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Speleothem Strontium Concentrations in Eogenetic Carbonates

Nicole Marie Ridlen

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By

Nicole Ridlen

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By

Nicole Ridlen

Approved:

John E. Mylroie
(Director of Thesis)

Rinat I. Gabitov
(Committee Member)

Brenda L. Kirkland
(Committee Member)

Micheal E. Brown
(Graduate Coordinator)

R. Gregory Dunaway
Professor and Dean
College of Arts & Sciences

Name: Nicole Ridlen

Date of Degree: May 17, 2014

Institution: Mississippi State University

Major Field: Geology

Major Professor: Dr.John E. Mylroie

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Candidate for Degree of Master of Science

Three questions were asked during this research. 1) Does the Sr content of Caribbean speleothems have a direct relationship with the age of the host rock at the time of speleothem precipitation?; 2) do older speleothems contain less Sr than younger speleothems in the same climatic setting?; and 3) will speleothems record the change in Sr concentration of eogenetic carbonates as a faster depletion in climates of higher precipitation as opposed to drier climates?

The speleothems and cave rocks in this study were analyzed with various methods in an attempt to understand the rock processes that affect speleothem Sr concentrations. Evidence to support the hypothesis that younger host rock contributes higher concentrations of Sr to speleothems was found in the stalagmites of Curacao while Bahamian stalagmites indicated climatic variations. The results have implications for using stalagmites from relatively young, eogenetic limestone as a proxy for Sr-related paleoclimate data.

DEDICATION

"Once you make a decision, the universe conspires to make it happen" –Ralph Waldo Emerson

This thesis is dedicated to the friends, family and colleagues who have supported my wild and crazy life, the cavers of Chouteau and Kansas City Area grottoes who helped me find my passion in the underground, and my two Siberian huskies that make sure I do not completely lose my sanity. A full list of everyone who contributed to my thesis is in the acknowledgements. Without all of these influences on my life I would likely be living in a cave instead of studying them.

ACKNOWLEDGEMENTS

When I made the decision to seek a graduate degree in geology I came in knowing exactly what I wanted to do. I wanted to do research related to speleothems. As soon as I made that decision it was as if the entire universe was ready to make it happen. When it comes to this study it is no exception. This research was done with the generous support and assistance of many different people. I could not have done it without the universe of people who were there ready to guide me down this path. While it is impossible to name everyone who made this research possible I would like to take the time to acknowledge many who I am indebted to for the lend of their voluminous skills, knowledge, and connections.

None of this research would have been possible without the inspiring guidance of Dr. John Mylroie, my advisor. Not only did he take me under his wing as a graduate student knowing I wanted to study what he likes to call “cave cancer” but he helped me find a research project that not only catered to my love of speleothems but also my thirst for doing something out of the ordinary. I could not imagine having a more attentive advisor than Dr. Mylroie and I am certain my colleagues agree. Few advising professors take the time and dedication to their student’s educational quest than him and without his assurance and inspiring enthusiasm none of this would have been possible. The world of academia will lose a great mentor when he retires in this next year.

My committee has been instrumental in the research process of my thesis. Dr. Jason Polk welcomed me into his lab and enlightened me about the world of speleothem research even though I was working at a different university. He is an incredibly busy man with many projects but still made time for me. I am almost certain he is not human as he sends emails at all hours of the day, indicating he does not need sleep to sustain himself. The guidance of Dr. Polk not only allowed me to head down the right path but gained me access to the wonderful lab at Western Kentucky University. I am indebted to Dr. Polk and I hope that collaborations in the future will allow me to repay his generous assistance.

Dr. Rinat Gabitov provided invaluable data for my Curaçao rock specimens by laser ablation at Rensselaer Polytechnic Institute. He took time during his visit to run my samples at the lab in New York and assisted me in interpreting and understanding this data. Sincere thanks are also given to graduate assistant Micheal Ackerson and Professor Bruce Watson for their assistance at RPI while Dr. Gabitov ran my samples.

The interpretation of my rock thin sections would have been impossible without the assistance of Dr. Brenda Kirkland and her wealth of carbonate knowledge. She took time during her sabbatical to provide me with the information necessary to identify the allochems and various properties of the rocks in thin section. The enthusiasm Dr. Kirkland displays for carbonate petrography is inspiring and will aid me in my research for years to come.

Much gratitude is extended to the staff at Mississippi State University's I^2AT center for assisting me with the x-ray diffractor machine. I-Wei was especially informative and walked me through every step as I learned to operate the new equipment.

Their expertise and technology allowed me to interpret the mineralogy of my rock specimens.

The Advanced Materials Institute lab at Western Kentucky University was instrumental in obtaining the trace element analysis of my samples. The lab manager, Pauline Norris and her lab assistant Stephanie spent hours showing me how to process the samples and run the ICP-OES. I learned a lot about the equipment through their knowledge and experience.

My multiple stays in Kentucky to work at Western Kentucky University would have been difficult without the generosity of soon-to-be Dr. Patricia Kambesis. She allowed me to stay at her place in Cave City and taught me how to properly map caves. Her expertise and dedication to the karst community is invaluable and I am proud to say I was able to work with her.

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None of this research would have been possible without the generous funding received from the William L. Wilson scholarship awarded by the Karst Waters Institute, the grant received from the Cave Research Foundation, the Erwin Russell fund, and ExxonMobil. If it were not for organizations like these we would not see the advancement in the studies of karst that have been made all these years. It is important to understand the interconnectivity of the world around us and it is wonderful that organizations exist that understand how integral the study of the world underground is to the world we know on the surface.

A big thank you goes to Joan Mylroie, aka "Momma Joan," for teaching me about the world of snorkeling and the finer things in life. We can study fossils all day but until you see a live reef in action it is impossible to appreciate the grand scheme of carbonate deposition. Thanks to my colleagues who helped me with collection in the field, most notably Ryan Travis and Erik Larson for hammering away with at rocks and lugging around the heavy specimens with me from airport to airport. Special thanks to Dr. Jon Sumrall for showing me the best method to cut thin section blanks.

There are many more people I would like to thank; Dr. Sally Zellers, Dr. John Nold, and Dr. Gary Krizanich of my undergraduate university for helping me succeed; Melissa Wergeles and Tanya Nevils for being the best friends I could ever have and always understanding and supporting the strange person I am; Claire Babineaux, Kayla Calhoun, Haley Bustin and all of my new friends in Starkville for getting me out of my little box every now and then; And my family back home for supporting me even though they have no idea what I am doing.

I am sure I missed some great people here and if I did just know I am grateful to each and every one of you. Every person that has touched my life has helped make this possible. This was not a feat I could have accomplished alone and it took every one of you in my universe to “conspire” to make it all happen.

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CHAPTER I

INTRODUCTION

The presence of strontium (Sr) in carbonate rocks has been long documented (Kulp et al., 1962) and recognized as a contributor to the trace element content of speleothems used for paleoclimate reconstruction (Goede et al., 1998). Sr in speleothems can originate from multiple sources although for the majority of current research the Sr is assumed to be infiltrated from a surface source (Sinclair et al., 2012; Van Beynen et al., 2008; White, 2004; Finch et al.,2003; Roberts, et al., 1998). In younger, eogenetic (diagenetically immature) carbonates the mineralogy is aragonite and the aragonite crystal structure accommodates Sr in replacement of Ca (White 2004; Hill and Forti, 1997). Over time aragonitic carbonate rocks will invert to the more stable polymorph mineral, calcite (Hill and Forti, 1997). This inversion releases Sr to the vadose zone, as the Sr cannot be accommodated in the calcite crystal lattice.

Carbonate host rocks that are predominantly comprised of aragonite will naturally have a greater Sr content than those rocks that are calcite. The older eogenetic rock units of the Caribbean typically have a higher calcite to aragonite ratio than those that are younger (Ruiz-Hernandez et al., 2010). It can then be hypothesized that younger carbonates in the Caribbean should have a greater amount of Sr contribution from the host rock into those speleothems than speleothems that form in older carbonates that are inverted to calcite.

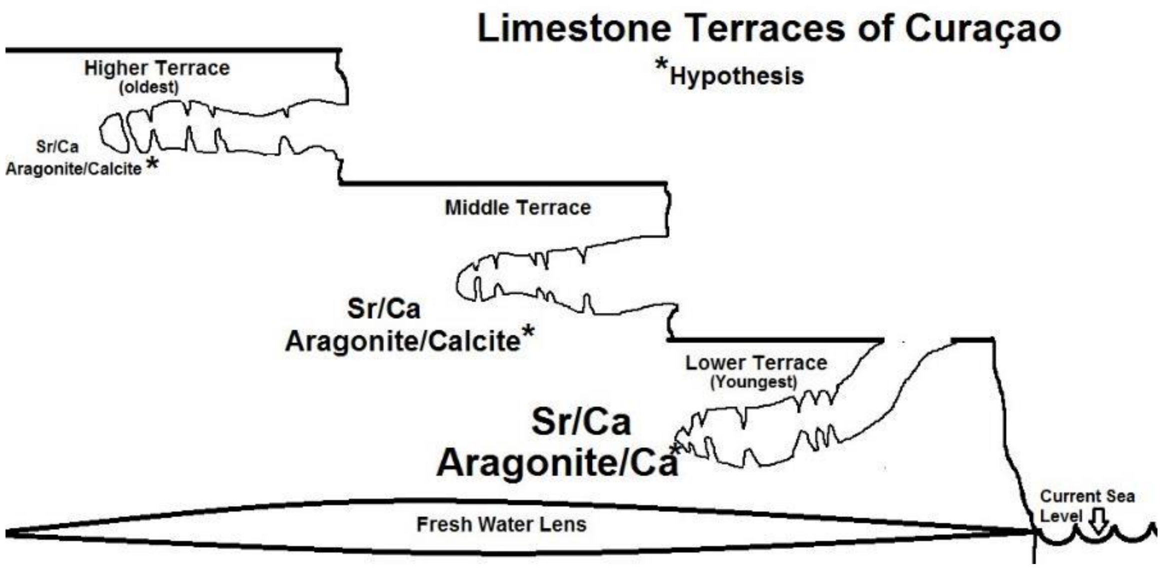

Figure 1.1 Hypothesis for Curaçao

The hypothesis of the Sr/Ca and Aragonite/Calcite ratios for the host rocks of caves in Curaçao. The larger font indicates a higher number.

Uplifted island carbonates, such as the carbonate units in the study area of Curaç ao, Netherlands Antilles (Figures 1.1 and 1.2), are often terraced where the oldest unit is on top and the youngest on the bottom (Schellmann et al., 2004). These units are composed of coral carbonates that were originally composed of aragonite (Schellmannet al., 2004). The inversion of aragonite to calcite is not only time dependent, it is also dependent on the flux of meteoric water through the limestone. Abaco Island, Bahamas, is the wettest island in the Bahamian archipelago (Figure 1.2); Long Island and San Salvador, Bahamas are some of the driest islands in the archipelago (Sealey, 1990). However, the islands have carbonates of the same approximate age, so any difference in aragonite inversion degree should be a climatic signal as opposed to an age signal as found in Curaçao (Figure 1.3).

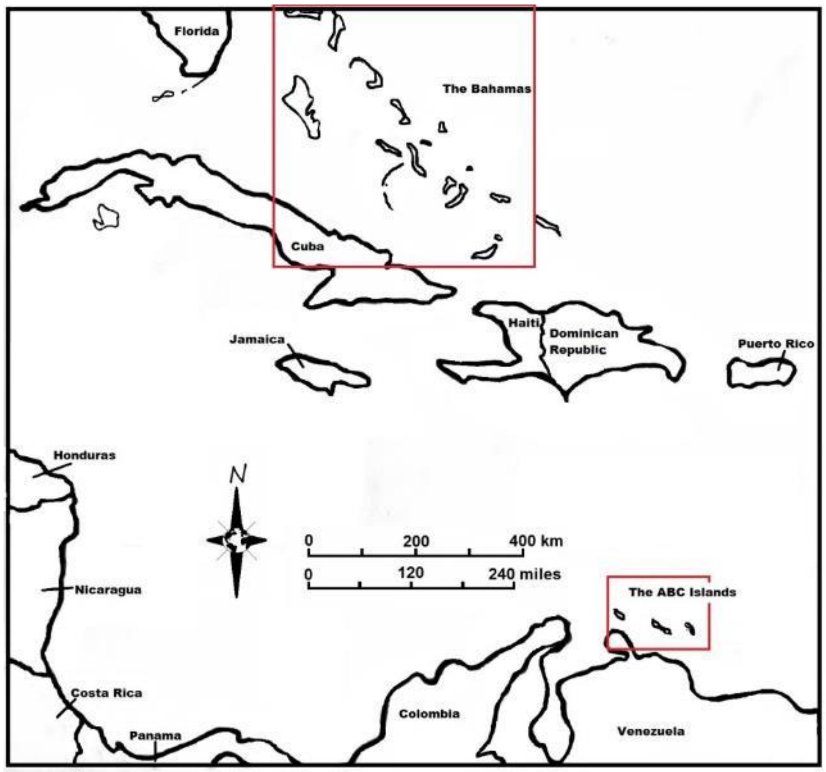

Figure 1.2 Map of Study Areas

Study areas include Curaçao near Venezuela, part of the ABC islands, and three islands in the Bahamian archipelago (Abaco, Long Island, and San Salvador).

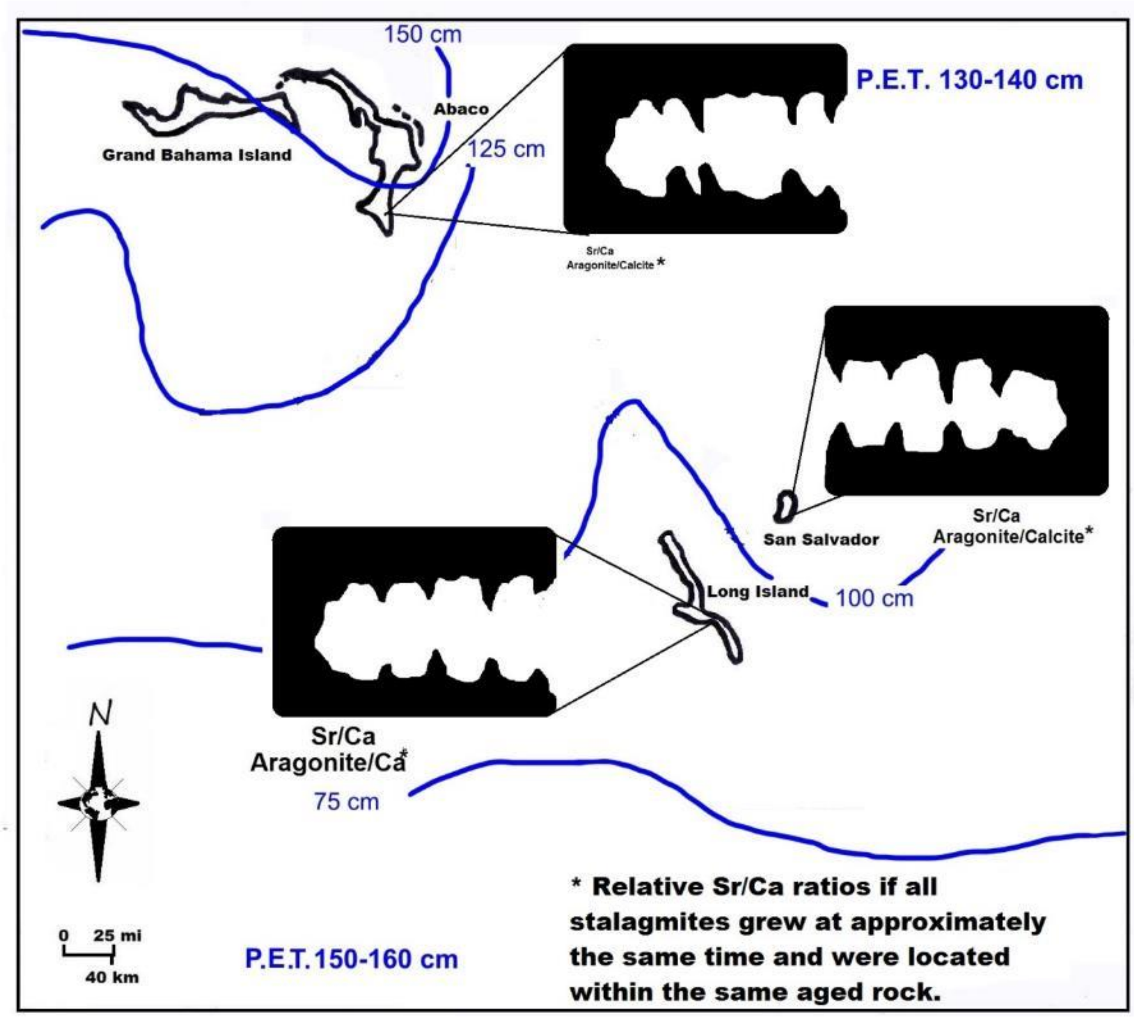

Figure 1.3 Hypothesis for Bahamas

The hypothesis for Sr concentrations in the stalagmites collected from the Bahamas. Larger font indicates higher relative values.

Speleothem research has become an integral part of paleoclimate data because these cave deposits preserve the conditions that were present at time of speleothem deposition. As cited earlier, most of this research focused on reconstructing the surface conditions at the time of deposition such as temperature, rainfall, and vegetation. However, the state of the host rock itself can also be preserved in the speleothem record.

This research sought to answer three questions. 1) Does the Sr content of Caribbean speleothems have a direct relationship with the age of the host rock at the time of speleothem precipitation?; 2) do older speleothems contain less Sr than younger speleothems in the same climatic setting?; and 3) will speleothems record the change in Sr concentration of eogenetic carbonates as a faster depletion in climates of higher precipitation as opposed to drier climates?

This research will contribute to the many past and future studies of speleothems. Work on speleothems has been predominantly in those located in much older geologic settings where the limestones are all calcite and Sr is more likely to be an infiltrate from an external source. The work on speleothems in younger, Sr-enriched host rocks will need to consider the possibly significant amount of host rock sourced Sr within the speleothem record. This could affect the interpretations of paleoclimatic data from the use of speleothems in young carbonates. By determining the correlation of host rock age with strontium concentration in the speleothem in contrast with the variation of strontium in differing climatic settings, earlier paleoclimatic studies may be able to calibrate their interpretations. Recently, research has shifted to oceanic islands to obtain speleothem climate records not available on continents. The rocks hosting the speleothem-containing caves are commonly young and aragonitic in these settings, so the research for this thesis is timely and important.

CHAPTER II

LITERATURE REVIEW

Carbonate Minerals

Three groups of carbonate minerals are identified and known to be present on the islands within this study. They are the calcite group ($CaCO_3$), the aragonite group ($CaCO_3$) and the dolomite group ($MgCa[CO_3]_2$), all of which contain CO_3 anions which are strongly bonded. When these minerals come into contact with hydrogen ions (acidity) they break down into cations Ca^{2+} and Mg^{2+}, CO_2 and H_2O. This is what causes the dissolution of carbonates and the genesis of a cave.

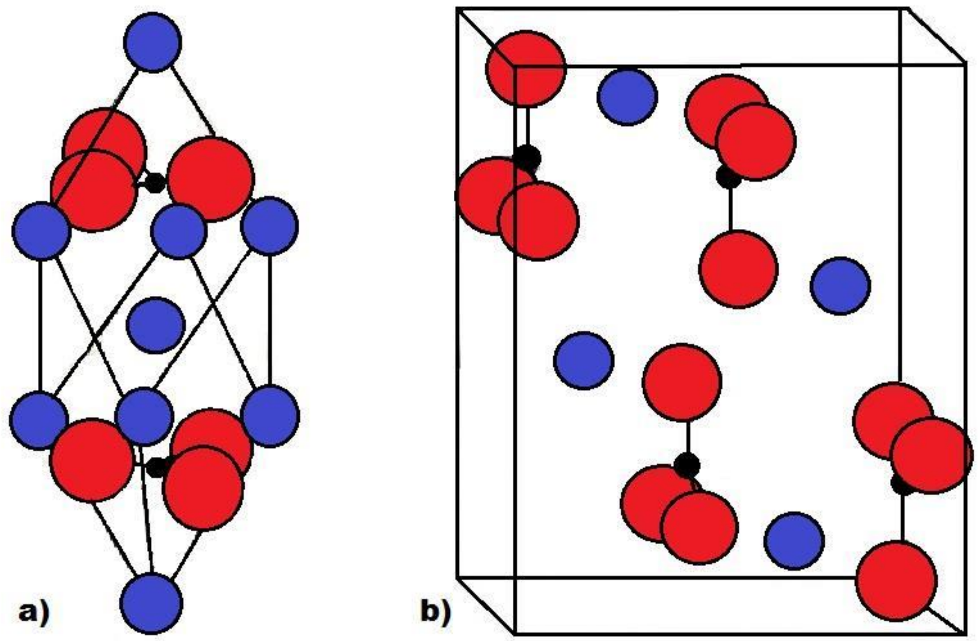

Figure 2.1 Calcite and Aragonite Crystal Structure

a) Calcite crystal Structure and b) Aragonite crystal structure. Blue spheres represent calcium, red spheres oxygen, and black spheres carbon.

The calcite group consists of five different minerals, all hexagonal in chemical structure, the most common of which is calcite ($CaCO_3$). Calcite has a 6-coordination of Ca to O and shows perfect $\{10\bar{1}1\}$, or rhombohedral, cleavage (Figure 2.1). It is the most stable form of calcium carbonate at surface temperatures (Figure 2.2).

The aragonite group consists of four different minerals that are orthorhombic in chemical structure with the most common mineral being a polymorph of calcite and that of the group's namesake. The larger cations in most of the minerals in this group do not permit a stable 6-coordination structure, so aragonite ($CaCO_3$) and the other group members have a 9-coordination of Ca to O. They show distinguishable cleavage on {010} and poor cleavage on {110}(Figure 2.1). Larger accommodation space in aragonite allows for trace elements like Sr to be substituted for Ca present in the structure, whereas calcite does not have adequate space (Figure 2.1). It is important to differentiate strontianite ($SrCO_3$) from aragonite with Sr ions within the structure, although some research has indicated that up to 40% of the Sr in coral skeletons can originate from strontianite (Greegor et al., 1997).

The dolomite group, which is not the focus for this study, consists of two minerals including the most commonly found of this pair, dolomite. Dolomite, like calcite, is hexagonal in structure but alternates Ca with Mg. It also presents $\{10\bar{1}1\}$ perfect cleavage, but the difference in size of the Mg and Ca in the alternating layers leads to curved rhombohedral crystals.

