.00963	8.35	0.00913	3.28	0.0123	2.97
Test weight (µg)	22					
Test length (µm)	377					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	2.40	3.80	2.23	2.11	2.43	2.81
Al/Ca	1.17	54.4	0.0530	13.9	0.567	17.1
Mn/Ca	0.0614	5.35	0.0458	4.19	0.0874	4.52
Zn/Ca	0.0175	14.4	0.0134	8.33	0.0516	7.05
Sr/Ca	1.37	1.81	1.45	1.32	1.42	1.86
Ba/Ca	0.0150	3.85	0.0146	8.62	0.0161	4.75
Test weight (µg)	13.1					
Test length (µm)	320					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.22	2.58	1.59	9.89	1.66	8.28
Al/Ca	0.100	50.2	0.120	41.0	0.0200	38.5
Mn/Ca	0.0260	11.7	0.0872	7.56	0.0826	19.0
Zn/Ca	0.0340	7.27	0.0942	7.89	0.153	44.7
Sr/Ca	1.14	1.80	1.15	7.57	1.29	3.19
Ba/Ca	0.00439	61.5	0.00765	23.5	0.00474	38.1
Test weight (µg)	13					
Test length (µm)	281					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.50	19.2	3.16	35.8	3.70	95.6
Al/Ca	0.221	895	0.297	503	0.6493	83.4
Mn/Ca	0.1187	22.8	0.1038	250	0.1711	234
Zn/Ca	0.0469	110	0.0572	249	0.0864	146
Sr/Ca	1.32	3.59	1.37	191	1.37	4.20
Ba/Ca	0.01094	17.3	0.02770	178	0.02580	42.9
Test weight (µg)	10.7					
Test length (µm)	n/a					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.41	7.46	1.53	16.0	1.72	18.6
Al/Ca	0.306	22.8	0.824	26.1	0.0625	227
Mn/Ca	0.1385	10.8	0.1024	54.5	0.1033	105
Zn/Ca	0.0418	49.1	0.0221	124	0.0451	212
Sr/Ca	1.17	7.77	1.19	3.61	1.33	2.51
Ba/Ca	0.08195	4.59	0.02924	7.10	0.03679	18.7
Test weight (µg)	19.6					
Test length (µm)	327					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2		f-1		f	
		% 2se		% 2se		% 2se
Mg/Ca	2.03	5.59	1.15	2.33	1.08	5.26
Al/Ca	0.00962	56.4	0.0421	6.19	0.0759	56.2
Mn/Ca	0.00866	38.9	0.00142	87.5	0.00143	168
Zn/Ca	0.0242	14.7	0.00924	10.0	0.00841	18.9
Sr/Ca	1.27	7.50	1.22	1.56	1.50	6.59
Ba/Ca	0.00828	9.06	0.00304	5.59	0.00288	10.7
Test weight (µg)	9.3					
Test length (µm)	311					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.68	2.40	2.04	4.02	1.91	4.00
Al/Ca	0.00654	27.4	0.0178	87.1	0.00327	73.2
Mn/Ca	0.00436	73.8	0.00146	143	0.00218	79.9
Zn/Ca	0.0133	8.70	0.00670	17.9	0.00686	17.4
Sr/Ca	1.34	1.43	1.42	4.26	1.41	2.99
Ba/Ca	0.00121	6.41	0.00107	18.9	0.00105	17.2
Test weight (µg)	12.4					
Test length (µm)	314					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.78	2.47	1.52	4.07	2.22	1.77
Al/Ca	0.0267	22.2	0.0395	20.3	0.00932	70.6
Mn/Ca	0.0188	7.94	0.0231	8.04	0.0192	7.88
Zn/Ca	0.110	3.46	0.101	5.41	0.188	4.05
Sr/Ca	1.29	1.44	1.48	3.89	1.36	2.40
Ba/Ca	0.00382	7.36	0.00292	7.00	0.00294	9.86
Test weight (µg)	7.2					
Test length (µm)	279					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	3.15	4.31	0.65	2.26	0.63	2.49
Al/Ca	5.68	2.99	-0.222	20.3	0.0755	12.0
Mn/Ca	0.0414	12.5	0.00114	91.4	-0.000843	195
Zn/Ca	0.0612	7.60	0.00392	28.2	0.00505	30.3
Sr/Ca	1.26	1.99	1.27	1.47	1.18	2.09
Ba/Ca	0.0110	10.7	0.00116	7.00	0.00127	41.6
Test weight (µg)	12.4					
Test length (µm)	308					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.09	2.84	0.86	2.27	0.97	2.03
Al/Ca	0.0374	90.0	0.00652	96.7	0.0359	29.2
Mn/Ca	-0.000216	733	0.00211	60.8	0.00700	23.0
Zn/Ca	0.0151	10.4	0.0373	5.42	0.291	2.59
Sr/Ca	1.26	2.74	1.27	1.99	1.34	1.45
Ba/Ca	0.000722	11.5	0.00115	12.6	0.00200	14.8
Test weight (µg)	7.2					
Test length (µm)	302					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.20	3.28	1.85	2.23	1.50	3.00
Al/Ca	0.380	39.8	0.134	7.20	0.0330	22.2
Mn/Ca	0.0297	9.02	0.00730	16.8	0.00311	43.2
Zn/Ca	0.425	6.93	0.111	3.82	0.0576	8.62
Sr/Ca	1.22	2.63	1.27	1.76	1.24	1.69
Ba/Ca	0.0532	4.11	0.0247	3.17	0.0242	7.02
Test weight (µg)	17.1					
Test length (µm)	349					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.832	7.08	0.815	2.31	1.36	1.72
Al/Ca	0.0609	29.0	0.200	4.37	0.0264	23.1
Mn/Ca	-0.000480	603	0.00324	41.0	0.00749	15.7
Zn/Ca	0.00600	43.9	0.00656	15.1	0.0323	5.89
Sr/Ca	1.21	7.87	1.29	2.03	1.40	1.35
Ba/Ca	0.000962	19.7	0.00101	9.74	0.00213	5.02
Test weight (µg)	14					
Test length (µm)	298					
Number of chambers	3.3					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	0.732	1.52	0.811	2.38	1.17	1.75
Al/Ca	0.00177	143	0.00367	85.9	0.00135	225
Mn/Ca	0.00194	49.6	-0.00160	69.6	-0.00140	83.7
Zn/Ca	0.000844	94.4	0.000778	117	0.00192	48.5
Sr/Ca	1.44	1.18	1.47	1.60	1.27	1.65
Ba/Ca	0.00107	5.45	0.00125	6.88	0.000684	8.79
Test weight (µg)	46.8					
Test length (µm)	429					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.548	1.59	0.568	2.70	0.637	1.74
Al/Ca	-0.00320	84.1	-0.00229	129	-0.00273	106
Mn/Ca	-0.00120	85.1	-0.000552	203	-0.000577	194
Zn/Ca	0.00333	31.9	0.00358	25.7	0.00441	23.5
Sr/Ca	1.41	1.40	1.49	1.56	1.33	1.21
Ba/Ca	0.000939	6.28	0.000813	8.60	0.000670	8.62
Test weight (µg)	33.1					
Test length (µm)	398					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	0.623	1.45	0.554	1.79	0.541	1.55
Al/Ca	0.00935	30.4	-0.00104	293	-0.00390	82.8
Mn/Ca	0.00114	90.2	-0.00251	47.4	0.000166	684
Zn/Ca	0.00228	37.8	0.00188	52.3	0.00334	29.4
Sr/Ca	1.32	0.980	1.44	1.25	1.31	1.28
Ba/Ca	0.000986	6.17	0.00100	7.06	0.000692	8.55
Test weight (µg)	51.8					
Test length (µm)	423					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	0.759	2.02	0.636	2.77	0.804	2.45
Al/Ca	0.0587	6.17	0.0388	16.8	0.00912	35.0
Mn/Ca	0.00203	56.6	0.00305	145	-0.00116	97.4
Zn/Ca	0.00344	29.5	0.00349	33.7	0.00547	19.9
Sr/Ca	1.17	1.47	1.23	1.96	1.27	1.36
Ba/Ca	0.00153	7.72	0.00140	11.8	0.00152	5.85
Test weight (µg)	34.1					
Test length (µm)	367					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.432	1.66	0.422	1.76	0.454	1.75
Al/Ca	0.00239	119	0.00404	74.8	0.0000630	4940
Mn/Ca	-0.00361	27.2	-0.000978	117	-0.000330	339
Zn/Ca	0.00448	19.7	0.00174	58.2	0.00313	33.5
Sr/Ca	1.49	1.02	1.45	1.32	1.29	1.21
Ba/Ca	0.000710	6.91	0.000620	8.91	0.000567	9.34
Test weight (μm)	29.1					
Test length (μm)	355					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	0.799	2.62	0.757	2.57	0.971	2.94
Al/Ca	0.0276	13.4	0.00979	33.5	0.00881	37.4
Mn/Ca	-0.0000994	1180	0.00138	86.0	0.00209	53.8
Zn/Ca	0.00443	23.7	0.00155	64.7	0.00555	19.6
Sr/Ca	1.33	1.25	1.43	1.63	1.55	1.78
Ba/Ca	0.00265	4.50	0.00262	5.38	0.000567	4.90
Test weight (µg)	34.4					
Test length (µm)	383					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.26	1.82	1.27	2.07	0.923	2.07
Al/Ca	0.0192	16.5	0.00739	50.1	0.00683	52.5
Mn/Ca	0.000152	732	-0.00175	77.0	0.0000577	2010
Zn/Ca	0.00401	25.9	0.00703	18.2	0.00903	14.4
Sr/Ca	1.34	1.91	1.32	1.94	1.30	1.63
Ba/Ca	0.00102	6.45	0.00105	7.77	0.000861	8.75
Test weight (µg)	38.5					
Test length (µm)	371					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	0.357	1.70	0.370	2.48	0.394	1.98
Al/Ca	-0.00185	146	0.00355	97.3	0.000389	920
Mn/Ca	-0.00109	88.4	-0.000297	406	0.000106	1160
Zn/Ca	0.000695	115	0.00111	94.2	0.0123	11.5
Sr/Ca	1.49	1.15	1.54	1.89	1.35	1.72
Ba/Ca	0.000827	6.37	0.000947	7.36	0.000739	9.16
Test weight (µg)	49.3					
Test length (µm)	393					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	0.388	2.03	0.390	2.52	0.517	2.02
Al/Ca	0.00375	83.4	0.00463	80.3	0.00111	303
Mn/Ca	-0.00120	89.5	0.000604	208	0.000804	141
Zn/Ca	0.00154	62.3	0.000979	107	0.00175	57.1
Sr/Ca	1.71	1.52	1.78	2.17	1.53	1.72
Ba/Ca	0.000671	7.98	0.000843	8.36	0.000534	9.70
Test weight (µg)	34					
Test length (µm)	334					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.609	1.79	0.548	1.87	0.732	1.87