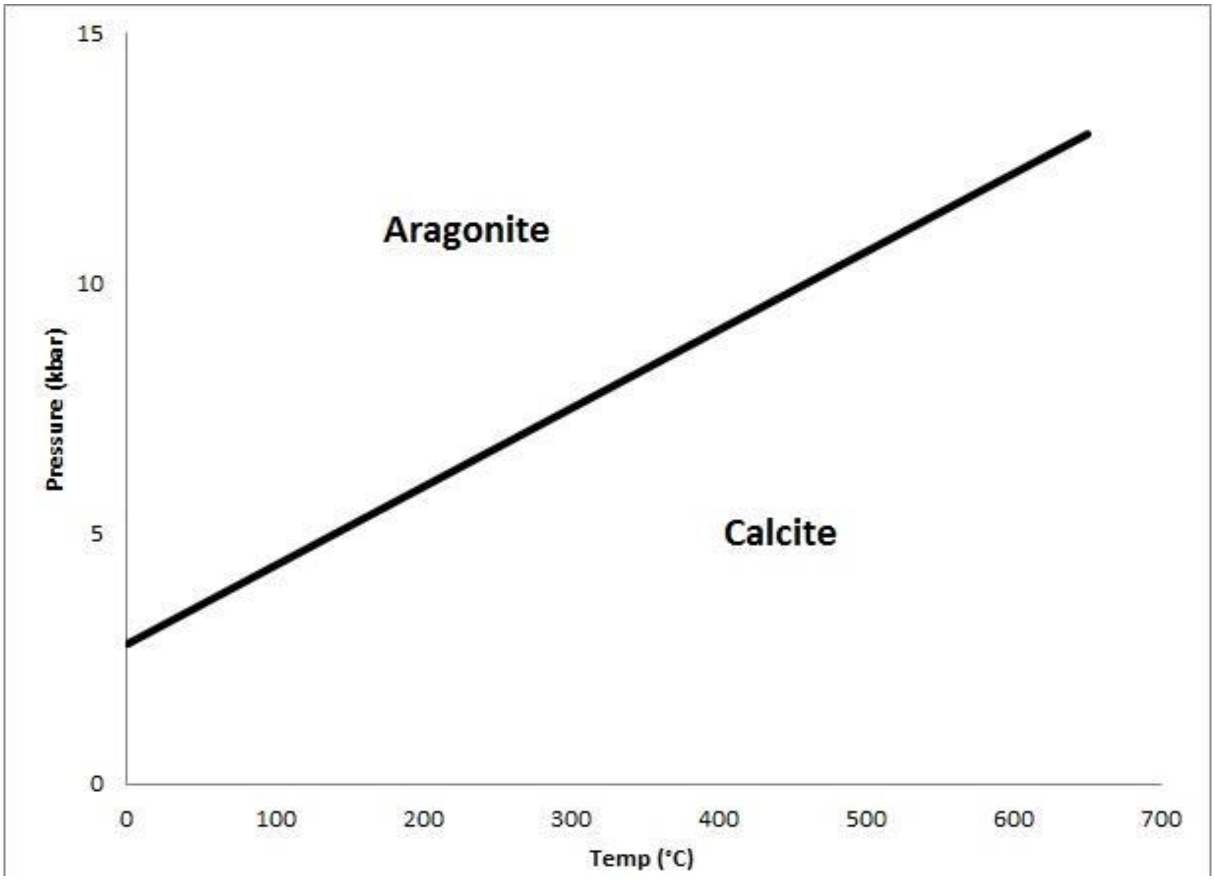

Figure 2.2 The Aragonite-Calcite Stability Chart

Modified from Dana's Manual of Mineralogy 21st edition. Klein & Hurlbut (1994).

Carbonate Rock

On Curaçao, Abaco, Long Island, San Salvador, and other islands in the Caribbean or Bahamas, there are three common carbonate rock types, including calcite, aragonite and dolomite. The depositional mineralogy of Quaternary limestones in the Caribbean is originally aragonite. It is deposited by corals, molluscs, green algae and various other carbonate-producing, warm-sea faring fauna. Some animals do produce high-Mg calcite structures (e.g. echinoderms and red algae), but this study area's geology is primarily sourced by aragonite-excreting organisms. While many minerals in the aragonite group are more stable as a 9-coordination mineral, aragonite itself is not stable at surface temperatures and pressures (Figure 2.2). Over time, and with fluid flux, rock that was originally deposited as aragonite will invert to calcite.

There have been many studies concerning the aragonite to calcite inversion (e.g. Dodd, 1966; Johannes and Puhan, 1971; Budd, 1988; Perdikouri et al., 2011). Given the same amount of time, the inversion of aragonite to calcite is a result of precipitation and infiltration so the rate at which it changes is a function of climate and hydrology (Budd, 1988). It is suggested for this transition to take longer in mixing zones than within the fresh water lens (Budd, 1988). It has also been proposed that Mg concentration has a relationship with the inversion of aragonite to calcite (Figure 2.3). During fluid flux and the inversion of aragonite to calcite the Sr is lost because calcite does not have a large enough accommodation space in the 6-coordination structure.

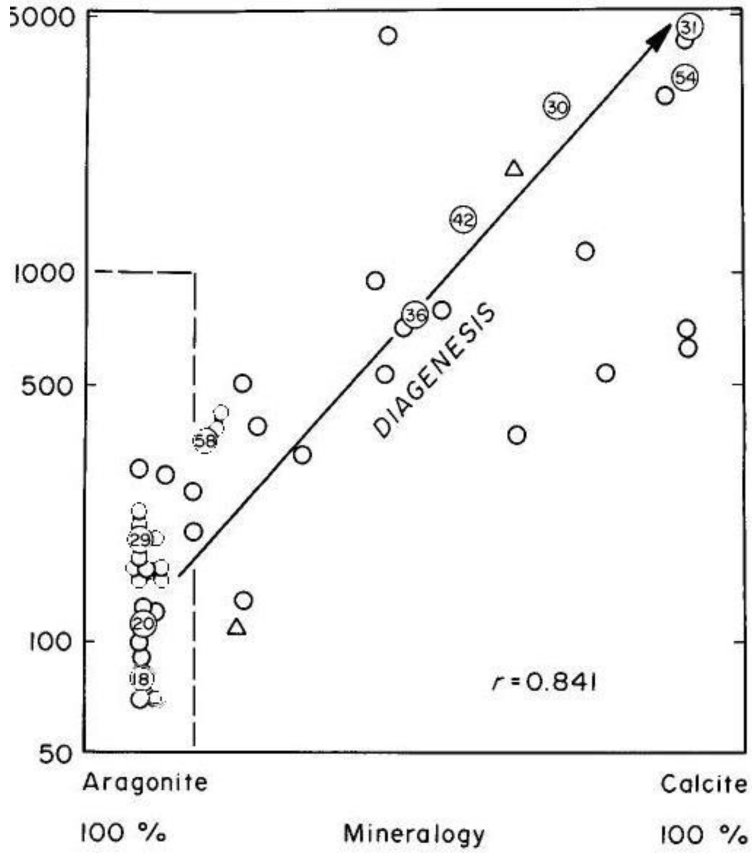

Figure 2.3 Carbonate Mineralogy in relation to Mg

The change in mineralogy in contrast to the Mg concentration (log scale) on vertical axis. From Brand, 1989.

Carbonate rock that is still in the depositional setting and has not undergone burial and uplift is called eogenetic (Choquette and Pray, 1970). Carbonates that have undergone burial and uplift are called telegenetic rocks. As a result of the pressure and processes that take place during burial, telegenetic rocks have a much lower primary porosity than eogenetic rocks. A typical eogenetic carbonate in the tropics has a very high primary porosity (Figure 2.4). Telogenetic rocks are almost always completely inverted to calcite.

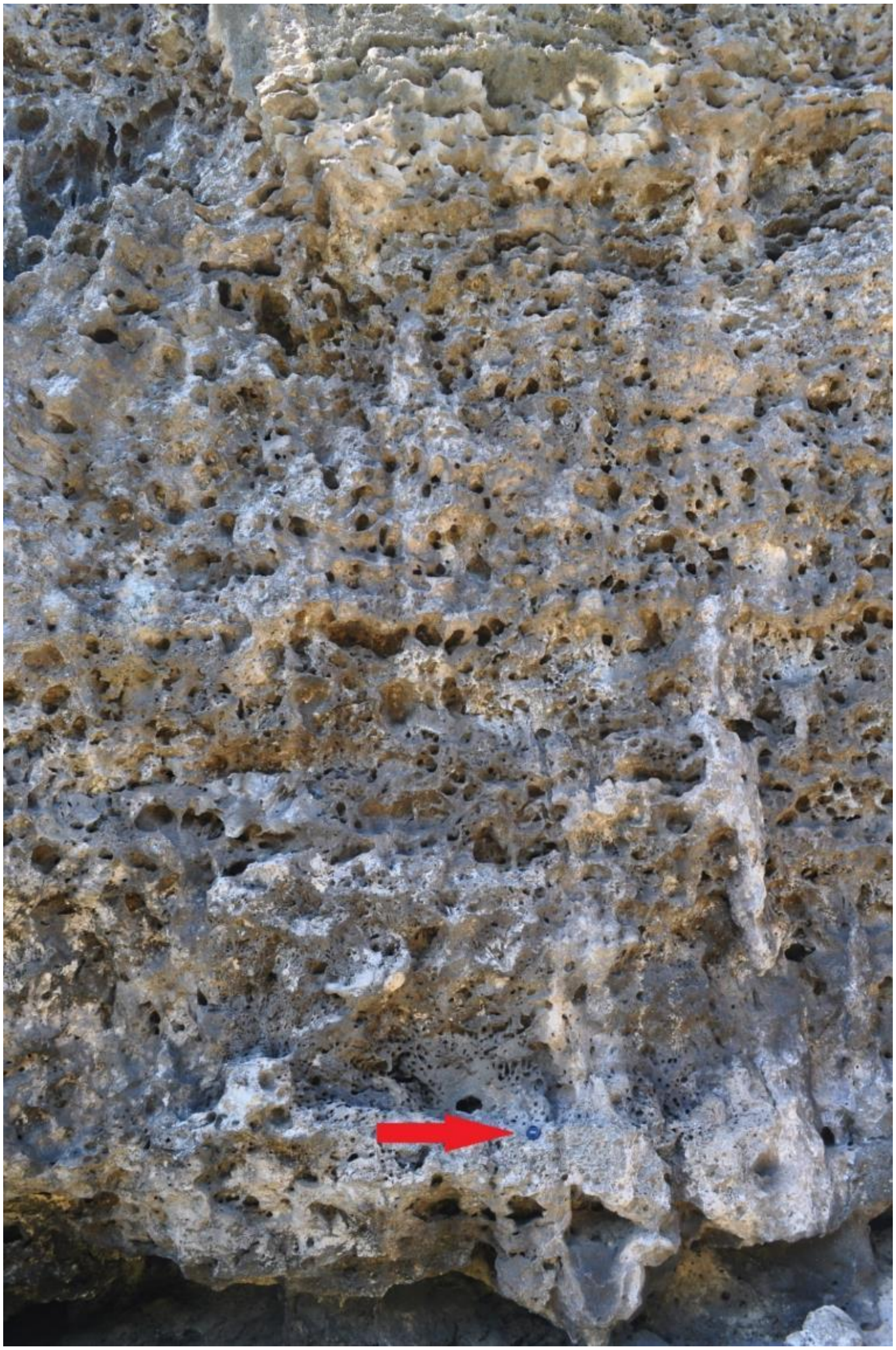

Figure 2.4 Eogenetic carbonate porosity

Typical porosity of eogenetic carbonates, in this case on Aruba. The red arrow points to a 52 mm lens cap for scale.

Cave Formation

When carbonate rock is exposed to water in the presence of hydrogen ions (i.e. acidity) dissolution can occur. This acidity can come from meteoric water, groundwater, or, in the case of flank margin caves, in the mixing zone between the fresh-water lens and saline water. The porosity of eogenetic carbonates is very high and as these pores are widened through dissolution they begin to intersect and cave formation begins. The Carbonate Island Karst Model (Jenson et al., 2006) illustrates the types of karst that form on carbonate islands (Figure 2.5).

The caves in the study areas for the proposed research are all flank margin caves. They are phreatic in origin, forming at the distal margin of the fresh water lens beneath the flank of the island (Mylroie and Carew, 1990). These caves form along sea level fairly rapidly due to the aggressive dissolution created by the mixing zone of fresh and salt water. The caves tend to be large, open rooms lacking the linear properties one would see in intracontinental stream caves.

These caves are later exposed as sea level drops or uplift occurs and the cave is breached by surface erosion. In the Bahamas, there is little to no tectonic activity and the major contribution to exposing these caves is glacioeustatic sea level decrease. On Curaçao tectonic uplift is the primary mechanism for cave exposure, but some exposure is still due to glacioeustatic sea level changes. The rates of uplift on the island of Curaçao are estimated to be between 0.066 and 0.060-meters per thousand years with the last interglacial sea level at 4-meters higher than at present (Schellmann, 2004).

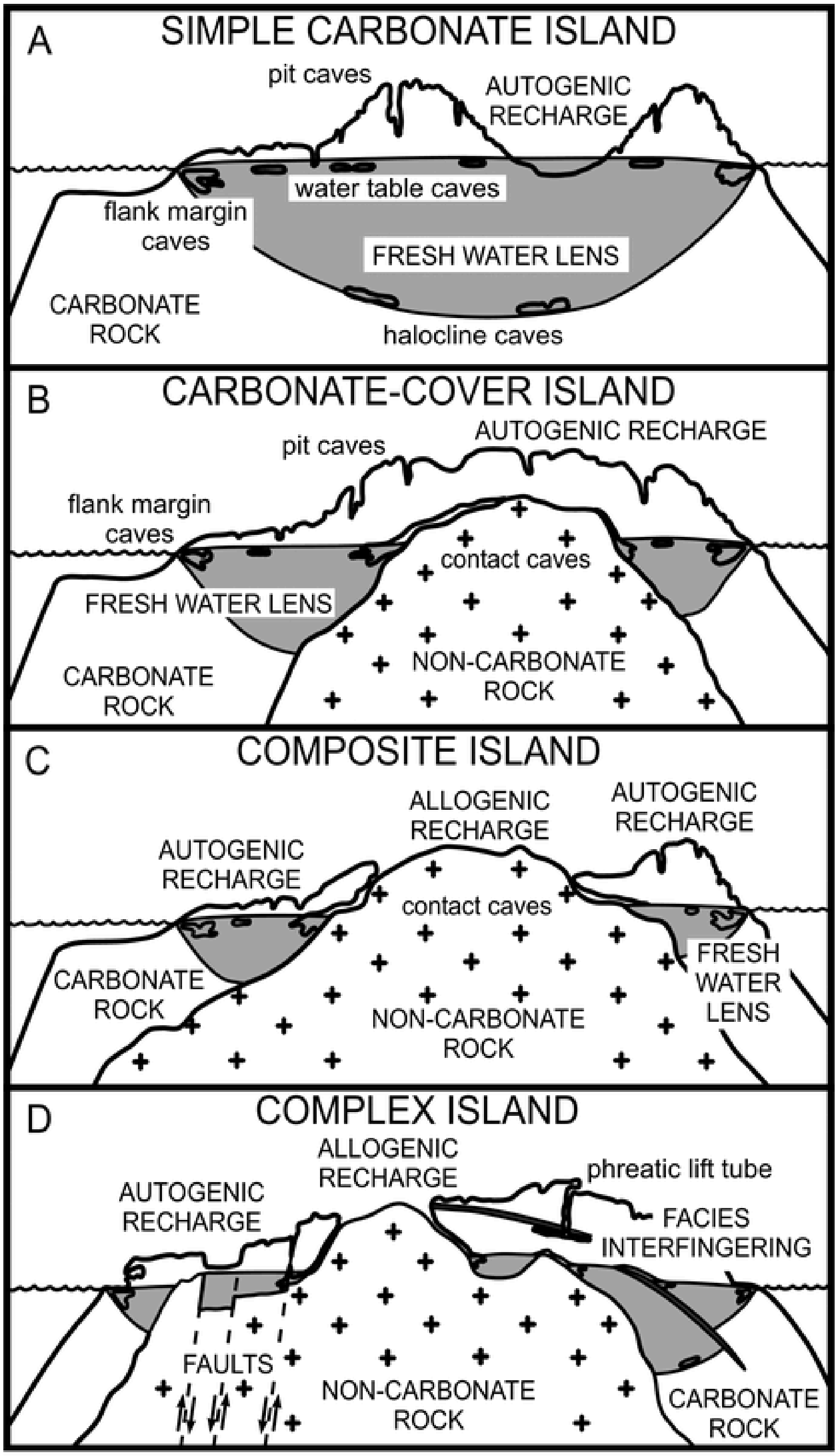

Figure 2.5 The Carbonate Island Karst Model

From Jenson et al., 2006.

Once the caves are exposed minor additional dissolution may occur due to vadose flow. The caves can be enlarged by both mechanical and chemical erosional forces. These processes are much slower than the mixing zone processes of the flank margin caves. Subaerial exposure allows for the precipitation of vadose speleothems, such as stalagmites, stalactites, and flowstone.

Speleothem Deposition

Once a cave is no longer subaqueous and is exposed or filled with air, secondary mineral deposits, called vadose speleothems, can begin to form. The term speleothem originates from the Greek words spelaion (cave) and thema (deposit) (Fairchild and Baker, 2012). Speleothems are composed of minerals precipitated from solution and deposited in the cave environment (Palmer, 2007). These cave minerals follow the definition of a typical mineral with the distinction that they form as a secondary mineral deposit within a cave (Self and Hill, 2003). They can form under both vadose (e.g. stalactites) and phreatic (e.g. dogtooth spar) conditions, so proper identification is important.

Out of the more than 250 known cave minerals, the three most common are calcite, aragonite, and gypsum (Hill and Forti, 1997). Calcite and aragonite comprise more than 95% of all known cave speleothem deposits (Hill and Forti, 1997). The speleothems are created as the minerals begin to aggregate into larger bodies and can be various in form. The study of ontogeny examines individual crystals and how they aggregate (Self and Hill, 2003).

The chemical process of speleothem formation includes dissolution and precipitation of carbonate minerals. In short, infiltrated water with high partial pressure of carbon dioxide, resulting from biological activity in the soil above the carbonate rock unit, dissolves away some of the carbonate within the bedrock (Fairchild and Baker, 2012). When the solution reaches the relatively low partial pressure CO_2 environment of the cave, already saturated in calcium carbonate, the mineral is precipitated from solution as the CO_2 degasses (Fairchild and Baker, 2012). The growth rate can vary greatly and can be related to atmospheric and surface conditions at the time of precipitation. Annual bands indicating seasons are distinguishable in some speleothems (Palmer, 2007).

The process of speleothem deposition allows for trace elements and impurities to be contained within the crystal matrix of the speleothem. This makes speleothems excellent for analyzing the conditions not only of the environment above the cave (White, 2004) but also the contents of the host rock. The most useful speleothems for these studies are stalagmites and flowstone since they provide the most complete and uninterrupted record of carbonate precipitation with easily defined growth axes (White, 2004).

The precipitation of aragonite in cave environments was once poorly understood, but it is now suggested that aragonite primarily precipitates in these low-temperature environments because of the presence of impurities like Mg (Hill and Forti, 1997; Self and Hill, 2003), the change in pH, temperature, carbon dioxide concentration or pressure (Škapin and Sondi, 2010) or prior calcite precipitation (which raises the Mg/Ca ratio). Speleothems often contain a mix of both aragonite and calcite; pure aragonite speleothems are rare (Hill and Forti, 1997). Aragonite growth that is not biologic in origin is often precipitated in speleothems only because of the inhibition of calcite precipitation (Fairchild and Baker, 2012).

Speleothems from the Pliocene have been found to preserve aragonite, but carbonate speleothems older than this are typically already inverted to calcite (Fairchild and Baker, 2012). Some studies indicate that aragonite can go through the transformation to calcite in the laboratory simply by the mechanism of core drilling, which induces heating (Gill, Olson, and Hubbard, 1995). Significant amounts of dolomite can be attributed to the precipitation of aragonite in some speleothems since the elevated Mg/Ca ratio required to precipitate aragonite requires a large amount of Mg (Cabrol and Coudray, 1982). The aragonite so common in younger carbonate cave bedrock will convert to speleothem calcite if the Mg/Ca ratio is low and even dolomite host rock can be precipitated as calcite speleothems (Palmer, 2007).

Stalagmites are a variety of speleothem that grow from the ground up. This makes them excellent speleothem candidates for research due to the timeline that is produced, similar to the rings on a tree. (Figure 2.6) The stalagmite can contain useful information about the drip water and mineralogy of the host rock of the cave it was deposited in as well as clues about the surface environment.

Figure 2.6 A slabbed stalagmite

A picture of a cut stalagmite showing the depositional sequence, youngest at top and oldest at bottom.

Aragonite and Strontium

Among the many trace elements that can be incorporated in the calcium carbonate mineral structure, Sr^{2+} is one of the largest ions. Since aragonite has a 9-coordinated cation site, in comparison to the 6-coordinated cation site of calcite, it more easily contains the Sr^{2+} ion (White, 2004). As illustrated earlier in Figure 2.3, the higher Mg content indicates calcite, while lower Mg can indicate aragonite. A correlation between Sr/Ca and Mg has also been observed (Figure 2.7). The coral carbonates of the Caribbean are originally deposited as aragonite and Sr is always present (Ruiz-Hernandez et al., 2010). Aragonite can incorporate the Sr^{2+} ion both during original host rock deposition and during secondary precipitation of speleothems (Finch et al., 2001; Allison et al., 2005). This means the Sr content in speleothems originating from an aragonitic host rock could have originated from an environmental condition at the time of speleothem precipitation or the environmental condition at the time of the host rock deposition.

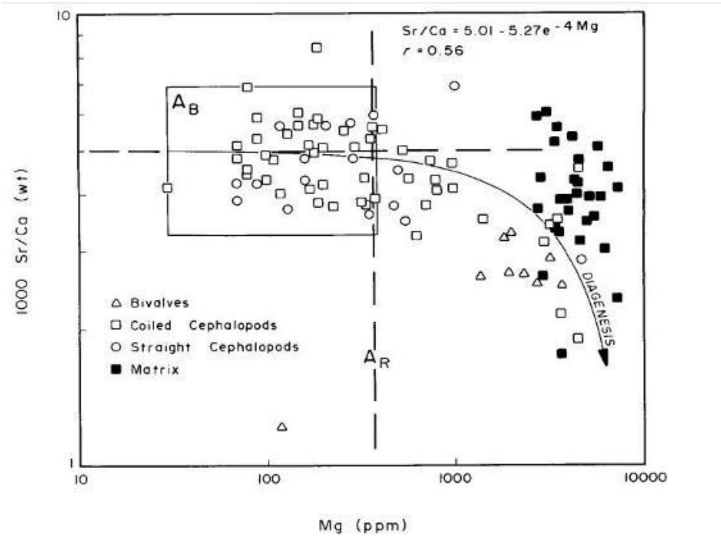

Figure 2.7 Sr and Mg trend in mollusks and matrix

The Mg and Sr concentrations in the Boggy Formation. From Brand (1989).

Some studies have indicated that Sr incorporation into carbonate rock may not originate from a Sr^{2+} ion but rather strontianite (Greegor et al., 1997; Ruiz-Hernandez et al., 2010). This is estimated in some corals to be 60% Sr^{2+} ion in the original aragonite and 40% in strontianite (Greegor et al., 1997). The Sr that is substituted in coral aragonite has been found to be stable and does not experience the strontianite phase separation (Ruiz-Hernandes et al., 2010).

The substitution of Sr for Ca in the aragonite structure of bedrock has been known to indicate sea surface temperatures, due to the temperature dependent nature of the substitution of Sr for Ca (Allison et al., 2005). The Sr/Ca ratio in coral skeletons has an inverse correlation with the temperature of seawater (Ruiz-Hernandez et al., 2010). This is in reverse of the Sr found in speleothems, the result of the leaching of the bedrock (Finch et al., 2001).

Studies often assume the Sr in speleothems originates from the change in chemistry of the hydrologic conditions in the epikarst and not changes in the host rock itself (Van Beynen et al., 2008; Finch et al., 2003; Huang et al., 2001; Ayalon et al., 1999). While it is known that aragonite can take on Sr during both precipitation of carbonate sediments that form the bedrock and during the precipitation of speleothems, the presence of Sr in the host rock has been largely overlooked by those studying paleoclimate records. Strontium has long been established as a component in host rocks (Kulp et al., 1962; Allison et al., 2005; Ruiz-Hernandez et al., 2009) and should be taken into consideration as a potentially major contributor of Sr in speleothem mineralogy. This is especially relevant in eogenetic limestones.