Al/Ca	0.000561	589	0.00689	46.2	0.00479	70.3
Mn/Ca	0.000405	290	0.000898	134	-0.000514	236
Zn/Ca	0.00438	24.6	0.00204	50.0	0.00408	27.2
Sr/Ca	1.49	1.48	1.48	1.62	1.45	1.51
Ba/Ca	0.000971	7.66	0.000836	8.11	0.000759	8.58
Test weight (µg)	33					
Test length (µm)	335					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.571	1.56	0.534	2.62	0.551	1.82
Al/Ca	0.00605	50.8	0.000113	3070	0.00455	73.8
Mn/Ca	-0.00131	81.5	-0.000765	155	-0.000881	135
Zn/Ca	0.00295	31.2	0.000711	141	0.00135	71.8
Sr/Ca	1.41	1.45	1.47	1.74	1.35	1.33
Ba/Ca	0.000953	6.32	0.000816	8.00	0.000740	8.76
Test weight (µg)	36.4					
Test length (µm)	382					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.071	1.67	1.149	2.11	1.211	2.61
Al/Ca	0.00486	62.9	0.006756	48	0.00771	42.7
Mn/Ca	0.00306	35.0	0.003724	33	0.001956	61
Zn/Ca	0.00874	12.4	0.000790	120	0.00108	114.5
Sr/Ca	1.35	1.36	1.43	1.72	1.43	1.52
Ba/Ca	0.000884	6.61	0.000694	8.09	0.000850	7.54
Test weight (μg)	18.2					
Test length (μm)	298					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.801	1.63	0.742	1.88	0.972	1.48
Al/Ca	0.0286	51.6	-0.0176	317	-0.0104	64.0
Mn/Ca	0.000493	43.1	-0.00195	489	-0.0000283	323
Zn/Ca	0.00353	41.0	0.00287	25.2	0.00260	44.5
Sr/Ca	1.22	1.36	1.34	1.43	1.31	1.33
Ba/Ca	0.000889	7.58	0.000770	7.84	0.000719	8.25
Test weight (μm)	37.6					
Test length (μm)	401					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	0.736	1.79	0.772	2.01	0.808	2.22
Al/Ca	0.0197	59.5	-0.0198	155	-0.00976	388
Mn/Ca	0.00240	308	-0.000653	339	0.000248	202
Zn/Ca	0.00115	36.6	0.00278	108	0.00368	17.9
Sr/Ca	1.48	1.39	1.55	1.87	1.36	1.50
Ba/Ca	0.000817	6.55	0.000899	8.28	0.000697	8.65
Test weight (μm)	22.8					
Test length (μm)	317					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	3.13	1.23	2.67	1.68	2.63	2.62
Al/Ca	0.0318	12.3	0.0138	14.7	-0.0237	13.7
Mn/Ca	0.00850	32.4	0.00142	18700	-0.00182	95.6
Zn/Ca	0.0271	6.25	0.0121	12.2	0.120	5.65
Sr/Ca	1.31	1.24	1.37	2.25	1.59	3.11
Ba/Ca	0.00246	4.55	0.00128	7.96	0.00273	8.37
Test weight (µg)	17.9					
Test length (µm)	322					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.76	1.73	2.14	1.82	2.22	1.68
Al/Ca	0.0436	49.7	-0.00155	42.5	0.0588	11.6
Mn/Ca	0.00764	25.1	0.0127	12.4	0.0146	12.4
Zn/Ca	0.0330	8.19	0.0160	9.45	0.0526	5.39
Sr/Ca	1.64	2.23	1.30	2.01	1.40	1.91
Ba/Ca	0.00368	5.48	0.00458	3.77	0.00181	4.33
Test weight (µg)	13.8					
Test length (µm)	324					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.41	3.06	1.08	3.79	0.929	3.44
Al/Ca	0.0994	27.3	0.0239	43.9	0.00877	20.8
Mn/Ca	-0.00104	445	0.000924	163	-0.0000497	81.1
Zn/Ca	0.00639	65.0	0.00138	134	0.00151	50.7
Sr/Ca	1.32	3.22	1.30	3.67	1.45	1.95
Ba/Ca	0.00449	7.28	0.00163	14.0	0.00181	8.56
Test weight (µg)	31.8					
Test length (µm)	387					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.601	2.17	0.528	2.18	0.440	2.34
Al/Ca	0.0148	28.2	-0.01090	40.8	-0.00539	76.2
Mn/Ca	-0.00151	92.4	0.0000748	1870	0.00118	122
Zn/Ca	0.00151	60.1	0.00152	65.1	0.00184	52.5
Sr/Ca	1.28	2.76	1.35	2.41	1.38	2.51
Ba/Ca	0.000887	7.96	0.000814	10.2	0.000633	10.5
Test weight (μm)	16.6					
Test length (μm)	314					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	3.89	2.43	3.18	2.86	4.14	3.57
Al/Ca	0.120	5.93	0.0407	14.6	0.0237	15.8
Mn/Ca	0.0260	4.30	0.00567	15.7	0.0219	4.27
Zn/Ca	0.0116	52.4	0.00522	74.3	0.00801	8.70
Sr/Ca	1.35	1.59	1.28	1.22	1.45	1.28
Ba/Ca	0.0194	11.2	0.00185	8.98	0.00432	6.03
Test weight (µg)	33.3					
Test length (µm)	390					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.64	2.13	0.754	1.37	0.902	2.23
Al/Ca	0.0184	89.8	0.0363	27.7	0.0163	14.8
Mn/Ca	0.00752	13.7	0.000361	235	0.00121	55.2
Zn/Ca	0.00594	11.6	0.00202	30.5	0.00199	21.1
Sr/Ca	1.34	1.14	1.05	1.03	1.25	0.87
Ba/Ca	0.00339	3.72	0.00103	11.3	0.00169	5.00
Test weight (µg)	35.5					
Test length (µm)	390					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.83	2.05	1.59	1.87	2.00	1.66
Al/Ca	0.0384	14.8	0.0615	17.1	0.0378	21.2
Mn/Ca	0.00870	10.3	0.00985	10.6	0.0112	9.10
Zn/Ca	0.0116	17.1	0.00641	12.6	0.0101	9.64
Sr/Ca	1.34	1.45	1.36	1.45	1.48	1.26
Ba/Ca	0.0115	7.61	0.00953	4.96	0.0151	64.6
Test weight (µg)	11.4					
Test length (µm)	407					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.15	2.10	1.57	1.50	1.80	1.61
Al/Ca	0.0887	4.42	0.0512	20.0	0.103	10.9
Mn/Ca	0.00823	9.56	0.00515	14.1	0.0125	55.7
Zn/Ca	0.00691	8.50	0.00395	13.2	0.00818	19.1
Sr/Ca	1.43	1.04	1.37	1.31	1.36	1.06
Ba/Ca	0.00832	3.12	0.00518	7.96	0.00459	8.96
Test weight (µg)	17.5					
Test length (µm)	337					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.84	1.19	1.50	1.82	1.58	2.55
Al/Ca	0.111	9.68	0.0361	38.3	0.0291	40.8
Mn/Ca	0.00441	25.9	0.00455	28.1	0.0104	14.1
Zn/Ca	0.00401	22.3	0.00588	18.7	0.0111	15.0
Sr/Ca	1.37	1.21	1.41	1.65	1.41	1.45
Ba/Ca	0.00525	3.77	0.00557	4.88	0.00384	4.69
Test weight (µg)	16.0					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.10	2.95	0.942	3.86	1.70	2.54
Al/Ca	0.187	7.17	0.371	59.4	0.324	10.5
Mn/Ca	0.000620	250	0.00588	97.6	0.0159	10.5
Zn/Ca	0.00492	22.5	0.00706	35.1	0.0124	14.4
Sr/Ca	1.21	1.52	1.20	4.04	1.42	1.67
Ba/Ca	0.00426	15.8	0.00609	39.4	0.00914	5.47
Test weight (µg)	36.0					
Test length (µm)	404					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.604	1.52	0.588	1.58	0.809	2.21
Al/Ca	0.00478	167	0.00219	344	0.0181	37.3
Mn/Ca	-0.00134	73.9	-0.000180	545	0.00713	14.2
Zn/Ca	0.00460	20.9	0.00285	34.1	0.0162	8.48
Sr/Ca	1.20	0.878	1.36	1.14	1.29	0.918
Ba/Ca	0.00114	6.59	0.00118	7.26	0.00210	6.02
Test weight (µg)	49.9					
Test length (µm)	426					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.15	2.55	0.78	1.40	1.43	3.59
Al/Ca	0.0669	24.7	0.0489	6.04	0.00234	98.6
Mn/Ca	0.00280	40.3	0.00169	85.4	0.00025	191
Zn/Ca	0.000645	108	0.00124	25.6	0.00133	22.4
Sr/Ca	1.16	2.14	1.29	0.910	1.34	0.773
Ba/Ca	0.0105	6.86	0.00282	4.07	0.0304	4.86
Test weight (µg)	54.3					
Test length (µm)	447					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.28	1.70	2.14	1.57	2.10	1.25
Al/Ca	0.0345	9.52	0.0104	63.1	0.0257	15.8
Mn/Ca	0.00798	6.93	0.00833	12.8	0.00623	13.4
Zn/Ca	0.00764	6.75	0.0115	7.59	0.0117	7.17
Sr/Ca	1.31	1.21	1.35	2.07	1.30	1.11
Ba/Ca	0.273	2.84	0.157	2.84	0.151	1.86
Test weight (µg)	23.2					
Test length (µm)	397					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.28	1.70	2.14	1.57	2.10	1.25
Al/Ca	0.0345	9.52	0.0104	63.1	0.0257	15.8
Mn/Ca	0.00798	6.93	0.00833	12.8	0.00623	13.4
Zn/Ca	0.00764	6.75	0.0115	7.59	0.0117	7.17
Sr/Ca	1.31	1.21	1.35	2.07	1.30	1.11
Ba/Ca	0.273	2.84	0.157	2.84	0.151	1.86
Test weight (µg)	23.2					
Test length (µm)	397					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	<i>*f-2</i>	% 2se	<i>*f-1</i>	% 2se	<i>*f</i>	% 2se
Mg/Ca	3.02	1.89	3.58	1.35	3.19	3.80
Al/Ca	0.00856	57.8	-	0.00179	418	82.9
Mn/Ca	0.00944	11.0	0.00690	23.4	0.0109	12.0
Zn/Ca	0.00886	10.6	0.0114	16.0	0.0112	11.0
Sr/Ca	1.40	2.11	1.50	1.64	1.58	6.77
Ba/Ca	0.00942	5.38	0.0123	3.78	0.00928	14.6
Test weight (µg)	27.4					
Test length (µm)	n/a					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	2.69	1.60	1.98	2.57	1.73	3.59
Al/Ca	0.0140	28.5	0.0875	7.23	0.546	186
Mn/Ca	0.0200	8.33	0.0167	6.04	0.0129	12.9
Zn/Ca	0.00676	9.92	0.00961	12.1	0.00788	24.4