Previous Studies on Speleothems Containing Strontium

The analysis of Sr content in speleothems has been a growing study in the paleoclimatic field (White, 2004). In almost all studies the Sr content is believed to be primarily of a surficial source (Huang et al., 2001; Van Beynen et al., 2008a; Van Beynen et al., 2008b; Finch et al., 2001; Finch et al., 2003; McDermott and Fairchild, 2002; Roberts et al., 1998). This seems a good assumption, since all of these studies are in areas of telegenetic carbonates with no remaining depositional aragonite present and hence no expected host-rock Sr source.

The Sr content in speleothems has been related to climate in various ways. It is thought that Sr/Ca ratios in carbonate cave waters can be enhanced due to prior calcite precipitation, or the selective leaching of Sr with respect to Ca, because of soils above the cave drying or freezing (Fairchild et al., 2000). The Sr concentration in speleothems has been related to seasonal variations of precipitation (Huang et al., 2001; Roberts et al., 1998), climatic variations in soil productivity (Van Beynen et al., 2008), precipitation, temperature, residence time (Verheyden et al., 2000), and vegetation cover (Finch et al., 2003; Finch et al, 2001; McDermott and Fairchild, 2002; Sinclair et al., 2012). The contribution of Sr from the sea spray of coastal caves has also been considered (Onac et al., 2001).

A study of a soda straw, stalagmite and drip waters collected from Grotta di Ernesto Cave in NE Italy concluded that Sr levels were higher in speleothems deposited in the winter or spring and could indicate the seasonal variations in the partial pressure of carbon dioxide (PCO_2) (Huang et al., 2001). This study also looked at the phosphorous content and noted a negative relationship with the Sr content, most likely due to phosphorous' inhibition of calcite precipitation (Huang et al., 2001). A Holocene stalagmite in northern Scotland showed an inverse relationship of Sr/Ca and Mg/Ca (Figure 2.8) and also established that these values vary seasonally, most likely in response to water residence time (Roberts et al., 1998). This small stalagmite collected from Uamhan Tartair Cave was Holocene in age, but was precipitated within host rock that was partially dolomitized and Cambrian-Ordovician in age (Roberts et al., 1998). The studies on the Italian speleothem and the Scottish speleothem both showed strong seasonal changes in Sr levels, but these were both located in telegenetic carbonates. Another study on South African speleothems also indicated annual variations in trace element content (Finch et al., 2003).

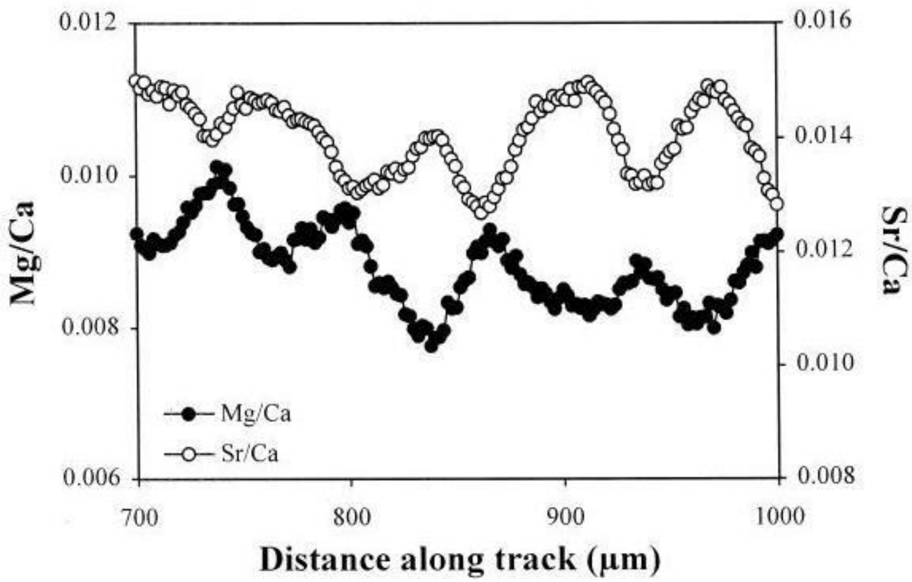

Figure 2.8 The inverse relationship of Sr/Ca and Mg/Ca

The clear inverse relationship of Mg/Ca and Sr/Ca in a speleothem from northern Scotland. From Roberts et al., (1998).

Soil productivity as a result of changes in precipitation was hypothesized to create the inverse relationship Sr has with $\delta^{13}C$ in a stalagmite from Florida (Van Beynen et al., 2008). The speleothem was collected from Briar Cave, which is located within the Late Eocene Ocala formation. The solar cycle was observed in this speleothem, a cycle that lasts 170-180 years and is in agreement with marine records from the Gulf of Mexico (Van Beynen et al., 2008).

A Belgian Holocene stalagmite was collected from PéreNöel Cave and examined for Mg/Ca, Sr/Ca and $^{87}Sr/^{88}Sr$ ratios (Verheyden et al., 2000).The long term trend in Sr/Ca ratios in this study was interpreted to be from the residence time of water from precipitation. The host rock of this cave was Devonian in age and had a higher Sr content than the author expected (Verheyden et al., 2000).

Aragonitic speleothems collected from a cave in South Africa were used to corroborate rainfall records by interpreting low trace element content as drought (Finch et al., 2003). While there seemed to be a trend, the correlation in this study was not great and further research is needed. Whether the residence time creates excess vegetation, or the vegetation can increase residence time of the water in the overlying soils, could be debated.

Only a few studies took considerable time to evaluate the contribution of Sr from a host rock source (Goede et al., 1998; Ayalon et al., 1999; Onac et al, 2001; Miklavic, 2012; Sinclair et al., 2012) even though it has long been established that Sr exists in the host rock (Kulp et al., 1962; Sinclair et al., 1998; Banner and Kaufman, 1994). Many of those that did consider the Sr content of the original host rock found little variation that would affect the reading of Sr as an infiltrate (Goede et al., 1998; Verheyden et al., 2000) but these rocks were telegenetic as opposed to the eogenetic carbonates found in the Caribbean.

During the traverse of a solution through the pore spaces of the bedrock, the Sr and Mg are slowly leached out (Sinclaire et al., 2012). In Sinclaire's study the Sr and Mg levels in the speleothems increased and decreased around same time instead of the inverse relationship seen in previous stalagmite studies within telegenetic rocks (Sinclaire et al., 2012; Roberts et al., 1998; Huang et al., 2001). The temperature influence on the Sr/Ca ratios of the speleothem has been ruled out in tropical speleothems (Sinclaire et al., 2012); although it is important to note that climatic factors, such as precipitation and aridity, can still affect the rate at which Sr is leached from the bedrock. While some studies had indicated Sr to be a result of the residence time of water in the soil

(Verheyden et al., 2000) and the differing vegetation cover (Finch et al., 2003; McDermott and Fairchild, 2002; Finch et al, 2001; Sinclair et al., 2012), it has also been proposed that the soil may be obtaining the Sr from the bedrock itself during denundation (Sinclair et al. 2012). Miklavic (2011) demonstrated high Sr levels in drip water and stalagmites from a flank margin cave on Guam developed in last interglacial eogenetic limestones (~120 ka).

Many research studies attempt to correlate the Sr levels in speleothems to something environmental. Whether this is residence time, precipitation, temperature or soil productivity, on annual or long term cycles, all of the past research focused on climate as the main factor of these Sr variations. Most of the research h took place on speleothems from caves in host rock of much older age that have undergone diagenesis. In younger rocks it may be important to note that these variations in Sr within stalagmites could be a signal of the host rock maturity, as reported by Miklavic (2011).

Since it is well understood that aragonite rocks much older than the Pliocene are likely going to be entirely inverted to calcite (Fairchild and Baker, 2012), it should be recognized that the young carbonates of Curaçao and other, similar carbonate terraces could have a different Sr content. Sr has been found in both the host rock and the speleothems of caves in the Bahamas (Onac et al., 2001). The interpretations of Sr content in speleothems of younger carbonates that did not consider the host rock contribution of Sr may need to be adjusted for accurate use as a climatic signal (Sinclair, et al., 2012).

Strontium Found in Young Host Rock Speleothems

It has already been demonstrated that Sr can be found in speleothems of many ages. The age of the host rock may have a direct impact on the source and levels of the Sr concentration in the speleothems that precipitate from the dissolution of these rocks. Younger host rock speleothems have been found to contain higher levels of Sr (Miklavic, 2011; Sinclair et al., 2012) and the contribution of Sr to speleothems of caves in these rocks could be considered significantly higher than those in older host rocks. Rock samples from San Salvador showed Sr concentrations of up to 379 ppm (Onac et al., 2001) indicating that the host rock could be a major source of the Sr^{2+} ion. The caves studied on San Salvador are flank margin caves that are created in the eolian calcarenites during glacioeustatic sea level highstands (Mylroie and Carew, 1990) and are similar to caves located in coral reef terraces on the island of Curaçao (Kambesis et al., in press) and Bahamian field locations (Mylroie and Mylroie, 2013).

The increase in Sr concentration has been used to support the argument that aragonite will only be replaced via a dissolution-precipitation process (Böttcher, 1991). This argument further supports the correlation of Sr to aragonite in cave environments. Additional support is lent by the study of primary biogenic aragonite altering to calcite that determined the chemistry of the calcite precipitated in the reaction was created by the chemistry of the primary aragonite (Brand, 1989). In the Caribbean it has been observed that calcite/aragonite ratios tend to increase as sampling moves downward through the bedrock to older portions (Beach, 1995).

Curaçao

The World Fact Book (2013) reports that Curaçao is 55 km off the coast of Venezuela, with a population of just under 150,000 people. The population was originally Arawak Indians until the settlement by the Dutch in 1634. As of 2010, Curaçao has become autonomous and relies on the Dutch government only for defense and foreign affairs. The economy is small and is primarily sustained by tourism, oil refinement and offshore finance. The island's highest point is 372 m above sea level, Mt. Christoffel, inside National Christoffel Park. The park consists of 23 km^2 of preservation and natural recreation areas.

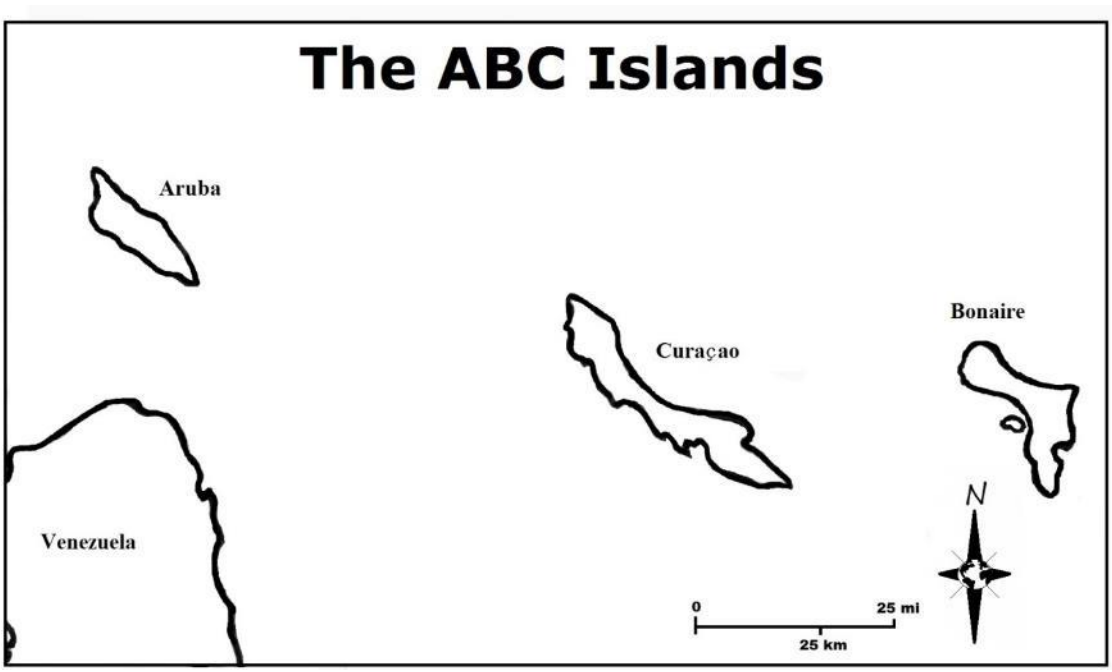

Figure 2.9 Map of the ABC Islands

The Dutch Antilles islands (known colloquially as the ABC islands). See also Figure 1.2.

Curaçao is the largest of the three Dutch Leeward Islands (figure 2.9) and is a long island of 425 km^2 with 364 km of coastline (De Buisonjé, 1974). Of the island's area, 26% is covered with Neogene and Quaternary deposits (De Buisonjé, 1974) (Geologic Map, Figure 2.10). The coral reef terraces of Curaçao are all Pleistocene in age and reflect both sea level changes and the slow uplift of the island (Schellmann et al., 2004;Santamaria and Schubert, 1974). The uplift on Curaçao began in early Miocene and has continued through the present (Schubert and Valastro Jr., 1976). A total uplift of several hundred meters is probable based on the evidence of the coral terraces, the highest erosional surface sitting at around 200-m high (Silver, Case and MacGillavry, 1975), or an average of 0.066-0.060 m/1000 yrs(Schellmann et al., 2004). The last interglacial was 4 m above the current sea level (Schellmann et al., 2004). The mineralogy of the terraces of Curaçao range from aragonite to calcite recrystallized from aragonite, to dolomite (Schellmann et al., 2004).

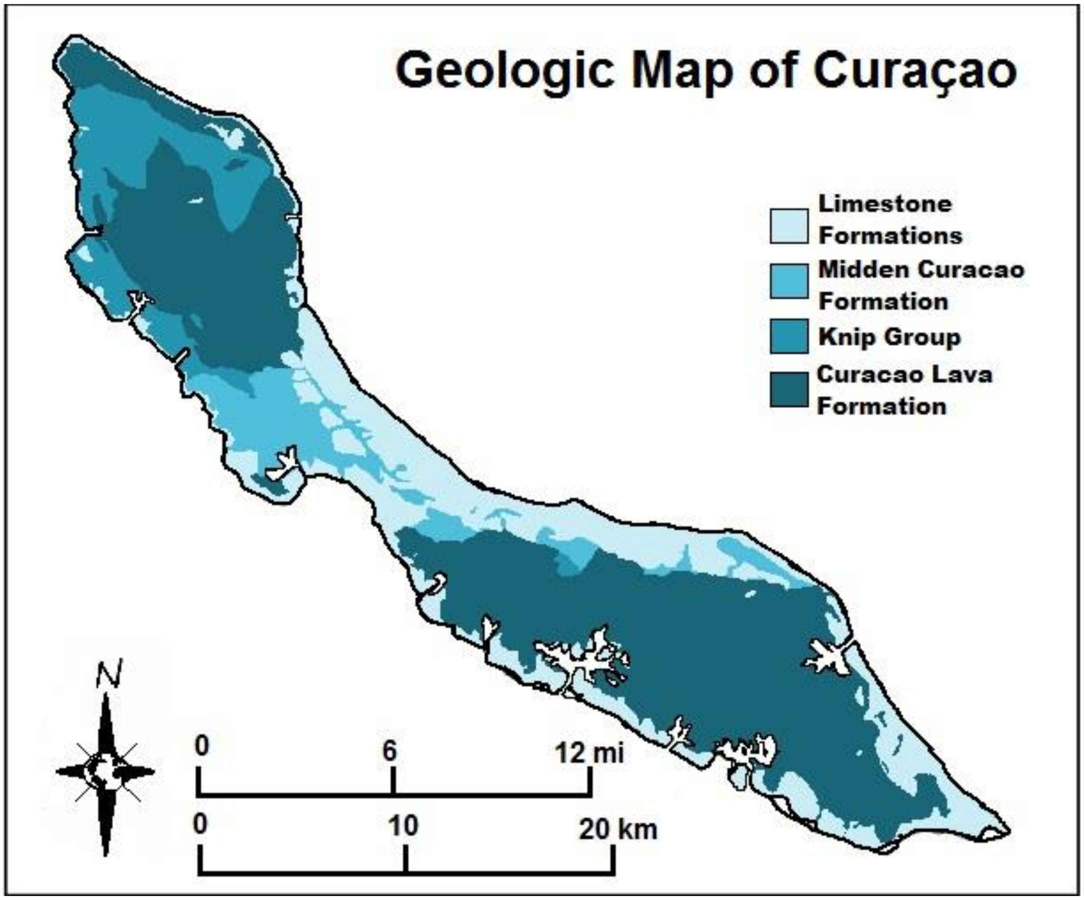

Figure 2.10 Geologic Map of Curaçao

Modified from Christoffel Park (2013).

The lower terrace of Curaçao is composed of transgressive deposits about 35 m thick with the top 10-15 m exposed above sea level (De Buisonjé, 1974). The lower terrace can be subdivided into three zones: the barrier reef zone, the lagoonal zone, and the Siderastrea zone (De Buisonjé, 1974). They contain calcirudites, calcarenites, and some non-calcarious deposits that consist of pebbles from older formations on the island (De Buisonjé, 1974). These deposits are late Pleistocene in age (Hornbach et al., 2010). Caves are present in this terrace but are not as numerous as the caves in the older, higher terraces (De Buisonjé, 1974); however, this could be an explorational bias as the older terraces are more denuded, and the flank margin caves there more likely to be exposed by erosion to create cave entrances (Kambesis et al., in press).

The middle terrace, much like the lower terrace, is transgressive and is divided into three stages: first trangressive phase, standstill, and second transgressive stage (De Buisonjé, 1974). During the first transgressive phase of the middle terrace, abundant coral colonies that are independently zoned *Montastrea annularis* and *Siderastrea* are found, as well as calcarenites and local basal conglomerate pebbles that originated from older formations on the island (De Buisonjé, 1974). During the standstill stage of the middle terrace one can find abundant eolianites. The second transgressive stage is distinguished by a lack of facies zonation while calcareous detritus, calcarenties and beachrocks are all found in the stage. The entire middle terrace is understood to be older than the lower terrace and is from the mid-Plesitocene (Hornbach et al., 2010)). The caves in the middle terrace were breached and exposed during the formation of the lower terrace and contain relatively abundant flowstone and dripstone (De Buisonjé, 1974). These caves forms at or just below the water table, most running perpendicular to the coastline (De Buisonjé, 1974) indicating they are likely flank margin caves.

The higher terrace on the island of Curaçao reaches a maximum height of 85 m and goes down to 50 m (De Buisonjé, 1974). The deposits indicate a standstill and regressive phase and are older than the middle terrace, but still aged from the mid-Pleistocene (De Buisonjé, 1974; Hornbach et al., 2010). In both the standstill and regressive phases, eolianite units are located above shallow marine deposits (De Buisonjé, 1974). The well-known commercial cave, Hato Cave, is located in this higher terrace and is one of the most extensive of the islands. This cave is also perpendicular to the coast and shows distinctive flank margin cave properties (Kambesis et al., in press).

The highest terrace is only found on the island of Curaçao and not on nearby Bonaire or Aruba, and is the oldest and highest carbonate unit De Buisonjé, 1974). These deposits, like the higher terrace, are regressive in nature and lack the caves that are found in the lower terraces (De Buisonjé, 1974). The highest terrace is composed of eolianites that slowly transition into calcarenites, and then into a subtidal facies that contains detrital coral colonies, gastropods and pelecypods (De Buisonjé, 1974).

The Seroe Domi formation is located along the leeward side of the island and is comprised of carbonates and dolomitized carbonates (De Buisonjé, 1974; Sumrall, 2013). The Mid Curaçao consists of turbidites from tectonic activity about 65 mya and the Knip Formation is about 75 myo and consists of Radiolaria. The Lava Formation is the oldest on the island and is comprised of basalt.

The caves on Curaçao are primarily flank margin and the island follows the Composite Island Karst Model (Kambesis et al., in press). The development of surface streams on the terraces and Seroe Domi formation is not common because of the high porosity of these rocks. The fresh-water lens received a primarily autogenic recharge although surface water flow over the center of the island that consists of non-carbonate units does occur to provide allogenic recharge.

The mean annual temperature for the island is 27° C with a 4° variation from night to day (De Buisonjé, 1974). Curaçao has a relatively high humidity averaging 75% considering it is semi-arid with a mean annual rainfall of 425-572 mm, the majority of the rainfall occurring between October and January (De Buisonjé, 1974). Located in the trade winds, the wind speed and direction are near constant averaging about 5 m/s (De Buisonjé, 1974).

The Bahamas

The first land in the New World that Christopher Columbus set foot on was San Salvador Island, Bahamas in 1492. At that time, the Lucayan Indians inhabited the area but 155 years later the British began settling the land (Carew and Mylroie, 1997). In 1973 the Bahamas gained independence from the crown and have since become a participant in foreign affairs (Carew and Mylroie, 1997). The economy is heavily reliant on tourism, which brings in 60% of the country's GDP (Carew and Mylroie, 1997).

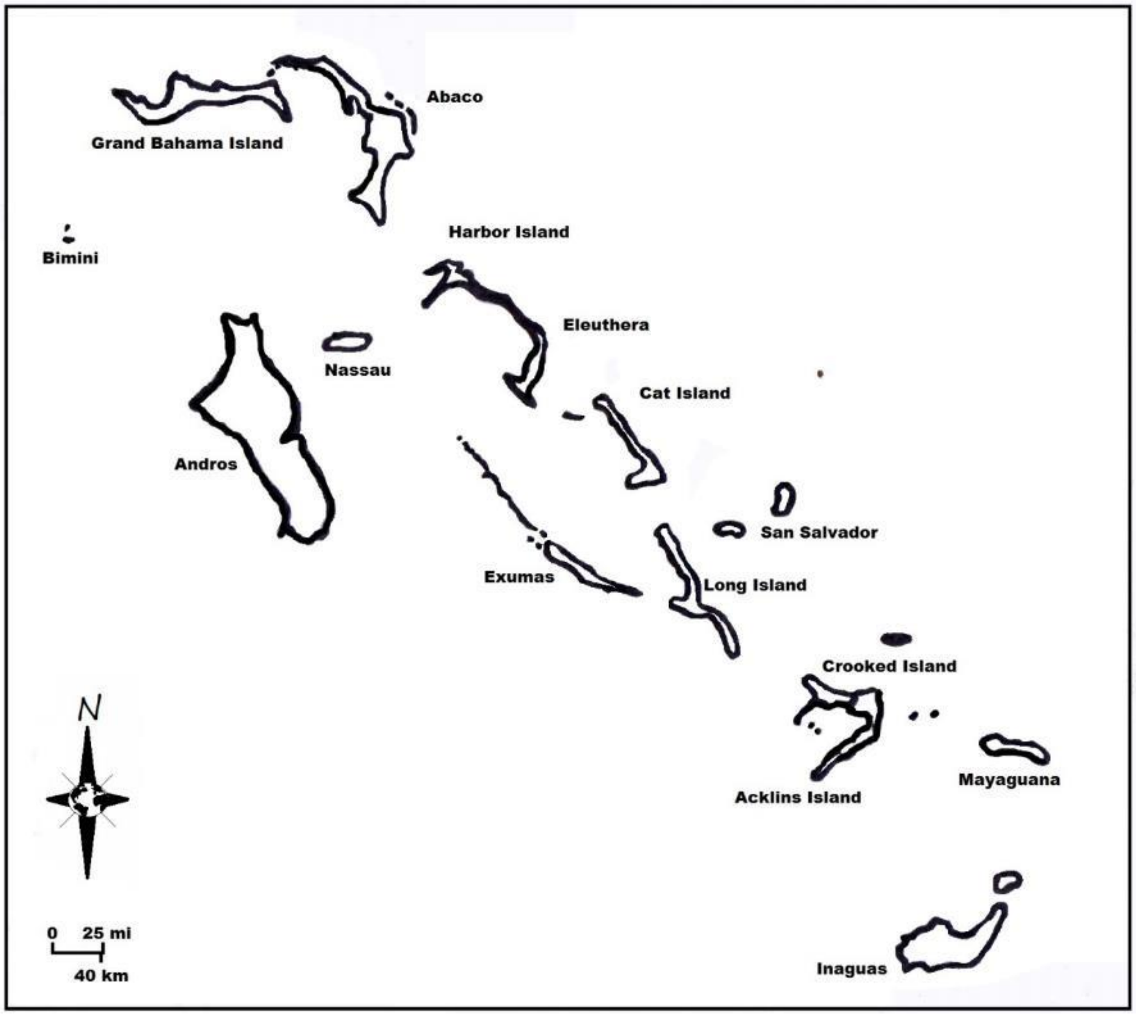

Figure 2.11 Map of the Bahamas

The islands in the study area are, from top to bottom, Abaco, San Salvador and Long Island.