Sr/Ca	1.32	1.53	1.41	1.53	1.46	10.5
Ba/Ca	0.00648	3.54	0.00629	16.2	0.00567	8.61
Test weight (µg)	34.9					
Test length (µm)	482					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.88	2.89	2.42	2.15	3.12	3.11
Al/Ca	0.107	49.9	0.0294	19.9	0.172	18.4
Mn/Ca	0.00833	13.3	0.00821	13.0	0.0117	11.9
Zn/Ca	0.00678	17.2	0.00967	13.5	0.0190	13.3
Sr/Ca	1.41	3.02	1.46	1.52	1.50	3.34
Ba/Ca	0.00418	11.6	0.00407	7.64	0.0145	14.1
Test weight (µg)	34.9					
Test length (µm)	482					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.61	1.74	1.27	2.37	1.65	5.10
Al/Ca	0.0511	16.2	0.0608	37.9	0.139	42.6
Mn/Ca	0.00632	25.0	0.00679	13.2	0.00902	14.1
Zn/Ca	0.0252	17.0	0.0244	17.5	0.0313	15.1
Sr/Ca	1.37	1.74	1.49	1.77	1.53	2.04
Ba/Ca	0.00761	4.64	0.00560	13.8	0.00825	6.17
Test weight (μm)	29.5					
Test length (μm)	452					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	f	% 2se
Mg/Ca	1.76	4.00	2.52	3.09	1.86	6.82
Al/Ca	0.0349	124	0.218	10.2	0.0875	77.1
Mn/Ca	0.00334	27.4	0.0105	38.5	0.00598	22.4
Zn/Ca	0.00468	19.7	0.0148	26.7	0.0200	12.5
Sr/Ca	1.34	1.58	1.35	3.49	1.44	2.02
Ba/Ca	0.00606	4.56	0.0171	10.3	0.00751	4.94
Test weight (µg)	21.9					
Test length (µm)	400					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.77	2.95	1.42	2.70	1.75	2.64
Al/Ca	0.0795	18.4	0.0336	13.7	0.0304	17.5
Mn/Ca	0.00811	36.0	0.00645	12.3	0.00820	9.76
Zn/Ca	0.00500	14.1	0.00539	14.2	0.00566	12.4
Sr/Ca	1.34	1.29	1.40	1.82	1.39	1.60
Ba/Ca	0.0114	4.63	0.00712	4.83	0.00749	6.25
Test weight (µg)	24.9					
Test length (µm)	422					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.26	3.06	2.14	2.02	2.46	3.07
Al/Ca	0.0273	31.3	0.0867	22.0	0.0459	78.9
Mn/Ca	0.0138	6.07	0.0130	6.24	0.0160	7.65
Zn/Ca	0.00762	10.2	0.0104	17.4	0.0138	9.92
Sr/Ca	1.36	1.59	1.38	1.75	1.41	2.77
Ba/Ca	0.0106	3.07	0.00903	6.77	0.00853	7.64
Test weight (µg)	30.7					
Test length (µm)	407					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.08	2.25	2.14	1.84	1.46	1.75
Al/Ca	0.0253	16.4	0.0274	18.7	0.0248	55.5
Mn/Ca	0.00965	8.48	0.0107	8.46	0.00745	14.8
Zn/Ca	0.0139	13.3	0.0217	5.08	0.0195	16.3
Sr/Ca	1.41	1.73	1.45	1.55	1.40	1.48
Ba/Ca	0.00944	4.71	0.00714	4.50	0.00655	15.8
Test weight (µg)	14.9					
Test length (µm)	356					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.81	1.84	1.71	2.45	1.59	4.26
Al/Ca	0.125	11.6	0.0533	50.5	0.0496	106
Mn/Ca	0.0274	12.0	0.0113	10.5	0.00676	15.0
Zn/Ca	0.0128	17.3	0.0168	15.2	0.00602	18.9
Sr/Ca	1.27	2.47	1.36	1.59	1.40	1.95
Ba/Ca	0.00798	10.7	0.00507	13.6	0.00438	15.4
Test weight (µg)	18.2					
Test length (µm)	295					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.803	1.44	0.758	1.45	1.00	1.22
Al/Ca	0.00000325	634	0.00717	113	0.00384	53.3
Mn/Ca	-0.00156	41.5	-0.000420	158	-0.00055	122
Zn/Ca	0.00148	23.9	0.000131	279	0.00104	36.6
Sr/Ca	1.21	0.96	1.28	0.96	1.29	0.73
Ba/Ca	0.000899	5.35	0.000798	5.87	0.00137	5.14
Test weight (µg)	55.3					
Test length (µm)	463					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.03	1.87	1.92	1.68	1.18	1.71
Al/Ca	0.0796	29.0	0.0360	11.5	0.0182	22.1
Mn/Ca	0.0109	7.40	0.00819	10.3	0.00495	13.9
Zn/Ca	0.00433	22.2	0.00459	12.1	0.00283	15.0
Sr/Ca	1.42	1.68	1.59	1.72	1.46	1.07
Ba/Ca	0.00560	5.03	0.00360	7.64	0.00287	3.50
Test weight (µg)	25.3					
Test length (µm)	409					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	2.12	2.04	1.54	1.80	1.51	2.89
Al/Ca	0.0552	34.5	0.0327	16.1	0.428	4.17
Mn/Ca	0.00849	10.5	0.00716	12.4	0.00820	9.69
Zn/Ca	0.00696	16.1	0.00560	12.8	0.0125	50.2
Sr/Ca	1.39	1.77	1.49	1.90	1.46	1.52
Ba/Ca	0.0144	10.0	0.00850	3.25	0.00871	7.36
Test weight (µg)	25.2					
Test length (µm)	406					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.81	2.93	1.45	2.36	1.54	2.50
Al/Ca	0.0719	7.94	0.0496	9.17	0.00538	71.3
Mn/Ca	0.0104	9.71	0.00525	66.4	0.00789	46.6
Zn/Ca	0.00563	14.1	0.00202	24.8	0.00555	16.2
Sr/Ca	1.22	2.04	1.20	1.39	1.36	1.55
Ba/Ca	0.00582	11.7	0.00221	6.54	0.00339	8.95
Test weight (µg)	13.8					
Test length (µm)	343					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.19	1.98	1.91	1.59	2.04	2.46
Al/Ca	0.150	9.26	0.0331	76.0	0.0282	18.0
Mn/Ca	0.00549	12.7	0.00616	39.1	0.00624	13.8
Zn/Ca	0.00615	13.3	0.00473	14.4	0.00500	16.3
Sr/Ca	1.38	2.79	1.40	1.25	1.39	1.62
Ba/Ca	0.00608	3.07	0.00415	4.06	0.00359	4.30
Test weight (µg)	16.6					
Test length (µm)	351					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	4.80	1.68	4.01	1.81	3.14	1.36
Al/Ca	0.881	5.43	0.0137	39.8	0.0684	12.0
Mn/Ca	0.00960	8.89	0.00507	17.4	0.00718	12.3
Zn/Ca	0.0320	19.5	0.0194	22.1	0.0169	45.4
Sr/Ca	1.41	1.65	1.47	1.39	1.48	1.70
Ba/Ca	0.0241	16.0	0.00352	10.5	0.00662	26.3
Test weight (µg)	13.4					
Test length (µm)	314					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.71	3.38	1.38	1.50	1.61	1.94
Al/Ca	0.0443	20.5	0.140	15.4	0.0418	17.6
Mn/Ca	0.00713	12.7	0.00603	13.4	0.00577	16.8
Zn/Ca	0.00566	17.5	0.00487	13.0	0.00729	21.2
Sr/Ca	1.35	2.03	1.39	1.79	1.36	1.89
Ba/Ca	0.0102	7.42	0.00550	5.16	0.00713	8.02
Test weight (µg)	19.0					
Test length (µm)	375					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.701	1.79	0.781	1.46	1.51	1.83
Al/Ca	0.0116	35.0	0.00409	96.1	0.0146	23.9
Mn/Ca	0.0000465	1260	0.000855	83.2	0.00285	22.8
Zn/Ca	0.00186	20.7	0.00173	24.3	0.00185	23.1
Sr/Ca	1.21	1.02	1.20	1.01	1.28	0.933
Ba/Ca	0.00102	5.26	0.00269	3.70	0.00210	4.57
Test weight (µg)	30.0					
Test length (µm)	372					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.722	1.28	0.754	1.82	0.743	2.53
Al/Ca	0.00666	35.7	-0.00101	226	0.00132	182
Mn/Ca	-0.00114	129	-0.000262	549	0.000266	551
Zn/Ca	0.00287	22.3	0.00321	19.9	0.00192	30.9
Sr/Ca	1.15	1.08	1.26	2.12	1.41	2.56
Ba/Ca	0.00146	8.54	0.000702	9.46	0.000629	10.5
Test weight (µg)	25.9					
Test length (µm)	348					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.69	2.70	1.67	2.81	1.45	2.90
Al/Ca	0.0713	15.5	0.0220	13.0	0.0267	12.6
Mn/Ca	0.00150	141	0.00712	23.0	0.00279	64.8
Zn/Ca	0.0105	75.1	0.0102	15.8	0.0145	52.1
Sr/Ca	1.31	3.34	1.33	2.27	1.43	2.64
Ba/Ca	0.00412	28.9	0.00378	5.45	0.00379	7.44
Test weight (µg)	16.9					
Test length (µm)	336					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.68	1.37	1.73	2.12	1.64	1.97
Al/Ca	0.00602	36.0	0.0115	23.1	0.00386	60.9
Mn/Ca	0.00300	43.2	0.00142	108	0.00947	15.8
Zn/Ca	0.000608	74.3	0.00472	34.8	0.00854	15.6
Sr/Ca	1.23	1.54	1.37	2.09	1.30	2.08
Ba/Ca	0.00112	16.8	0.00128	7.09	0.00246	5.89
Test weight (µg)	18.4					
Test length (µm)	350					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.642	2.26	0.569	2.45	0.754	2.88
Al/Ca	0.0451	10.9	0.0153	17.9	0.00136	168
Mn/Ca	0.00300	38.3	0.00578	29.2	0.00540	26.9
Zn/Ca	0.00250	63.8	0.00412	133	0.00450	16.6
Sr/Ca	1.28	1.31	1.26	1.81	1.25	1.74
Ba/Ca	0.000923	8.90	0.000638	11.5	0.000500	11.5
Test weight (µg)	28.3					
Test length (µm)	358					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	0.659	1.73	0.715	2.62	0.658	3.35
Al/Ca	0.00187	98.3	-0.000396	664	0.00392	56.4
Mn/Ca	0.000228	524	-0.000323	504	0.000206	644
Zn/Ca	0.000721	55.9	0.00268	28.4	-0.177	1.27
Sr/Ca	1.26	1.29	1.25	2.01	1.24	1.15
Ba/Ca	0.000692	7.52	0.000662	11.0	0.000640	9.36
Test weight (µg)	30.3					
Test length (µm)	359					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.15	1.73	1.85	2.62	1.62	3.35