There are over 700 islands and cays in The Bahamas (Figure 2.11), each with their own distinct properties (Albury, 1975). The Abacos are the furthest north of these islands and consists of a 193 km long island chain (Bahamas, 2013A). Abaco is claimed to be the boating capital of the world and has a strong tradition of boat building (Bahamas, 2013a). Long Island, known in the past as "Yuma" by the Arawak Indians and "Fernandina" by Christopher Columbus, is a 129 km long island that is intersected by the

Tropic of Cancer (Bahamas, 2013b). It is home to some of the biggest karst features of the Bahamas including Hamilton's Cave, one of the biggest caves in the country, and Dean's Blue Hole, the deepest known blue hole in the world at 202 m depth. San Salvador Island, once called "Guanahani" by the Lucayan Indians, received its name from Christopher Columbus when he landed there in 1492 (Bahamas, 2013c). The population is just over 1000 and thrives on tourism for their main income (Bahamas, 2013c).

The Bahama Banks and platforms are composed of relatively young carbonates from the Quaternary. The higher elevations are primarily eolianites while the lower elevations are mixed subtidal and eolianite facies. (Carew and Mylroie, 1997). The last high-stand to occur in this area was 6-m above current sea level, the MIS 5e highstand ~ 120 ka (Mylroie and Carew, 2008). The carbonates of these islands, like Curaçao, are composed of aragonite or aragonite that has stabilized to calcite.

Meteoric waters infiltrating the eogenetic carbonates of this area help to cement the rock units as well as inverting aragonite to calcite, and develop a secondary porosity (Vacher and Mylroie, 2002). The cementation of the eolianite dunes occurs rapidly and they are likely still *in situ* (Walker, 2006). The carbonates can also be further cemented by sea spray, especially on the surface, which can lead to a higher strontium content in the host rock (Onac et al., 2001).

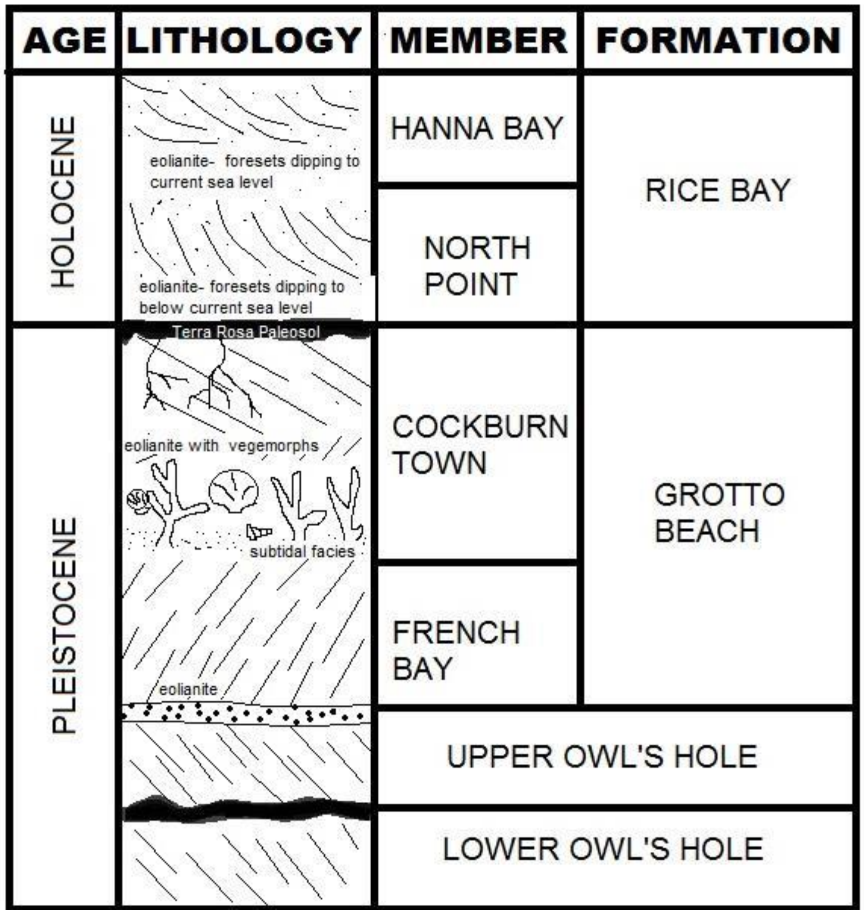

Figure 2.12 Stratigraphy of the Bahamian Archipelago

Modified from Mylroie and Carew (2013).

The Bahamas have experienced many fluctuations in sea level and the deposition of carbonates during these fluctuations is distinctive, as can be seen in the stratigraphic column (Figure 2.12). The eolianites can be described as transgressive phase if they have well-preserved bedding planes and few to no vegemorphs or regressive if they have extensive vegemorphs (Mylroie and Carew, 2013). The Holocene Rice Bay formation is composed of two members, both eolianite, which can be differentiated by differing slopes of dune foresets. The younger member, Hanna Bay, foreset beds dips to current sea level while the North Point member foreset beds below current sea level.

The Grotto Beach formation is separated from the Rice Bay formation with a distinctive red to pink terra rossa paleosol. The paleosol indicates that the rocks below are Pleistocene in age. The Grotto Beach formation has two members, the Cockburn Town member is the youngest of the two and is characterized by an eolianite with vegemorphs (Figure 2.13) or a subtidal facies. Below the relatively older French Bay member is a trangressive-phase eolianite lacking the abundant vegemorphs seen in the overlying member.

Figure 2.13 Vegemorphs

The abundant vegemorphs typical of the Cockburn Town member. 52 mm lens cap for scale.

The karst in the Bahamas includes karren, caves, and blue holes, and follows the Simple Carbonate Island Karst Model (Figure 2.14). These rock units have not undergone burial and uplift making them relatively young and porous in comparison to typical continental carbonate rocks. The development of surficial karren in the Bahamas is characterized by homogenous, highly-porous young limestones and has been called eogenetic karren (Taborosi et al., 2004). Karren is considered an epikarst, occurring at the surface, and is characterized by sharp and jagged surface texture. It is very prevalent both in the Bahamas and on the platforms of Curaçao.

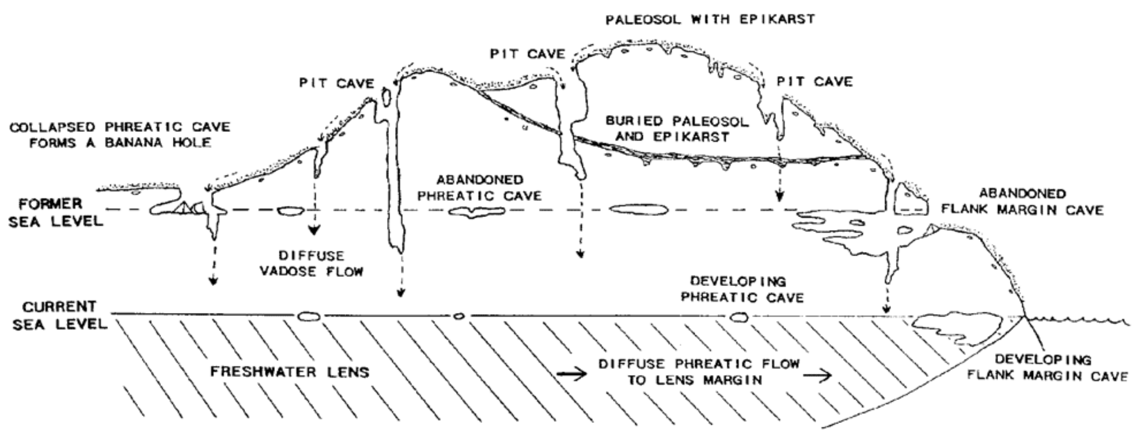

Figure 2.14 Karst found on a simple carbonate island
From Mylroie and Carew (1995).

The caves in the Bahamas consist of banana holes, pit caves, flank margin caves and sea caves (Mylroie and Carew, 2005). The caves are all in eogenetic rock, forming while diagenesis of the rock units is on-going. Banana holes form in a similar way to flank margin caves in the mixing zone of the fresh water lens. Pit caves are formed in the vadose zone and are vertical shafts that do not typically interact with the fresh-water lens.

Sea (littoral) caves are pseudokarst caves created primarily by the physical energy of the waves and are small caves confined to the coast.

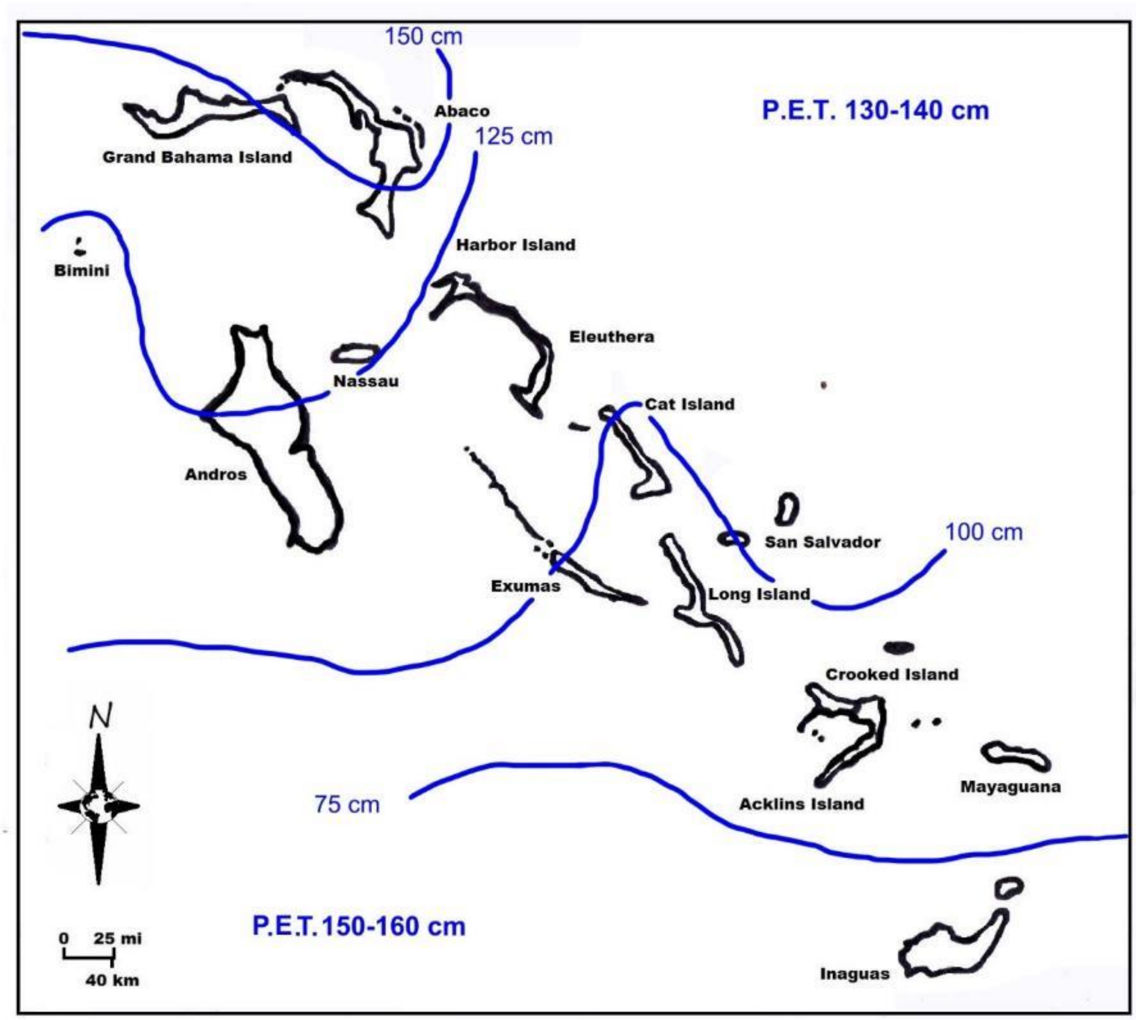

Figure 2.15 The precipitation and evaporation rates of the Bahamas
Modified from Whittaker and Smart, (1997).

The climate of the Bahamas varies depending on the latitude. The islands furthest north are cooler in the winter and receive the most rainfall. The islands furthest to the south are slightly warmer and receive less rainfall (Figure 2.15). Abaco receives the most rainfall out of all of the Bahamian islands with a positive water budget while Great

Inagua receives the least and has a negative water budget. Long Island and San Salvador also have negative water budgets, but San Salvador is close to the "break even" water budget boundary and somewhat intermediate between the extremes of Abaco and Long Island.

CHAPTER III

METHODOLOGY

The field work on the island of Curaçao took place in December of 2012, while the field work on the islands of Abaco, Long Island and San Salvador took place in June of 2013. Prior field work of Dr. J. E. Mylroie, J. R. Mylroie, P. Kambesis, E. Larson and others provided knowledge of the caves in these field areas that allowed for planning of sample collection. Due to the delicate nature of exporting specimens, permission was sought before planning.

Permission for six stalagmites (two each from three caves, one cave in each terrace) was obtained from the Carmabi Foundation for Curaçao (their national park service) by Dr. John Mylroie. Permission for multiple stalagmites was obtained for collecting on Abaco Island, San Salvador Island and Long Island from the Bahamas Environment, Science and Technology (BEST) Commission, issued to Dr. John Mylroie. All paperwork was carefully arranged before travel to these countries. Details of each sample can be found in appendix A.

Collection

Curaçao

The caves identified as the preferred caves for collection were Lardem Cave in the lowest, youngest terrace, Raton in the middle terrace, and Hato within the top, oldest terrace (Figure 1.1 and 3.1). The stalagmites were carefully selected as the most optimum specimens within the caves. They were collected from deep within the caves identified as primary candidates for this study to ensure humidity was high and airflow was minimal (Frappier, 2008). They were collected from hidden locations to preserve the cave's internal appearance.

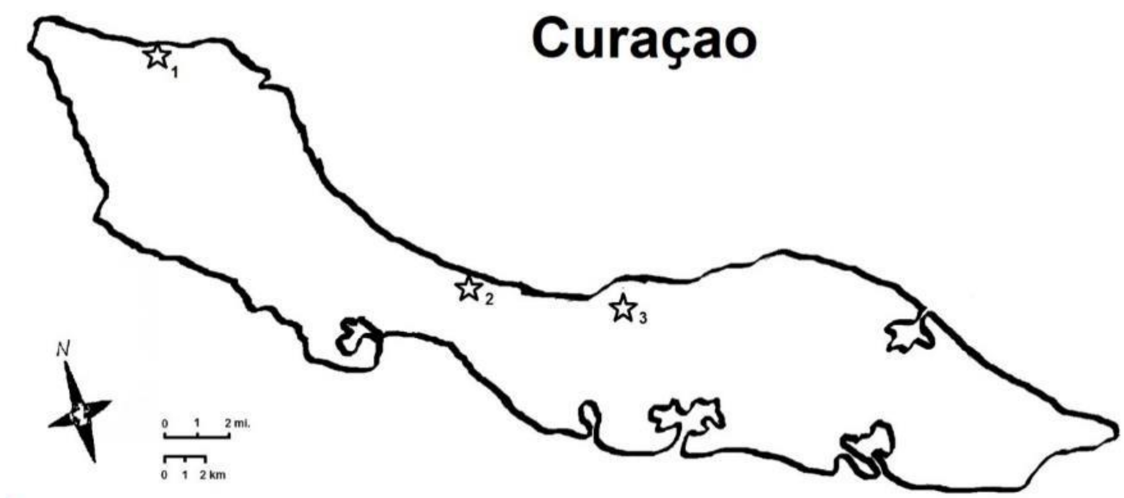

Figure 3.1 Map of Curaçao cave locations

Lardem Cave (1), Raton Cave (2) and Hato Cave (3).

The first cave visited on Curaçao was Lardem cave in the lower terrace. This cave is located only 20 meters from the coast where the limestone terrace drops down as a cliff to sea level. One small entrance allows access by crawling and opens up into a broad room with low ceilings. Two stalagmites were identified as optimal candidates for specimens located in the NW portion of the cave in close proximity. These stalagmites had apical tips that were clean and still receiving drip water from above. They were labeled to easily identify the location at which they were collected. The first letter indicates the island where the sample was collected, the second letter(s) indicate the cave from which it was located and the number indicates the individual sample number. In this case the stalagmites were labeled CLD1 and CLD2. Rock samples were also collected, one from the wall within the Lardem cave (CLD3), one from the ceiling within the cave (CLD4) and one from the surface above Lardem cave (CLD5).

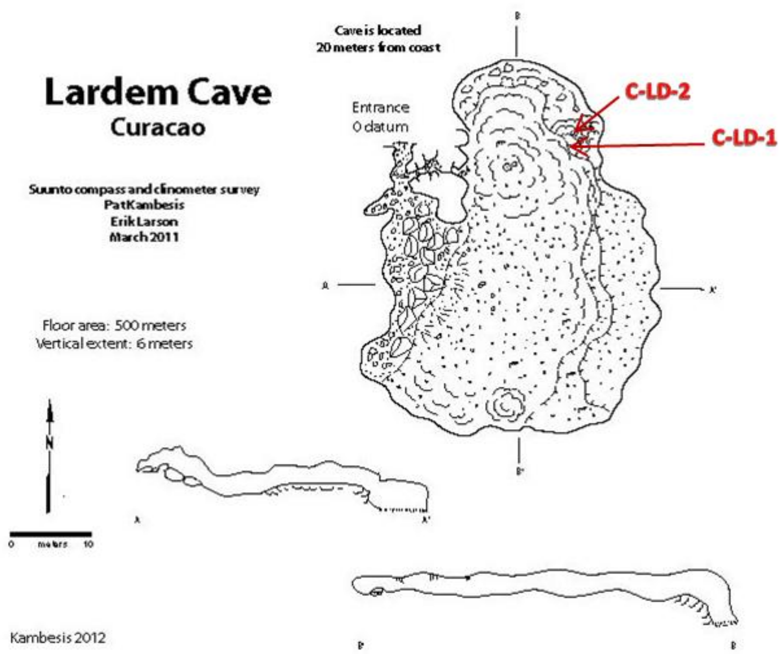

Figure 3.2 Lardem Cave map

Stalagmite collection locations are labeled.

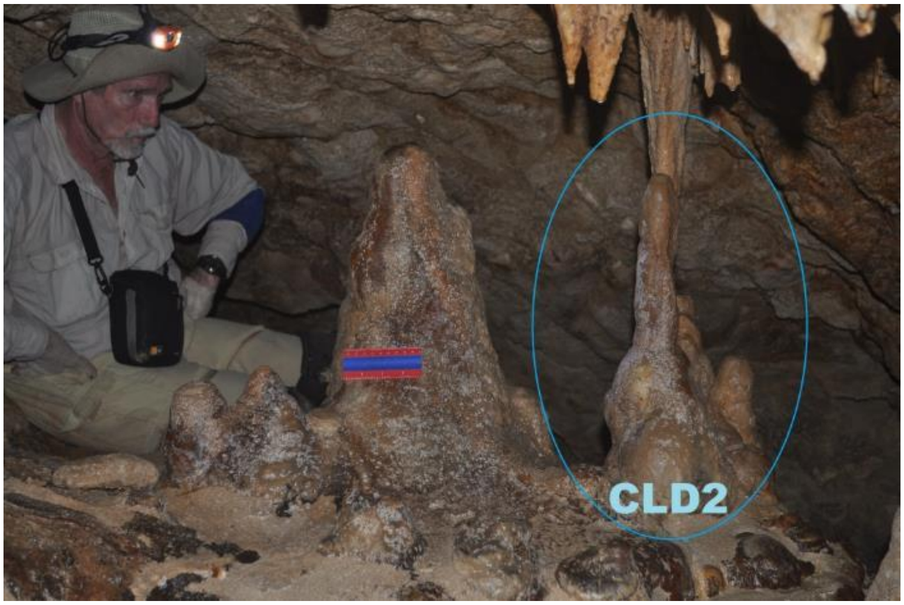

Figure 3.3 Photo of stalagmite CLD2

Red and blue ruler to the left is 10 cm long for scale.

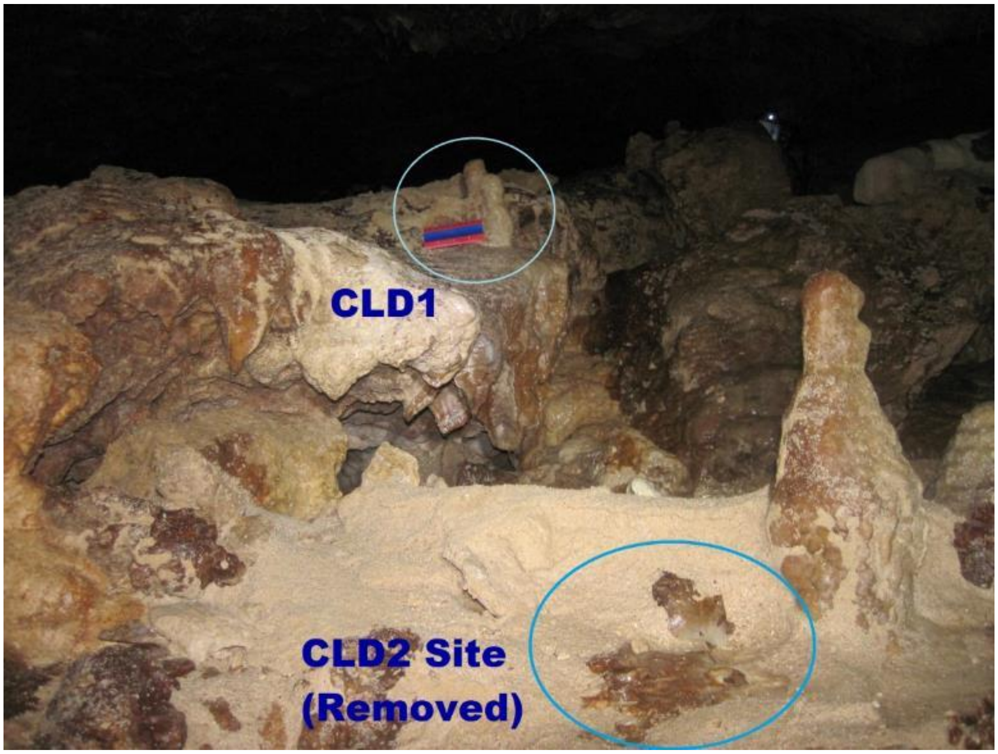

Figure 3.4 Photo of proximity of CLD1 and CLD2

Figure 3.5 Photo of CLD2 and CLD3 collection sites

Figure 3.6 Photo of CLD1 and CLD4 collection sites

These samples were carefully collected with rock hammer and chisel and labeled in the field with all steps thoroughly photo documented. The rock samples were labeled with an arrow to indicate the upright direction for reference. The proximity of the stalagmites collected in Lardem cave necessitated the removal of only one cave ceiling rock, wall rock and surface rock. In caves where stalagmites were collected a greater distance apart a separate set of ceiling, wall and surface rock was collected for each area.

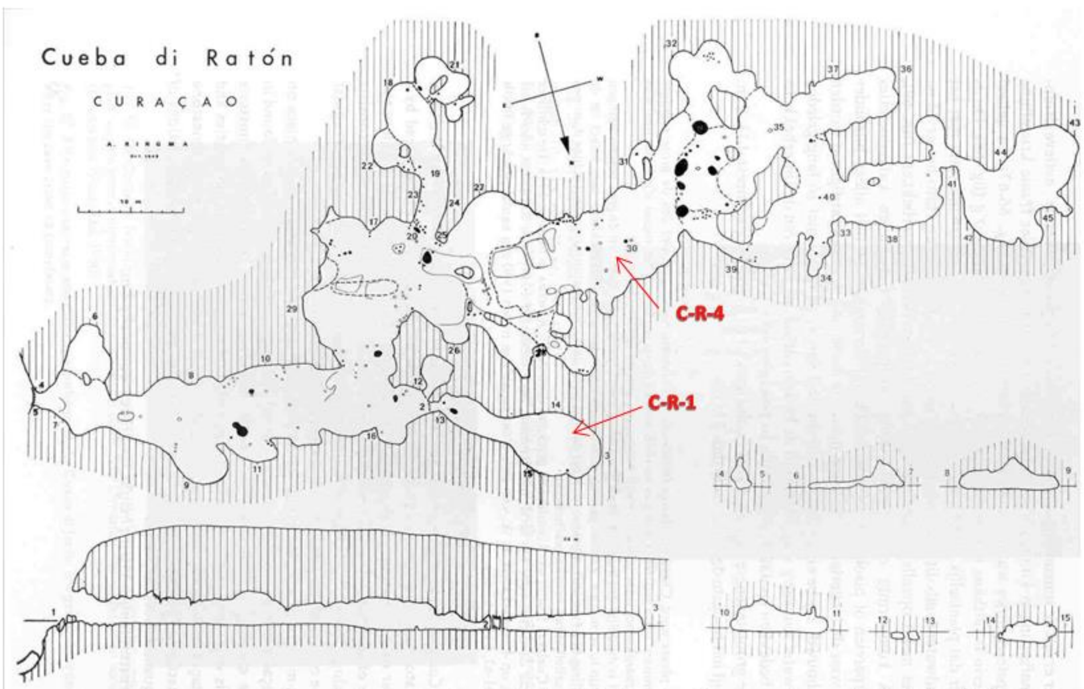

Figure 3.7 Map of Raton Cave

Stalagmite collection sites labeled.

Raton cave is located in the middle terrace and accessed by driving across the Hato plain and a short hike up to the entrance on a vertical cliff marking the beginning of that rock unit. After a careful observation of the stalagmites present in the cave it was determined that the stalagmites to henceforth be called CR1 and CR4 were optimum for collection. They both displayed an apical tip still receiving drip water from above and were located in rooms removed from the entrance with little airflow.

These stalagmites were not in close proximity, as the stalagmites in Lardem were, so a set of ceiling rock, wall rock and surface rock samples were collected in the vicinity of each of the two stalagmites. CR2 is a wall rock sample obtained in Raton cave near stalagmite CR1 and CR3 is a ceiling rock sample located in the same vicinity. CR5, wall rock, and CR6, ceiling rock, were collected within the cave near stalagmite CR4. CR7 was collected as a surface rock from the face of the cliff Raton is entered upon and CR8 is a surface rock collected above Raton cave.

Figure 3.8 Photo of stalagmite CR1

Collected in Raton Cave, 52 mm lens cap for scale.

Figure 3.9 Photo of stalagmite CR4

Ruler is 10-cm for scale.

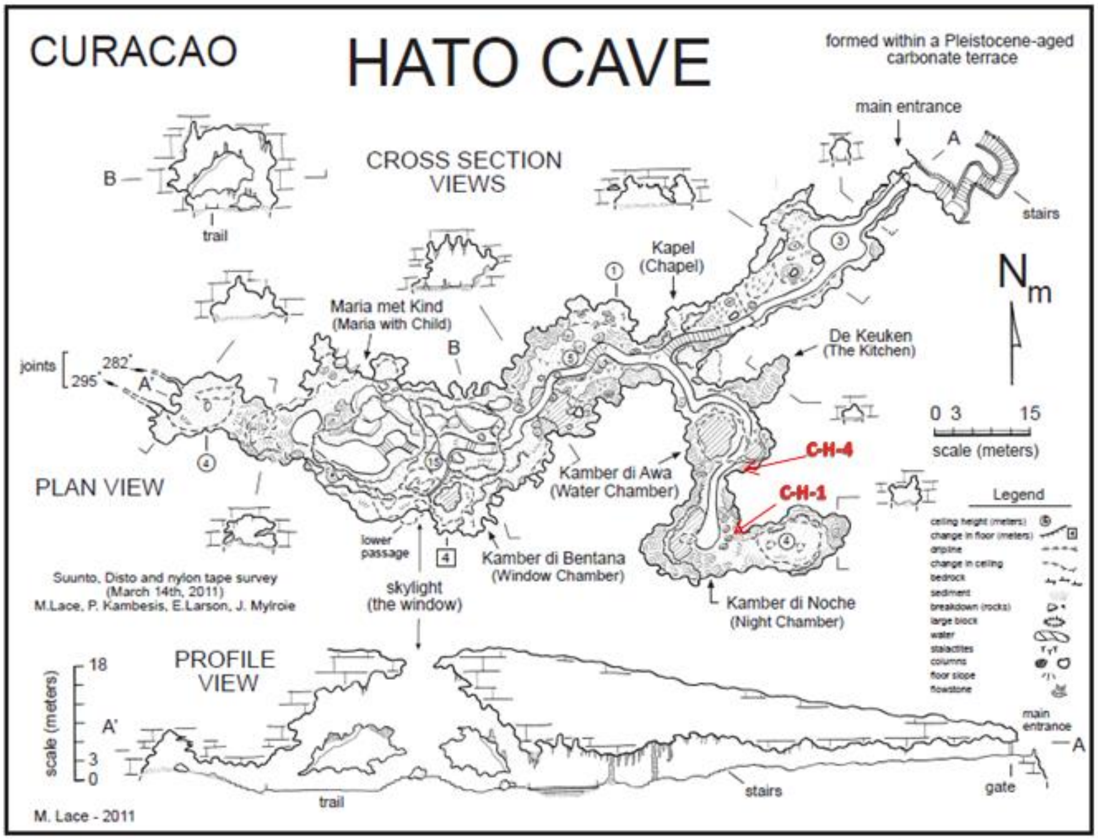

Figure 3.10 Hato Cave map

Stalagmite collection sites labeled.

The last cave to be collected from for this research on the island of Curaçao was a commercial cave, Hato Cave. Care had to be taken while selecting specimens for study as the beauty of the cave for frequent visitors was of the utmost concern. Two stalagmites were identified as candidates based on the properties displayed as well as being out of view of the tour route.

Stalagmites were collected with hammer and chisel and carefully photo documented throughout the entire process. The stalagmites were not located in the same room so a set of cave wall, cave ceiling and surface rock were collected for each of the two stalagmites collected. The stalagmite CH1 was accompanied by nearby cave wall rock CH2 and cave ceiling rock CH3. CH8 was determined to be a surface sample located approximately above the location of CH1. The wall rock samples CH5 and CH6 were collected near stalagmite CH4 and CH7 was a rock collected from the surface above Hato Cave approximately directly atop CH4.

Figure 3.11 Photo of stalagmite CH1

Collected in Hato Cave, an active commercial cave on Curaçao. The stalagmite is hidden from tourist view by a column. Ruler is 10-cm for scale.

Bahamas

The specimens from the Bahamas were collected from three islands that are located in areas that have differing precipitation budgets. Abaco, the northern-most island in the study area, has a positive water budget with the highest precipitation rate of the three. Long Island has a negative water budget with the least amount of precipitation. San Salvador has a water budget and precipitation between the two extremes of this study (see Figure 2.15 earlier in text). The first island visited was Long Island and the two caves that were identified as prime candidates for collection were Salt Pond and Hamilton's.

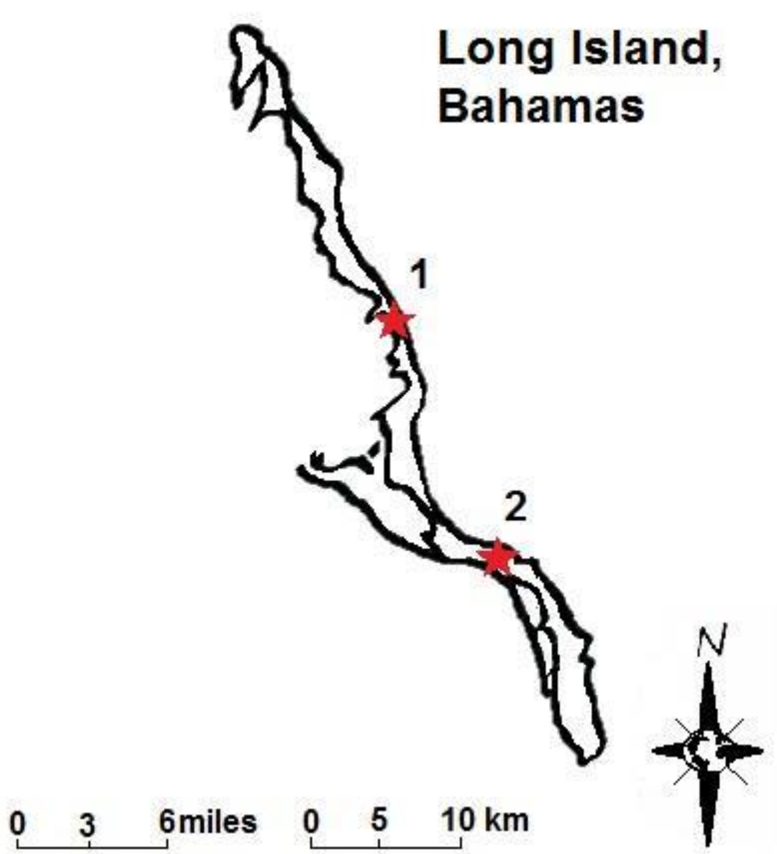

Figure 3.12 Map of Long Island, Bahamas

Collection sites in Salt Pond Cave (1) and Hamilton's Cave (2).

Hamilton's Cave is one of the largest caves in the Bahamas with many dissolutional openings in the ceiling that (figure 3.13). Tours are offered to visitors and it remains as a largely undeveloped commercial cave. It is a large bat habitat for the island and is home to maternity colonies of *Erophylla sezekorni*, known as the Buffy Flower Bat.

Figure 3.13 Photo of Hamilton's Cave

Joan Mylroie standing in a beam of light from an opening in the ceiling.

The multiple entrances and skylights were avoided for collection sites to make sure specimens were susceptible to the least amount of airflow that could potentially bring in contaminants for the study. For this reason the specimens were collected in close proximity in the southwestern portion of Hamilton's Cave. Two stalagmites were collected, LH1 and LH4, along with a set of cave wall, cave ceiling and surface rocks.

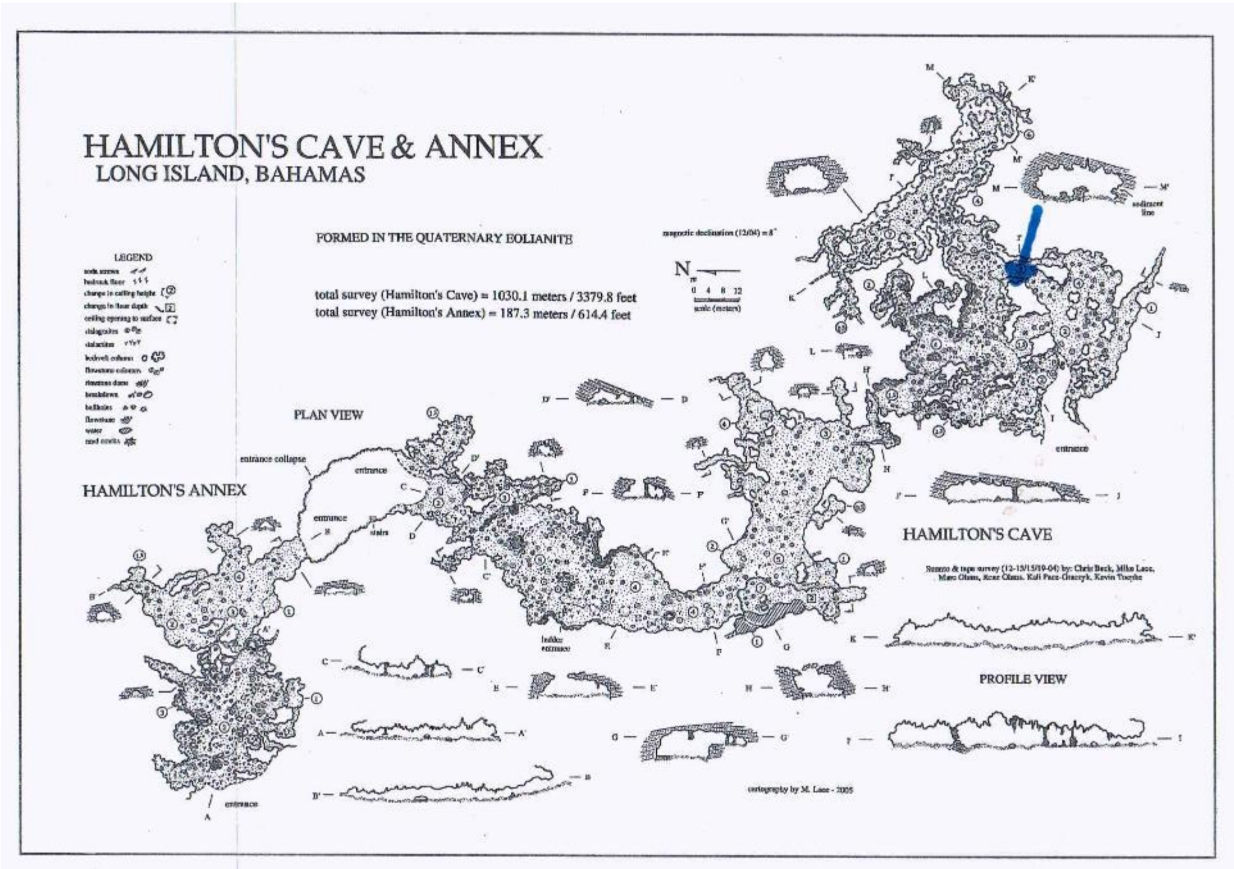

Figure 3.14 Hamilton's Cave map

Specimens were all collected in close proximity at the location indicated with the blue arrow.

LH1 is a taller stalagmite collected from Hamilton's Cave that had two spots of what appeared to be active drip water while the shorter stalagmite collected, LH4, was located only a few centimeters to the south of LH1 and only indicated active drip water on the apical tip. Two ceiling rock samples were collected from near the stalagmites as the first sample was covered in flowstone. A wall rock specimen was collected from the immediate vicinity of LH1 and LH4 and an additional wall rock was collected from across the passage. Two surface rock specimens were collected from approximately above the location of the stalagmite collection site.

Figure 3.15 Photo of stalagmite LH1 and LH4
52-mm lens cap for scale.

All samples were photographed *in situ*, collected with rock hammer and chisel, and carefully labeled. Rock samples were labeled with the upright direction indicated by an arrow drawn directly on the rock. Care was taken to make sure the removal would not be obvious to the visitors of Hamilton's Cave in the future.

Salt Pond cave was visited next on Long Island. This cave is near the coast and located on private property. It is also a habitat of many bats, primarily Buffy Flower Bats. The cave has been flooded by multiple hurricane events with the most recent hurricane line clearly visible on the cave walls (Figure 3.17).

Two stalagmites were selected for collection from this cave. They were both deposited on the same base rock in immediate proximity (Figure 3.18). The stalagmites were collected from a location in the cave identified as optimal for the purposes of this study. The immediate proximity required the collection of only one ceiling rock, wall rock and surface rock specimen at this location.

Immediately beneath the base of stalagmites LS1 and LS4 a West Indian Topshell was discovered (Figure 3.19). The stalagmites were carefully photographed, collected with rock hammer and chisel, and labeled. The rock samples were collected in the immediate vicinity of the stalagmite specimens and labeled with an arrow directly on the sample to indicate the upright direction. The specimens were all carefully washed to remove any organic matter for clearance of U.S. Customs and wrapped with the permission for specimen export form.

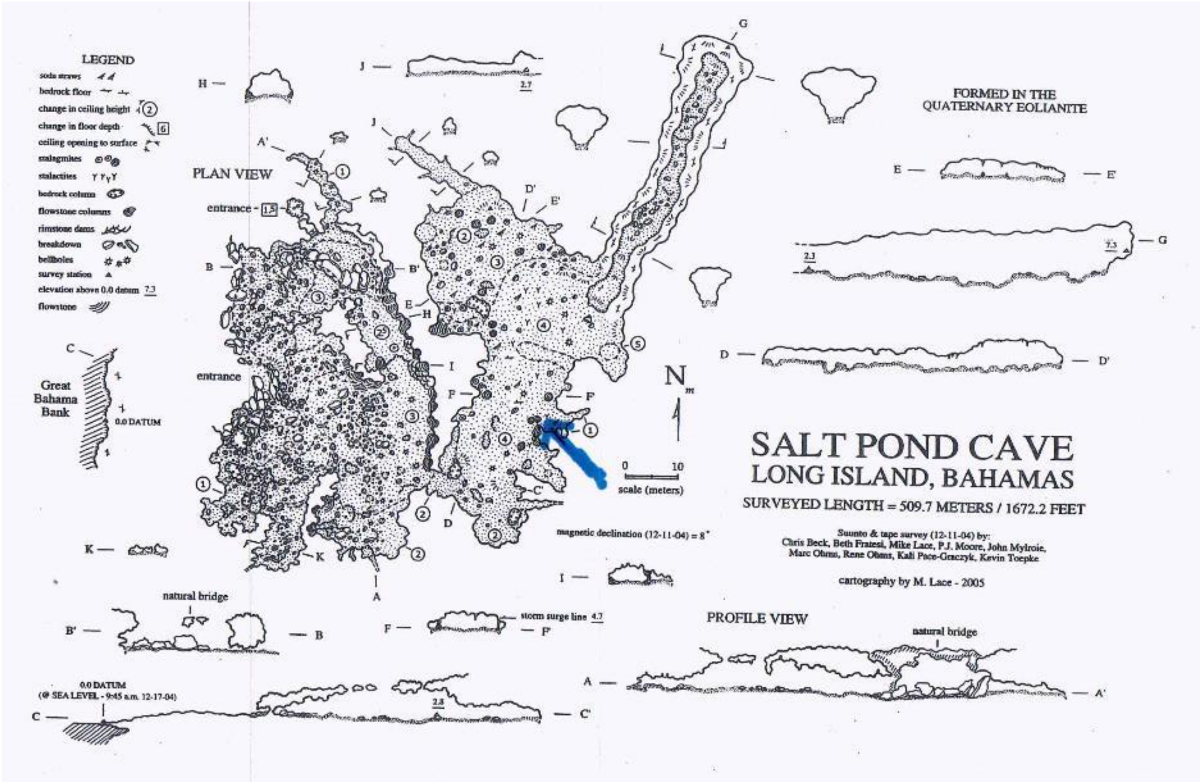

Figure 3.16 Salt Pond Cave map

All specimens were collected in close proximity at the location indicated by the blue arrow.

Figure 3.17 Photo of hurricane flood lines

Dr. John Mylroie showing the flood lines created by historic hurricanes in Salt Pond Cave.

Figure 3.18 Photo of stalagmites LS1 and LS4

Closer stalagmite is LS1 with LS4 immediately behind. 52-mm lens cap for scale.

Figure 3.19 Photo of Salt Pond Cave specimens

A West Indian Topshell (LS6, located to the right of the label) is *in situ* where it was found underneath the base shared by LS1 and LS2 (base is top center). Ruler is 10-cm for scale.

Abaco was visited next during June of 2013 for the fieldwork required for this research. It is the island located furthest north in the study area and has the highest average annual precipitation of the three Bahamian islands in this study. Abaco is surrounded by many cays and islets. The caves collected for in this study were located on the southern end of the main island (Figure 3.20).

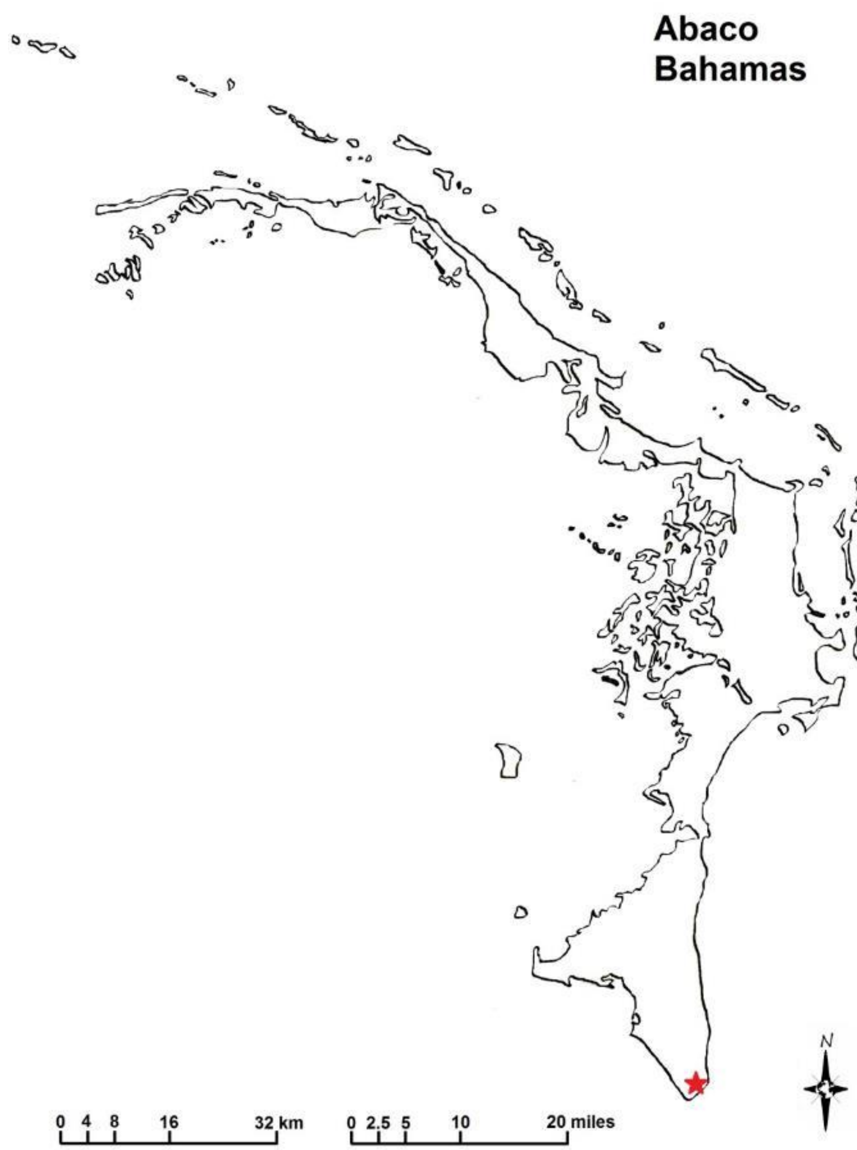

Figure 3.20 Map of Abaco, Bahamas

Caves collected from were Hole in the Wall Cave and Roadside Cave, located in close proximity on the south end of the island, indicated with a red star.