Al/Ca	0.0389	98.3	0.0275	664	0.00271	56.4
Mn/Ca	0.00964	524	0.00244	504	0.00614	644
Zn/Ca	0.0224	55.9	0.0101	28.4	0.007	1.27
Sr/Ca	1.20	1.29	1.15	2.01	1.24	1.15
Ba/Ca	0.00284	7.52	0.00128	11.0	0.00135	9.36
Test weight (µg)	17.8					
Test length (µm)	328					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.12	1.15	0.970	2.50	0.973	2.23
Al/Ca	0.0195	6.55	0.0138	10.7	0.00601	73.9
Mn/Ca	0.0112	12.0	0.000537	62.2	-0.00162	20.1
Zn/Ca	0.00670	5.20	0.00396	10.3	0.00251	11.4
Sr/Ca	1.23	1.02	1.20	2.36	1.32	2.06
Ba/Ca	0.00410	4.16	0.00100	8.08	0.00132	7.51
Test weight (µg)	23.2					
Test length (µm)	364					
Number of chambers	4.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.57	1.87	2.18	1.96	1.95	2.09
Al/Ca	0.0220	11.2	0.0656	7.67	0.0257	12.7
Mn/Ca	0.0183	7.41	0.0212	10.9	0.0205	8.21
Zn/Ca	0.0144	8.57	0.0283	9.23	0.0327	6.09
Sr/Ca	1.25	1.26	1.37	2.77	1.28	2.23
Ba/Ca	0.00416	3.52	0.00365	7.27	0.00345	5.28
Test weight (µg)	22					
Test length (µm)	n/a					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.759	2.51	0.528	2.01	0.553	2.10
Al/Ca	-0.000436	540	0.00399	60.3	0.000915	269
Mn/Ca	-0.00303	43.2	-0.000184	687	0.000721	183
Zn/Ca	0.00251	22.7	0.00482	16.2	0.00199	29.9
Sr/Ca	1.21	1.75	1.27	1.74	1.22	1.31
Ba/Ca	0.000671	9.39	0.000763	9.06	0.000502	10.6
Test weight (µg)	27.8					
Test length (µm)	347					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.24	1.70	1.20	1.59	1.51	1.67
Al/Ca	0.00571	33.4	0.0328	9.84	0.0135	21.9
Mn/Ca	0.00508	25.4	0.00608	23.9	0.0119	11.3
Zn/Ca	0.00152	28.1	0.00430	17.1	0.0329	5.47
Sr/Ca	1.31	1.32	1.20	1.16	1.22	1.54
Ba/Ca	0.00275	4.10	0.000763	6.03	0.00282	4.17
Test weight (µg)	27.8					
Test length (µm)	347					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.04	2.40	2.04	1.67	2.35	2.14
Al/Ca	0.0448	10.9	0.0560	6.82	0.0197	37.8
Mn/Ca	0.0211	7.49	0.0263	5.89	0.0447	7.46
Zn/Ca	0.0329	18.5	0.0367	5.19	0.0646	6.27
Sr/Ca	1.41	2.19	1.36	1.30	1.43	3.33
Ba/Ca	0.00298	6.63	0.00361	4.12	0.00422	15.1
Test weight (μm)	11.7					
Test length (μm)	n/a					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.06	1.66	0.993	1.74	1.97	2.05
Al/Ca	0.0149	16.8	0.0210	12.6	0.00170	123
Mn/Ca	0.00300	44.4	0.00360	38.1	0.00703	17.2
Zn/Ca	0.00815	9.13	0.00551	13.5	0.00733	11.0
Sr/Ca	1.27	1.86	1.24	1.78	1.20	1.36
Ba/Ca	0.00303	4.58	0.00225	5.49	0.00196	6.19
Test weight (µg)	33.4					
Test length (µm)	366					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	0.700	1.79	0.992	2.11	0.715	4.23
Al/Ca	0.0374	12.0	0.0512	11.5	0.0370	72.1
Mn/Ca	0.00605	27.1	0.0106	15.4	0.00259	151
Zn/Ca	0.00956	9.18	0.00722	13.6	0.0259	13.8
Sr/Ca	1.35	1.33	1.50	1.48	1.67	3.70
Ba/Ca	0.00268	28.2	0.00307	5.16	0.00199	17.3
Test weight (μm)	17.8					
Test length (μm)	350					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.67	1.77	1.26	1.86	1.54	2.26
Al/Ca	0.0537	7.88	0.0210	15.8	0.0168	26.0
Mn/Ca	0.0349	6.91	0.0312	5.40	0.03752	6.11
Zn/Ca	0.0990	3.05	0.107	3.32	0.134	3.33
Sr/Ca	1.55	1.58	1.57	1.43	1.54	2.15
Ba/Ca	0.00398	3.61	0.00353	4.48	0.00322	5.97
Test weight (µg)	13.2					
Test length (µm)	332					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.752	1.40	0.619	1.84	0.852	1.79
Al/Ca	0.0129	24.3	0.00586	64.9	0.00230	152
Mn/Ca	0.000889	162	0.00150	115	0.00176	86.2
Zn/Ca	0.00619	10.3	0.000835	58.5	0.0104	9.06
Sr/Ca	1.59	1.01	1.54	1.18	1.47	1.16
Ba/Ca	0.000871	7.09	0.000793	9.18	0.000756	8.81
Test weight (µg)	46.5					
Test length (µm)	385					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.954	2.35	0.981	1.72	1.25	1.65
Al/Ca	0.0364	15.7	0.00661	53.3	0.00247	172