Hole in the Wall Cave was identified as a primary candidate from previous visits. This cave is named after the lighthouse named for the erosional natural bridge in the cliffs that existed until a hurricane in 2012. Three stalagmites were collected from Hole in the Wall cave with accompanying cave wall, cave ceiling, and surface rock specimens for each. AH1 was a small, actively growing stalagmite located in a tight squeeze. AH4 was collected from a crawling-height passage and AH9 was collected near the entrance.

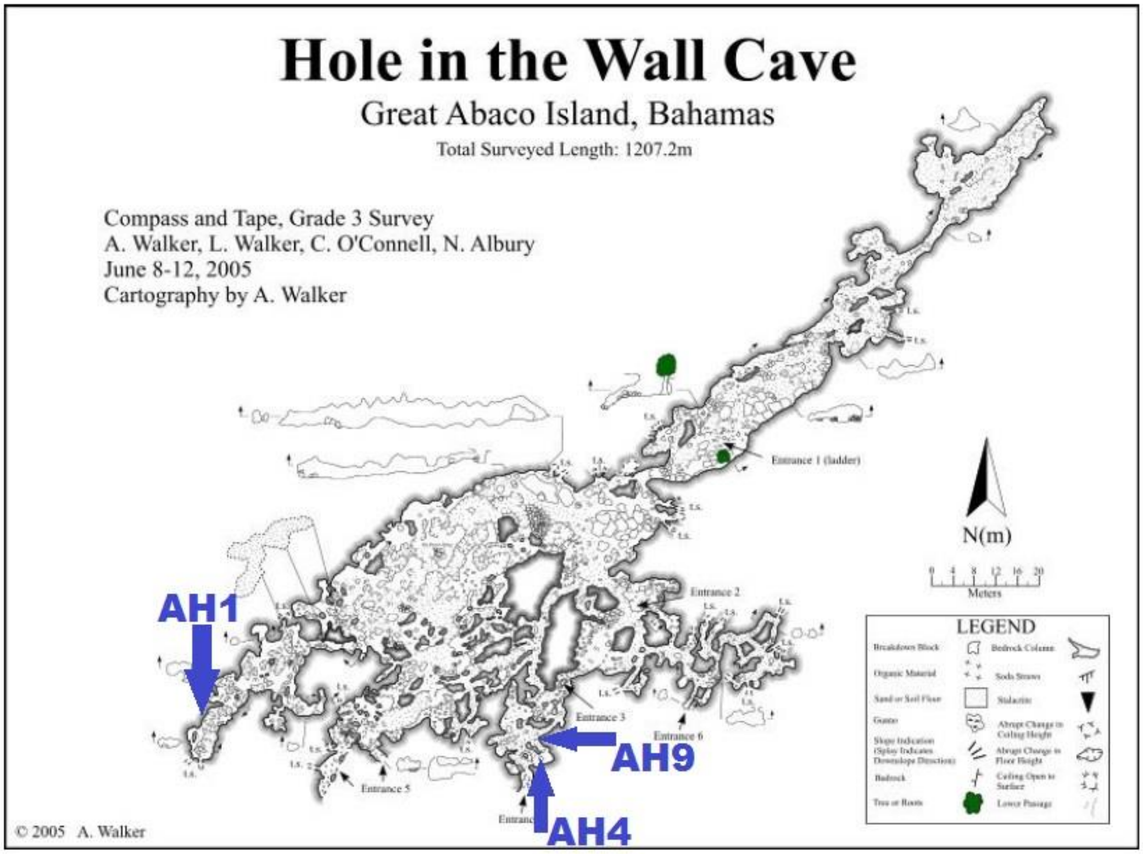

Figure 3.21 Hole in the Wall Cave map

Stalagmite collection locations are labeled.

All stalagmites were carefully photographed *in situ* prior to removal, then collected with a rock hammer and chisel. A cave wall and cave ceiling rock specimen were collected nearby for stalagmites AH1 and AH4, one set for each. A high wall/ceiling rock specimen was collected near stalagmite AH9. A surface rock was collected from the approximate area above AH1 and one surface specimen for AH4 and AH9.

Figure 3.22 Photo of stalagmite AH1

52-mm lens cap for scale.

Figure 3.23 Photo of removal of stalagmite AH4

A small cave that was recently discovered along the road that leads up to the Hole in the Wall Lighthouse (Figure 3.24) was explored and a small stalagmite collected. The cave was named Roadside Cave and sketched for reference. A stalagmite labeled AR1 (Figure 3.25) was collected along with a cave wall and cave ceiling rock nearby.

Figure 3.24 Photo of Hole in the Wall Lighthouse

Figure 3.25 Photo of stalagmite AR1

Collected in newly discovered Roadside Cave. 52-mm lens cap for scale.

The last field location to be worked was San Salvador Island. This island is inthe middle ground regarding water budget of the Bahamian islands to be sampled for this study. The location of Light House cave on San Salvador Island is indicated on Figure 3.26. Light House Cave is located in the interior of the island near the Dixon Hill Lighthouse (Figure 3.27). A metal ladder that was installed for the use of educational field trips that frequent the Gerace Research Center accesses it easily.

Figure 3.26 Map of San Salvador, Bahamas

Light House Cave location indicated with a red star.

Figure 3.27 Photo of Dixon Hill Lighthouse

Light House cave is a flank margin cave with passages partially filled with water that are subject to tidal fluctuation. It has been heavily visited by researchers and students as an excellent example of flank margin cave development. It is located a short hike from the Dixon Hill Lighthouse where it gets its name.

Two stalagmites were identified for collection after exploration and observation of speleothems available for sampling. SL4 was a larger stalagmite collected near the ladder entrance of Light House cave. A bulbous stalagmite labeled SL1 was collected near station marker "C11" and was discovered to be hollow upon removal. See Figure 3.28 for location of each stalagmite. The extent of the cavity was undetermined in the field and retained as collection due to the removal.

A cave wall and cave ceiling rock sample were collected near each stalagmite, all carefully labeled with an arrow indicating the upright direction. All samples were photographed and removed with rock hammer and chisel. Each specimen was carefully labeled for identification and wrapped with the permission to export approval form.

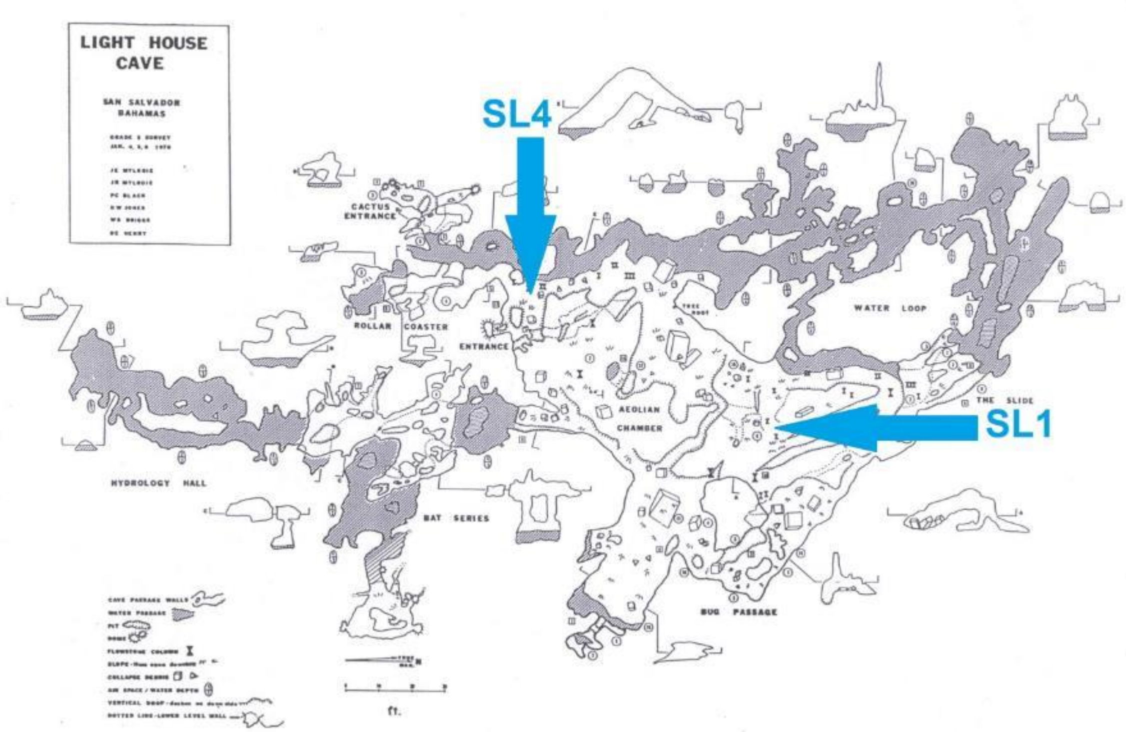

Figure 3.28 Light House Cave map

Stalagmite collection locations indicated with blue arrows and labels.

Surface samples SL7 and SL8 were collected above Light House cave approximately above stalagmites SL1 and SL4 respectively. These samples were collected with a rock hammer and labeled with an arrow indicating the upright direction written in marker directly on the specimens. All samples were carefully rinsed of all organic matter to prevent any unforeseen problems with customs as they were exported to the U.S. for research.

Figure 3.29 Photo of stalagmite SL1

Collected from Light House Cave. 52-mm lens cap for scale.

Sample Preparation

Rock Samples

All rock samples were carefully cut into blanks for the creation of thin sections. The rock blanks were each cut with a wet saw (Figure 3.30) with a diamond tipped blade manufactured for the purpose of cutting tile and stone. They were cut to specifications set by Spectrum Petrographics, the company chosen to create the thin sections. Each blank was notched with the wet saw to preserve the upright direction previously marked on the samples in the field.

Figure 3.30 Photo of wet saw

The saw used to cut rock samples into blanks the correct size for thin section preparation.

The samples were cut slowly to prevent the inversion of any aragonite into calcite and the water was changed between cave rocks to prevent contamination. The remaining rocks were bagged and labeled after drying for the use of geochemical analysis. Samples were documented and sent to Spectrum Petrographics in Vancouver, WA for production.

Figure 3.31 Photo of thin section rock blanks

Rock blanks were notched to indicate upright direction and sent to Spectrum Petrographics for thin section preparation.

The remaining rock samples were used to drill powder for use in the ICP-OES at Western Kentucky University. This was done with the use of a hand dremel, gloves, a carbide bit, and an air compressor. Three separate powder samples were drilled for each rock sample and labeled a, b and c. (e.g. CLD3a, CLD3b and CLD3c). The samples were carefully poured into a vial, sealed, and the drill bit and work area cleaned with the use of the air compressor between every sample.

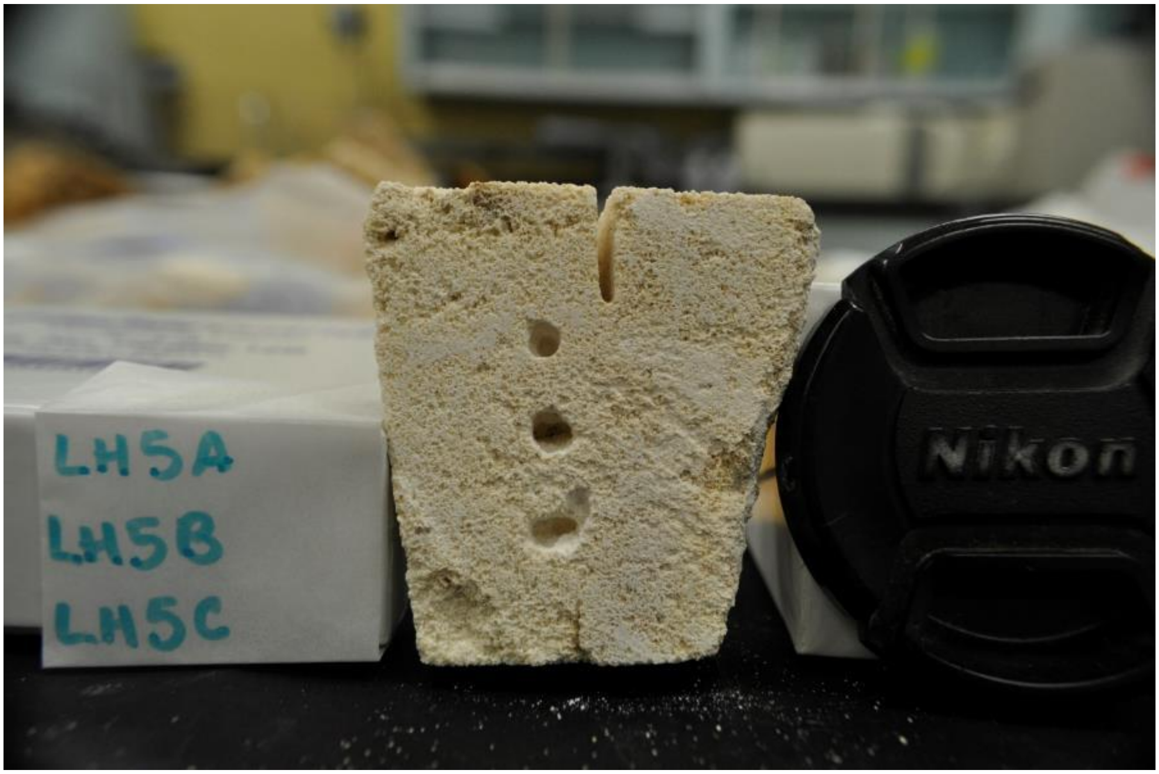

Figure 3.32 Photo of rock sample drilled for powder

Powder samples for the rock specimens were collected from different vertical distances. Nikon lens cap is 52-mm for scale.

Rock samples from Curaçao were analyzed for composition using laser ablation and ICP-MS at the Rensselaer Polytechnic Institute by Dr. Rinat Gabitov. The Bahamas rock samples as well as additional samples of the Curaçao rocks were prepared in powder form through the ICP-OES at Western Kentucky University. The process was thoroughly documented in notebook and photograph for each rock specimen for further reference if needed (Figure 3.32).

Stalagmites

The preparation of the stalagmites was done at Western Kentucky University in the Earth Sciences and Technology building under the guidance of Dr. Jason Polk. Stalagmites were cut in half parallel to the growth axis, perpendicular to the growth layers. They were then evaluated for feasibility of study. It was determined that stalagmites CH4, LS1, LS4, LH1, AH4, AH9 and SL1 were not of the quality to bother polishing and sampling for the purpose of this study. The remaining nine stalagmites included five from Curaçao, one from Long Island, two from Abaco and one from San Salvador. It was anticipated that some stalagmites from these areas would be difficult to work with. It was fortunate that five out of the six stalagmites collected from Curacao were determined to be useful. At least one stalagmite from each island in the Bahamas was found to be useful for this study upon cutting. This gave a great cross-section of each field area and saved the time and money from being spent on stalagmites that were discovered after slicing to be less reliable for elemental analysis.

Stalagmites were then carefully polished with a rotary hand tool starting with a coarse girt and moving to a finer grit one step at a time. They were finished with a final buff with 0.1 micron aluminum oxide polishing compound to get a clean view of the individual growth layers of the stalagmites. Each stalagmite was then photographed for reference in the study (Figure 3.33).

Figure 3.33 Photo of cut and polished stalagmite CH1

Drilling of the larger samples was first attempted to be drilled with the micro-mill (Figure 3.34) using a program to drill powder every 0.5 cm, but it was found these stalagmites broke easily when drilled in this manner. It was decided to hand drill the rest of the stalagmites to prevent total destruction. Stalagmites were then marked with pencil every 0.5 cm along the growth axis to indicate where to drill for powder. The dremel was used to drill samples next to each mark and carefully poured into a vial and sealed (Figure 3.35). Between every sample the air compressor was used to clean the bit and the work area to prevent contamination from prior samples.

Figure 3.34 Photo of micro-mil drilling on stalagmite CLD2

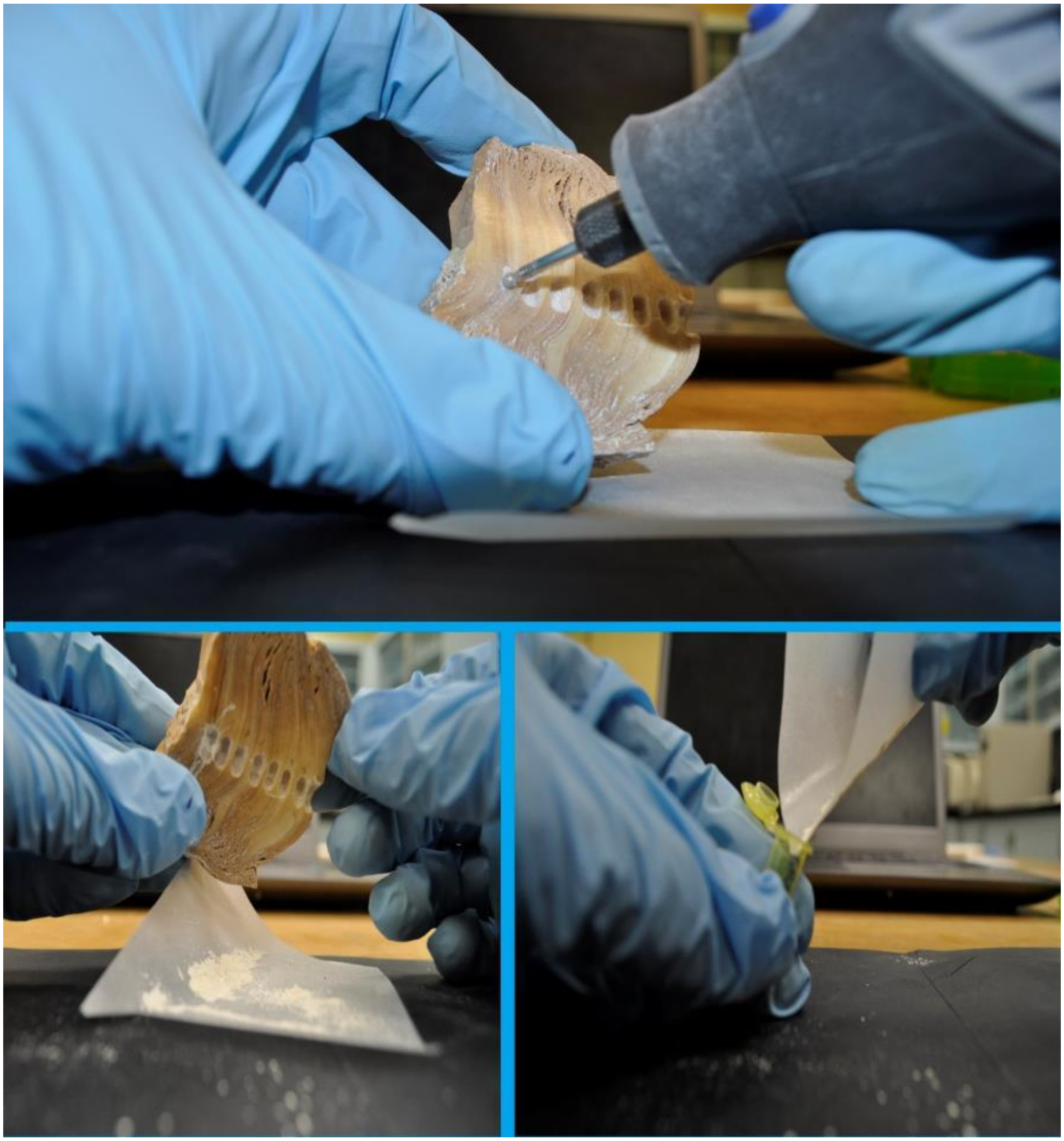

Figure 3.35 Photos of hand drilling stalagmite powders

Top: Hand drilling the stalagmite specimens every 0.5 cm. Bottom Left: Making sure all powder is deposited on the weighing paper Bottom Right: carefully pouring the powder into a vial for storage.

All powders were placed in vials that were labeled twice to ensure accuracy. The stalagmites and rock specimens are currently in storage at Western Kentucky University under the care of Dr. Jason Polk as a collaborative research effort. All steps were carefully documented in a lab notebook as well as photo documented for reference.

ICP-OES Preparation and Operation

After all powders for rock samples and stalagmite samples were drilled they were taken to the Advanced Materials Institute for preparation. There the powders were carefully weighed into digestion tubes to be about 0.01g per sample. The precise weight for each powder sample was recorded in the lab notebook and was ensured to never be below 0.010 g or above 0.018 g for consistency. A Libror AEG-455M balance (Figure 3.36) was used for all powder weighing.

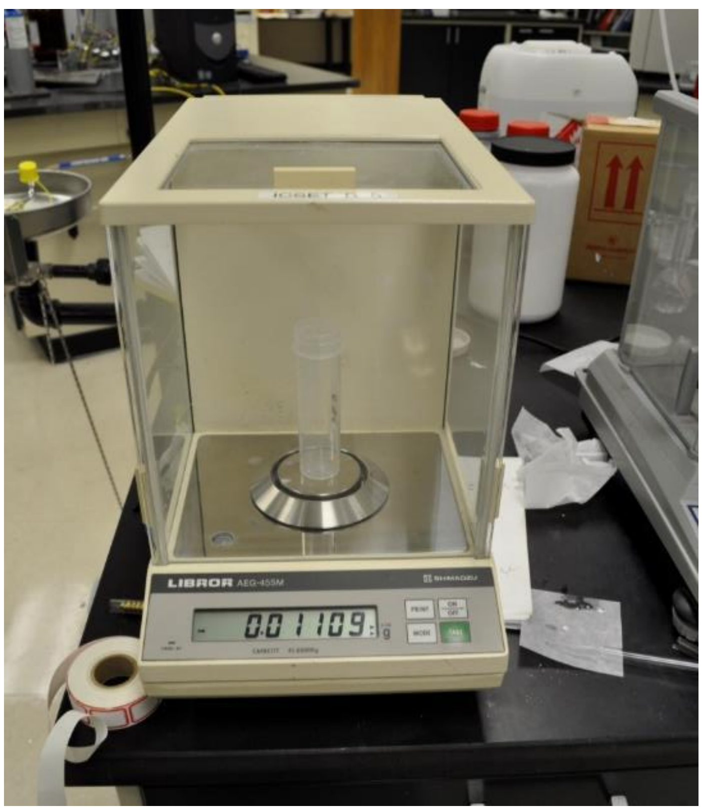

Figure 3.36 Photo of balance

The weighed powder samples in the digestion tubes were then digested (Figure 3.37) by adding 1 mL of trace metal grade nitric acid and 9 mL of nano-pure water. The solution was created in the digestion tubes, the caps screwed on loosely, and placed on a hot block for 30 minutes to complete the digestion process. After completion of digestion the samples were removed from the hot block and the lids tightened to ensure proper seal.

Figure 3.37 Photos of the digestion process

The digestion process of nitric acid (left) measured precisely with pipettes (top right) into the digestion tubes with weighed powder samples and nano-pure water then placed on the hot block (bottom right) to complete digestion.

Six standards were created for the ICP-OES calibration including a blank, 0.5 ppm, 1 ppm, 2.5 ppm, 5 ppm and 10 ppm solutions of various elements including Ca, Sr, Mg, U and more (Figure 3.38). These solutions were loaded into the ICP-OES auto-sampler (Figure 3.39) and the Ostracod method was selected as the method for operation.

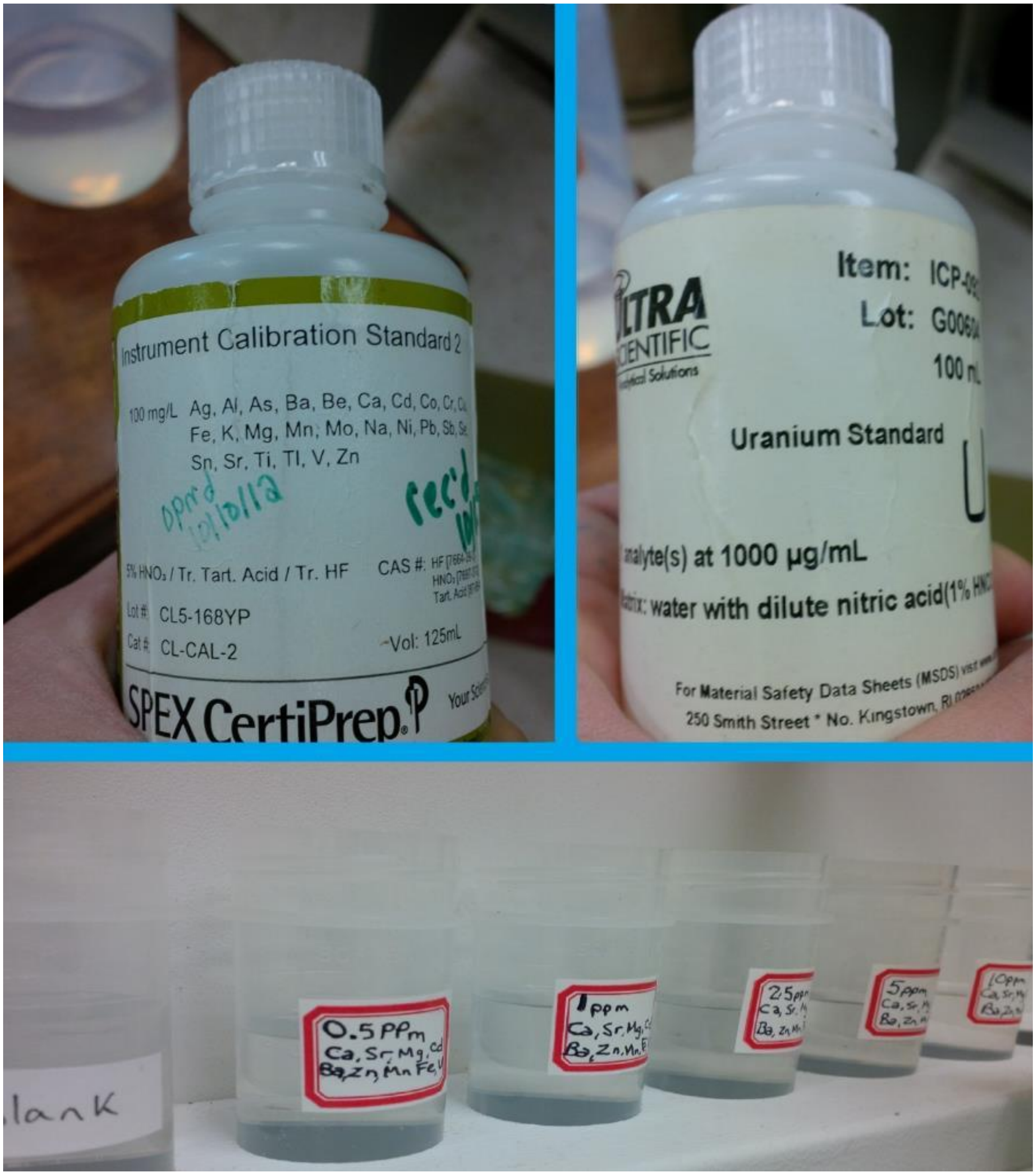

Figure 3.38 Photos of calibration standards preparation

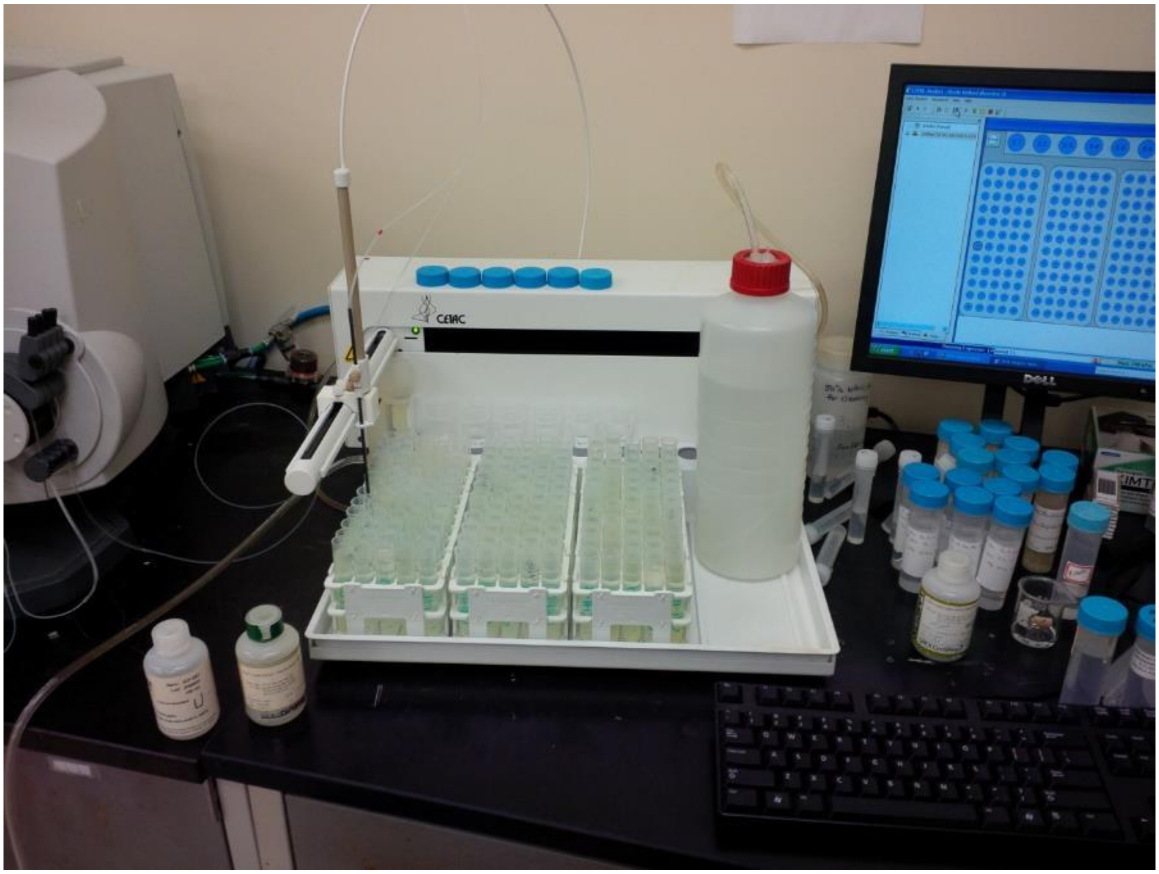

Figure 3.39 Photo fo the ICP-OES auto-sampler

The samples were then poured from the digestion tubes into the ICP tubes and loaded into the auto-sampler, each sample label carefully written on the tube as well as entered into the computer program for proper recording. Two blanks were placed for every tray for complete flushing of the system. A fully-loaded machine could run 232 samples once the two blanks per tray were added. There were a total of 393 samples to be run at full strength.

The ICP-OES is a machine that uses a plasma torch (Figure 3.41) to vaporize the samples while a sensor reads the resulting spectrum. The acronym stands for Inductively

Coupled Plasma Optical Emission Spectrometry. The equipment used at the Advanced Materials Institute of Western Kentucky University was a Thermo Scientific 1CAP6500 Duo (Figure 3.40). Each element is associated with certain wavelengths and is recorded by the computer. Elements have multiple wavelengths and all selected wavelengths are recorded in the data. In this case argon case is used to produce the plasma torch.

Figure 3.40 Photo of the ICP-OES at Advanced Material Institute of WKU

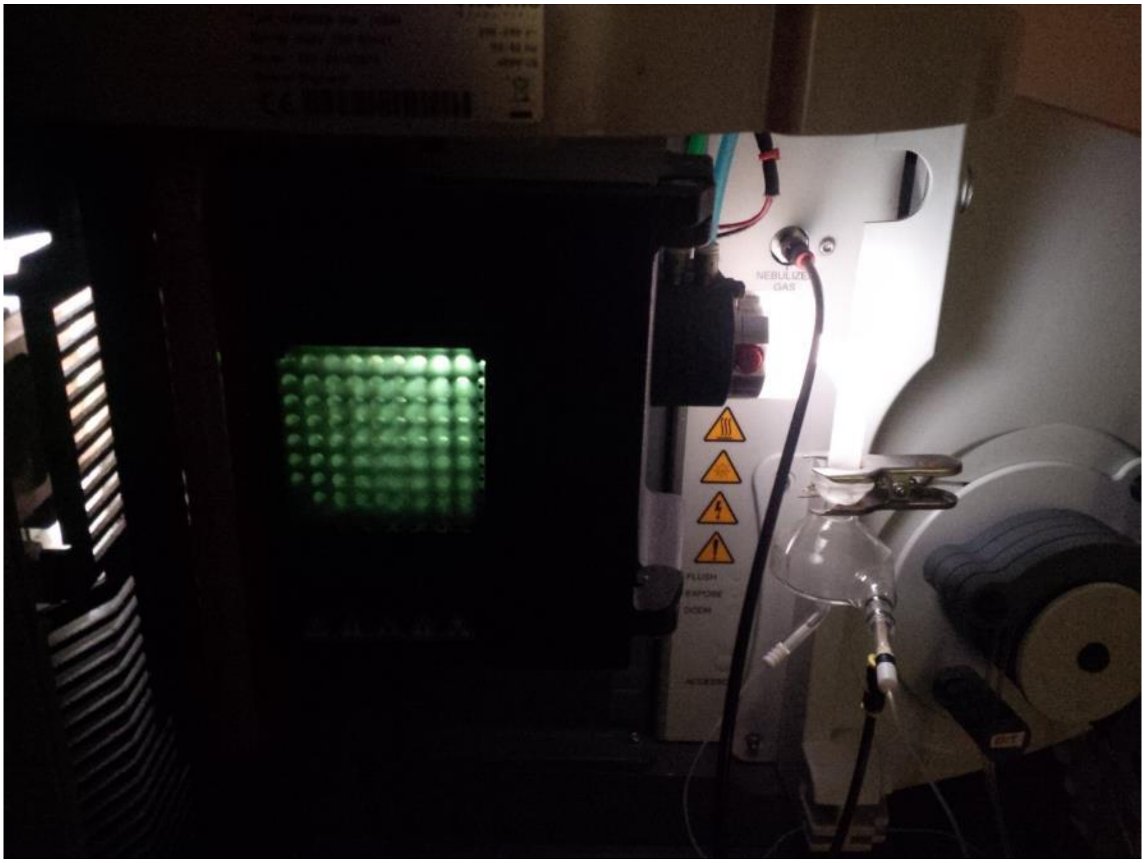

Figure 3.41 Photo of the ICP-OES plasma torch

It was observed that the full-strength solution was so high in calcium that the ICP-OES was overwhelmed by the wavelength and was not detectable at a proper concentration. The 393 samples were ran a second time at a 1:100 dilution to get the data for calcium. Full strength solution still provided useful data at a high resolution for Sr and Mg necessitating the running of all solutions twice to get the full range of data.

Once all 786 samples and blanks were processed, reports were created using the software on the computer that runs the ICP-OES. It created a large Excel document of all the data produced from the digested powder samples. Remaining powder was retained in the case any samples necessitated a second run on the machine.

XRD Analysis

A Rigaku SmartLab X-ray Diffraction System (Figure 3.42) located at the Institute for Imaging and Analytical Technologies (I^{2}AT) on Mississippi State University's campus was used to obtain mineralogy identification of the rock specimens. Powder samples, already prepared for use in the ICP-OES processing, in excess, were used for the XRD processing. In this machine radiation is diffracted by the powder sample at different angles. Minerals that have the same chemical composition, but differing crystal structures, will cause the scintillation detector of the XRD to detect peaks in the radiation at different angles. Aragonite and calcite have the same chemical composition that could be indeterminable by spectrometry.

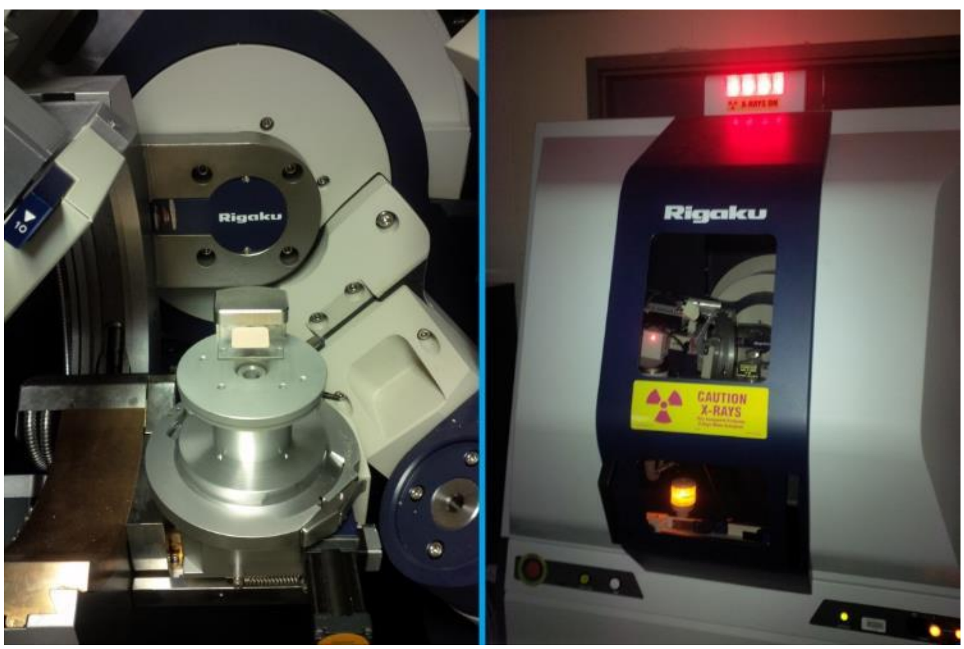

Figure 3.42 Photos of the XRD machine

The Rigaku XRD machine located at I^{2}AT on Mississippi State campus. Left photo shows a powder sample prepared and loaded for processing, right photo shows the XRD in use.

CHAPTER IV

RESULTS

Thin Sections of Rock Samples

The rock sample blanks sent off to Spectrum Petrographics in Vancouver, WA were returned within a couple months. Due to the eogenetic nature of the rock samples a blue epoxy had to be used to fill in the pores in order to facilitate the thin section creation process. The notch to indicate the upright direction was preserved in thin section to help aid in interpretation of the rocks. The thin sections were then reviewed under microscope to identify allochems as well as potential mineralogy. All thin section images are in Appendix B.

Curaçao Rock Samples

Rock samples from within the lower terrace of Curaçao contained well-preserved fossils when collected from inside the cave. The rock specimen collected from the surface was highly altered. In both cases, crystals growing into the pores of the rock from all directions indicated vadose conditions during crystallization. The cave rocks had abundant forams and red algae. Pore spaces that suggest the prior presence of aragonite allochems were found. A slide from Lardem Cave is shown in Figure 4.1. The surface rock collected from above Lardem Cave contained some aragonitic corals.

The caves in the higher terraces had progressively less preserved fossils and different pore spaces. The rock samples from within Raton cave, in the middle terrace, displayed predominantly broken fossil pieces with the exception of echinoderm spines which were remarkably preserved and, fortunately, sliced perpendicular to the length to display striking gear-like allochems (Figure 4.2). The rocks collected from within Raton Cave contained abundant forams, red algaes, and voids shaped like bivalves suggest that aragonite allochems have previously been present. The rocks collected from above Raton Cave did still have some aragonitic coral present. The rocks collected from the oldest carbonate terrace, from within Hato Cave, displayed abundant forams, echinoderm spines, and voids that suggest prior presence of coral. The rock specimens collected from the surface above Hato Cave were well cemented and the only allochems that remained were forams, echinoderms and red algae. Voids that had a shape that suggested the prior existence of coral were found in the samples.

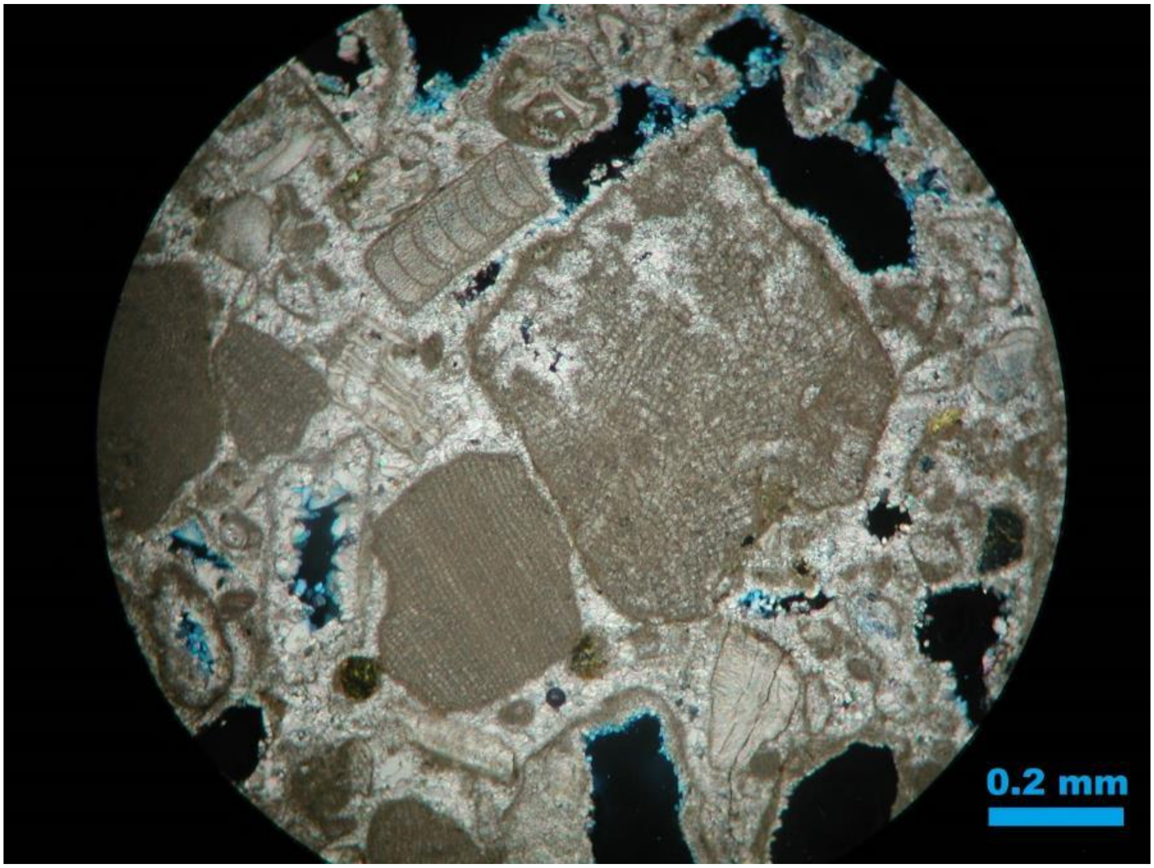

Figure 4.1 Photo of thin section of Lardem Cave rock

Rock collected from within the cave, which is located in the youngest mid-Pleistocene carbonate terrace.

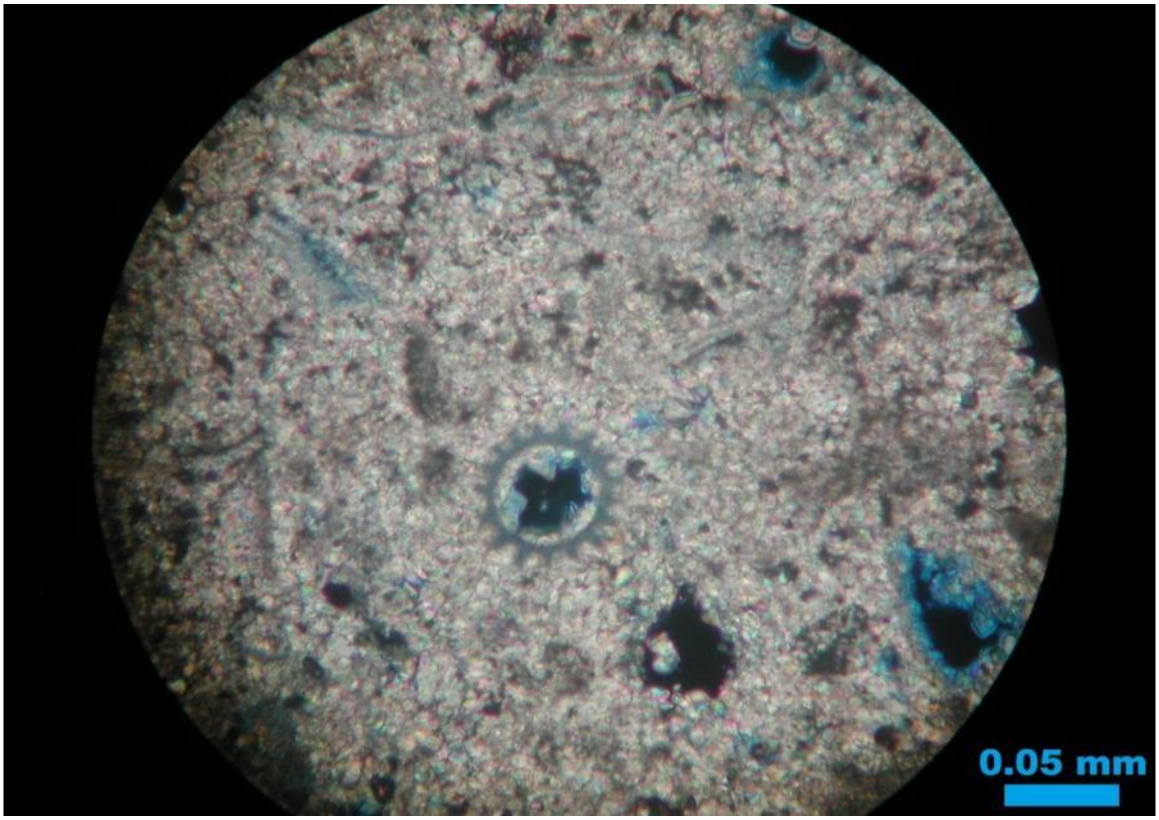

Figure 4.2 Photo of thin section of Raton Cave rock

Collected from Raton Cave in the middle terrace of Curaçao, this sample contained a remarkably well-preserved echinoderm spine (near image center).