Mn/Ca	0.00410	56.1	0.00550	29.2	0.0133	12.8
Zn/Ca	0.00955	38.6	0.00166	32.7	0.0115	9.30
Sr/Ca	1.23	2.08	1.37	1.60	1.42	1.27
Ba/Ca	0.000856	17.2	0.00124	8.33	0.00387	8.93
Test weight (µg)	64.7					
Test length (µm)	442					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.00	1.75	2.63	1.73	1.98	1.32
Al/Ca	0.0282	12.8	0.0757	5.98	0.00167	206
Mn/Ca	0.0138	8.84	0.00960	13.0	0.0214	5.52
Zn/Ca	0.0320	5.39	0.0120	11.9	0.0125	10.7
Sr/Ca	1.33	1.37	1.34	1.14	1.30	1.27
Ba/Ca	0.00439	3.55	0.00559	5.37	0.00359	3.81
Test weight (µg)	16.1					
Test length (µm)	365					
Number of chambers	3.5					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	*f	% 2se
Mg/Ca	1.68	1.20	1.14	1.45	1.23	2.11
Al/Ca	0.0110	38.5	0.0268	16.4	0.0301	21.4
Mn/Ca	0.0173	8.56	0.00725	18.5	0.0197	10.8
Zn/Ca	0.0207	8.11	0.0126	11.9	0.0126	17.7
Sr/Ca	1.37	1.09	1.29	1.34	1.35	1.81
Ba/Ca	0.00318	4.30	0.00237	5.24	0.00207	8.05
Test weight (µg)	14.6					
Test length (µm)	370					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	1.71	2.02	1.90	1.42	1.56	1.59
Al/Ca	0.0157	25.1	0.0148	26.7	0.0152	24.8
Mn/Ca	0.0300	4.88	0.0270	5.41	0.0283	4.96
Zn/Ca	0.0413	5.45	0.0403	5.27	0.0452	4.86
Sr/Ca	1.38	1.22	1.33	1.52	1.36	1.52
Ba/Ca	0.00478	3.77	0.00619	5.27	0.00437	4.25
Test weight (µg)	13.5					
Test length (µm)	353					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.35	1.89	2.12	1.60	2.03	1.72
Al/Ca	0.0390	13.1	0.0427	10.3	0.0479	9.78
Mn/Ca	0.0409	5.14	0.0329	4.90	0.0439	4.42
Zn/Ca	0.0148	14.8	0.0143	13.0	0.0233	8.29
Sr/Ca	1.49	2.14	1.47	1.51	1.48	1.49
Ba/Ca	0.00371	5.47	0.00651	4.81	0.00381	7.65
Test weight (µg)	8.8					
Test length (µm)	476					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	2.25	1.40	1.57	1.49	1.22	1.72
Al/Ca	0.00693	50.9	-0.00297	141	-0.00470	85.7
Mn/Ca	0.00925	12.9	0.0000151	9230	0.00145	91.8
Zn/Ca	0.0960	4.08	0.00438	33.9	0.0147	11.4
Sr/Ca	1.28	1.22	1.40	1.38	1.30	0.991
Ba/Ca	0.00654	3.92	0.000909	8.87	0.00110	7.53
Test weight (µg)	46.5					
Test length (µm)	453					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.673	1.29	0.568	1.54	0.782	1.89
Al/Ca	0.00524	66.5	-0.00736	56.3	0.00471	80.7
Mn/Ca	0.000696	165	0.00174	79.0	0.000982	123
Zn/Ca	0.0258	6.39	0.0123	14.0	0.0107	14.3
Sr/Ca	1.45	0.941	1.46	1.11	1.38	1.20
Ba/Ca	0.00129	5.88	0.000806	9.39	0.000825	8.73
Test weight (µg)	34.9					
Test length (µm)	384					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	*f-2	% 2se	*f-1	% 2se	*f	% 2se
Mg/Ca	2.40	1.58	2.48	2.29	2.48	1.45
Al/Ca	0.0147	25.8	0.00716	55.2	0.00495	79.2
Mn/Ca	0.0315	4.25	0.0282	5.70	0.0287	4.76
Zn/Ca	0.0274	6.50	0.0384	5.80	0.0676	4.34
Sr/Ca	1.50	1.14	1.49	1.16	1.49	1.38
Ba/Ca	0.0265	2.72	0.0210	4.08	0.0170	4.85
Test weight (µg)	11.3					
Test length (µm)	332					
Number of chambers	3.8					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	0.803	1.38	0.614	1.88	1.40	1.95
Al/Ca	0.00878	41.7	0.00955	43.2	-0.000784	488
Mn/Ca	0.00622	19.6	0.00389	33.9	0.00894	13.9
Zn/Ca	0.00407	31.2	0.00139	101	0.00209	61.0
Sr/Ca	1.46	1.18	1.55	1.43	1.47	1.27
Ba/Ca	0.00119	6.02	0.00134	6.64	0.00409	4.54
Test weight (µg)	37.8					
Test length (µm)	376					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean

X/Ca (mmol/mol)	f-2	% 2se	f-1	% 2se	f	% 2se
Mg/Ca	1.92	1.15	1.87	1.50	2.27	1.58
Al/Ca	0.00318	123	-0.00278	153	-0.000269	1380
Mn/Ca	0.0000220	5560	0.00325	39.7	0.00317	37.1
Zn/Ca	0.000619	215	0.00581	25.2	0.00622	21.3
Sr/Ca	1.19	1.00	1.21	1.57	1.25	1.25
Ba/Ca	0.000789	7.77	0.000734	9.18	0.00124	6.76
Test weight (µg)	23.1					
Test length (µm)	333					
Number of chambers	3.0					

* chamber excluded from chamber and sample mean