Bahamian Rock Samples

The rocks from the Bahamas are all calcarenites with well-sorted peloidal bioclastic eolianites. The rocks from Abaco are poorly cemented and contain allochems of forams, red algae, echinoderms and a few bivalves. San Salvador's rocks contain allochems of forams, red algae, green algae, gastropods and some coral. The rocks from Long Island, Bahamas are predominantly composed of red algae and forams. The cave rocks from all of these locations were poorly cemented in comparison to the surface rocks. Photos of all thin sections can be found in Appendix B.

Curaçao Stalagmites

The levels of Sr in the stalagmites from Curaçao, averages 8.68 ppm Sr and 8.28 ppm Sr in Lardem Cave, located in the youngest eogenetic carbonate of this study, were notably higher than the Sr of Raton (averages of 0.31 ppm Sr and 0.30 ppm Sr) or Hato (an average of 0.25 ppm Sr) (Figure 4.3). The stalagmites in Raton and Hato were close in value although it was discernable that overall the stalagmite from Hato had a lower Sr ppm than the stalagmites of Raton in the middle terrace (Figure 4.4).

The majority of the stalagmites from Curaçao show a trend of increasing Sr ppm progressing down the axis (to older material) indicating that Sr levels have decreased over time. There are some small scale variations that are noted in the data likely due to seasonal or climatic fluctuations. It is important to note that since all three of the caves in the study area are located within a few kilometers of each other the same change would have taken place at all cave locations at the same time.

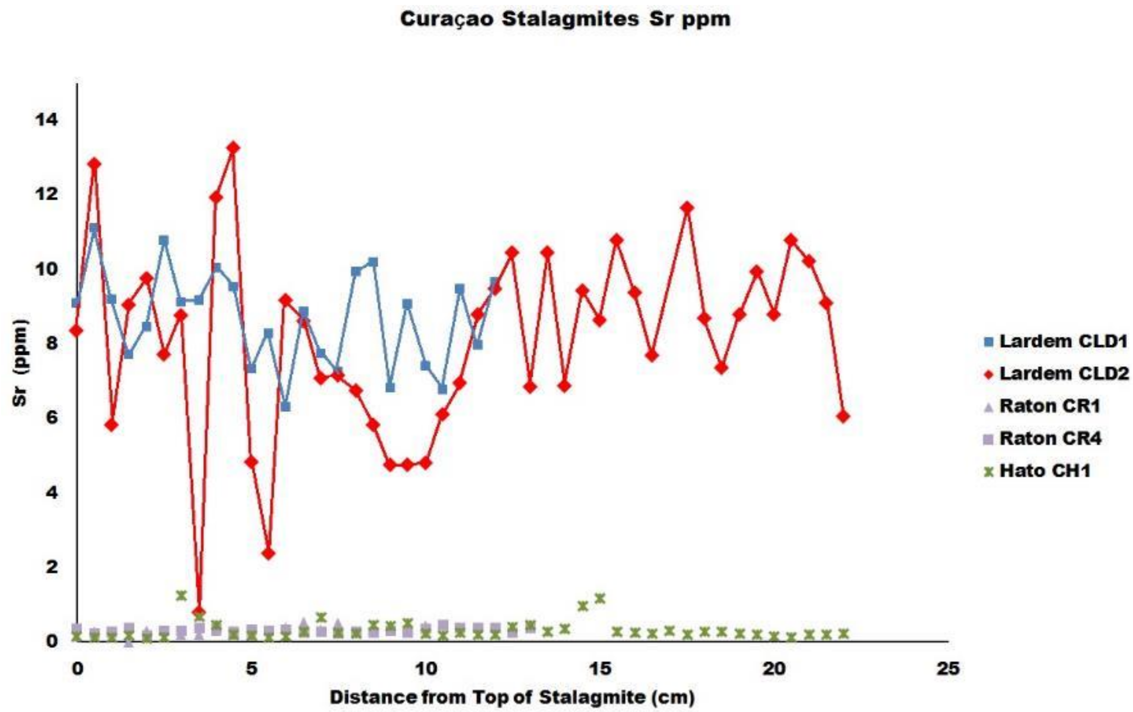

Figure 4.3 Sr ppm for stalagmites of Curaçao.

Note that Lardem is a cave located in the youngest rock unit while Hato is a cave in the oldest rock unit of this study.

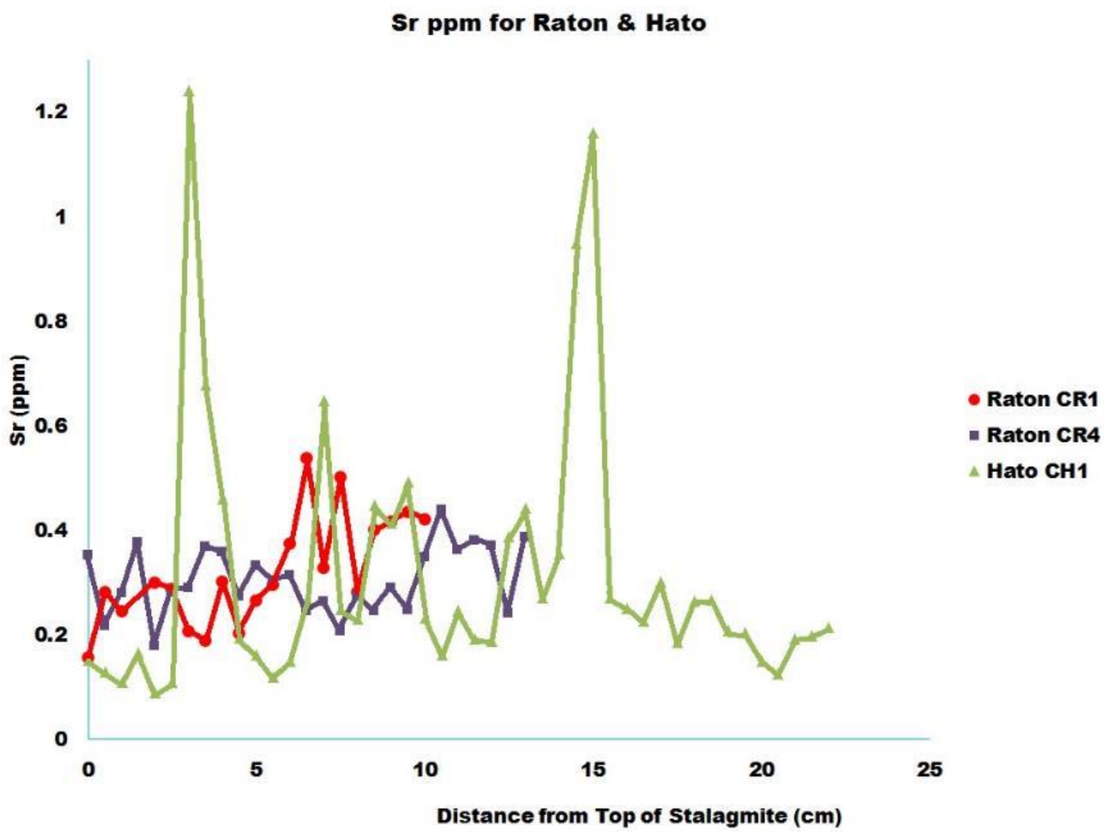

Figure 4.4 Sr ppm for Raton Cave and Hato Cave stalagmites

Expanded in scale from Figure 4.3.

When an image of the stalagmite is placed in the plot, so that the data points on the X-axis align with the sample spot location, changes in the visual appearance of the stalagmite sometimes reflect a change in Sr concentration of the sample (Figure 4.5 and 4.6). These appear to be hiatus points in the stalagmite growth, a time of indeterminable length where precipitation ceased and the water chemistry changed.

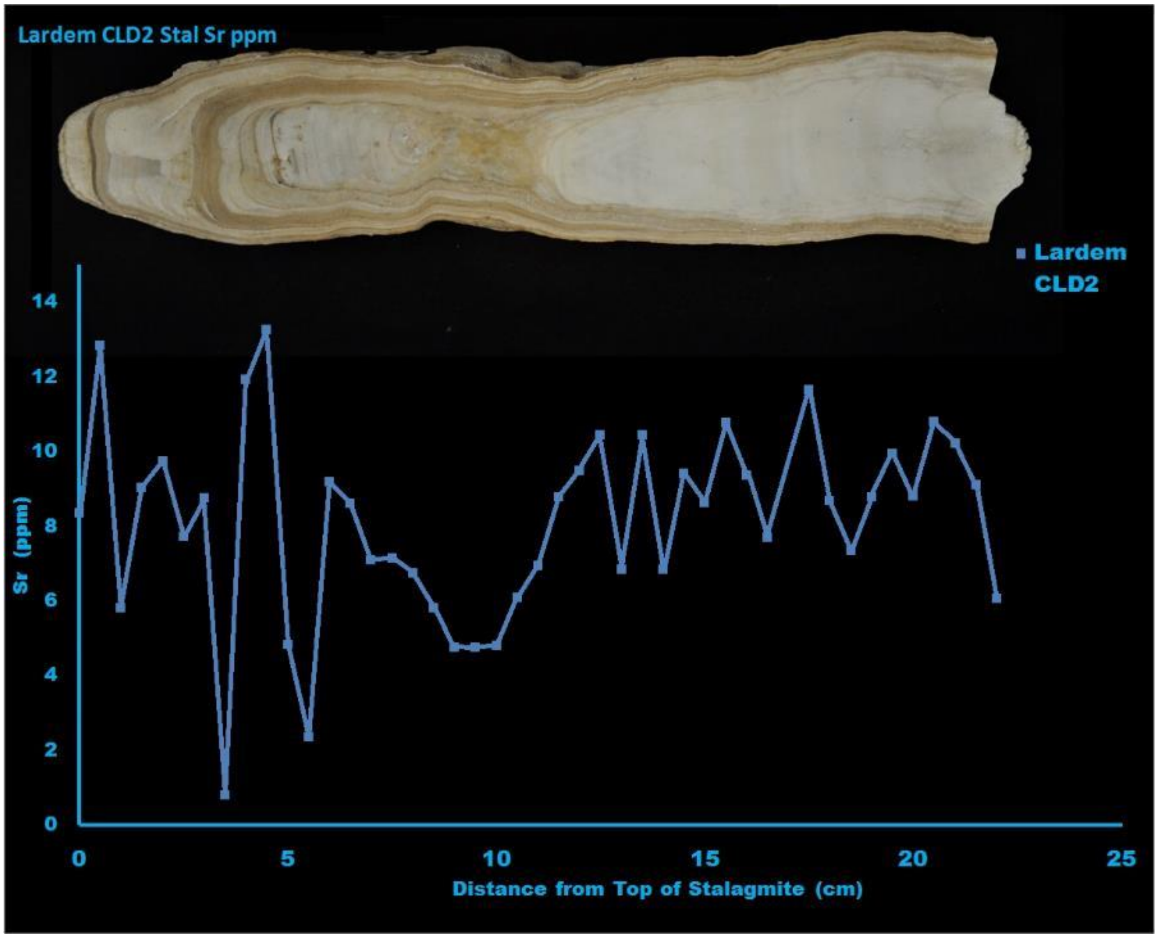

Figure 4.5 Sr ppm for stalagmite CLD2

The photo of the stalagmite is aligned with the x-axis sample locations. Note the change in Sr ppm is in line with stalagmite appearance.

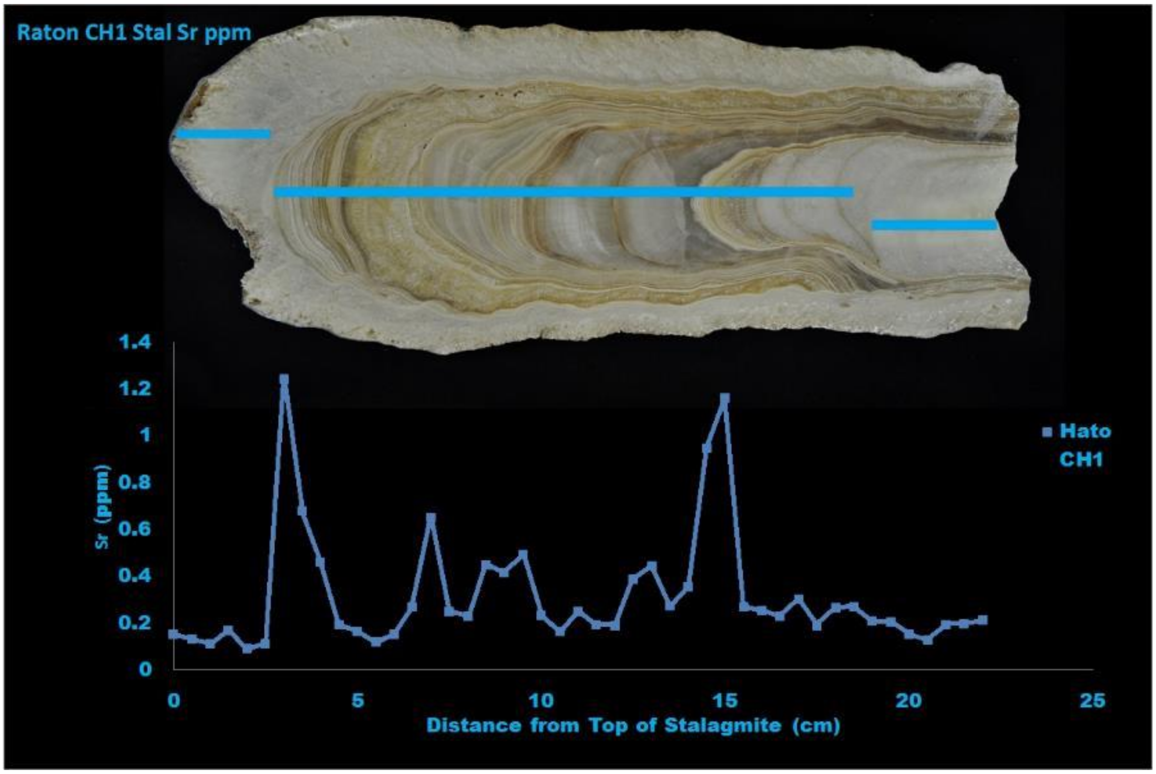

Figure 4.6 Sr ppm for stalagmite CH1

The x-axis is aligned with the sample locations on the photo of the stalagmite above. The peaks appear to align with distinct changes in stalagmite appearance.

One way to look at the Sr content of the stalagmites is in comparison to Mg. As the Sr is depleted from the rock above Mg would become a higher percentage of the rock content simply by subtraction of other elements. Mg does not actually increase in amount but rather other elements decrease leaving Mg having less competition as dissolution occurs. The plot showing Sr ppm and Mg ppm for Lardem stalagmite CLD2 shows an interesting inverse relationship of these two elements. The plot showing the Sr ppm and Mg ppm for the stalagmite from Hato shows a higher level of Mg concentration and a lower Sr concentration. See Figures 4.7 and 4.8.

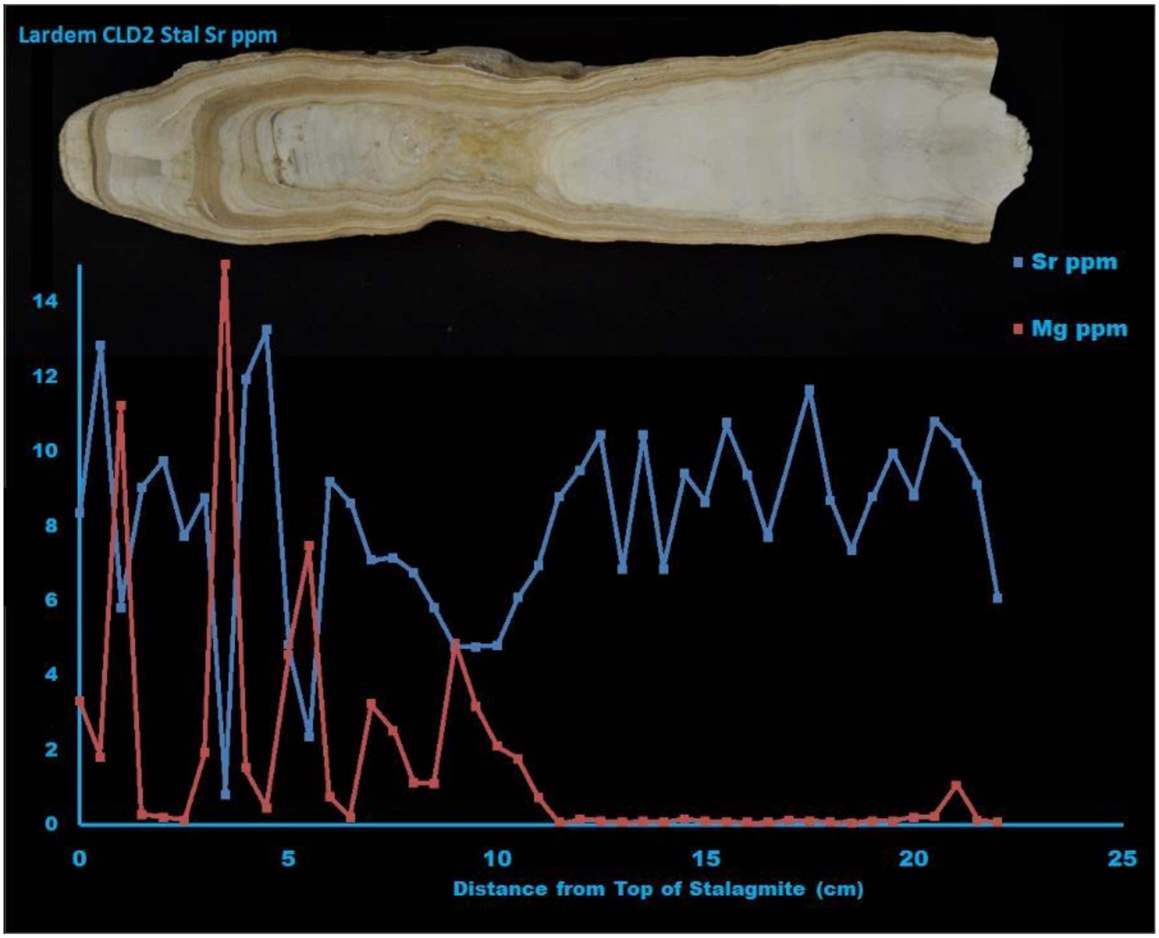

Figure 4.7 Sr and Mg ppm for stalagmite CLD2

The Sr ppm and Mg ppm for stalagmite CLD2 located in Lardem Cave in the late-Pleistocene carbonate on Curaçao. Note the troughs of Sr concentration 10 cm and higher correlate with a peak in Mg concentration. The vertical axis indicates ppm.

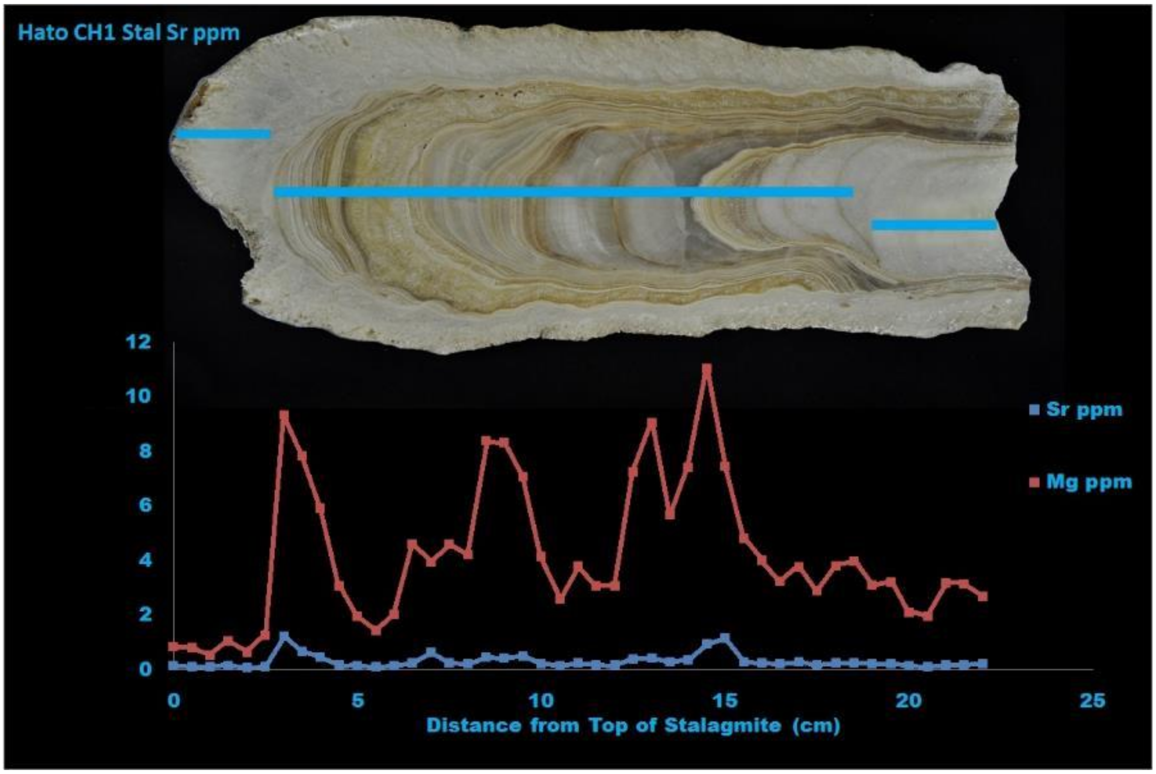

Figure 4.8 Sr and Mg ppm for stalagmite CH1

The stalagmite collected from Hato Cave located in the oldest mid-Pleistocene carbonate unit on Curaçao. The vertical axis indicates ppm. Note the Mg concentrations are higher than the Sr concentrations as opposed to Figure 4.7 showing a stalagmite from Lardem Cave.

The stalagmite from Hato Cave in the oldest carbonate terrace of the study area has a Sr concentration that is an order of magnitude lower than the Sr in the stalagmite of Lardem. The Mg concentration of Lardem is lower than the Mg concentration of Hato. As the water infiltrate travels through the overlying rock it will pick up the Sr preferentially if it is present. If Sr has been depleted from the rocks the water could pick up the Mg.

Curaçao ICP-OES Rock Data

The rock samples collected tell a story about the chemistry of the rocks at present. As expected the Sr levels in the surface rocks decreased with age and also with distance from the shoreline (Figure 4.9). The location of the terraces on Curaçao, with the oldest at the highest elevation and the youngest at the lowest elevation closest to the coast, can further influence the amount of trace elements. It is expected that Sr may be incorporated in the rock as a result of sea spray. In fact, the surface rocks above Lardem, located only 20 m from the coast, have an order of magnitude greater Sr than the Sr content of the interior cave rocks.

Rock samples from within the cave tell a different geochemical story. Hato rocks seem overall depleted of Sr and Mg in comparison to the younger Raton and Lardem rocks. The Lardem and Raton specimens have an interesting relationship, especially when coupled with the Mg ppm data from the same rock specimens. Lardem cave rock samples, both wall and ceiling, seem to be overall lower in Sr ppm than Raton and the stalagmites from within Lardem (Figure 4.10). The Mg ppm is the opposite, with Lardem being higher and Raton being lower (Figure 4.11).

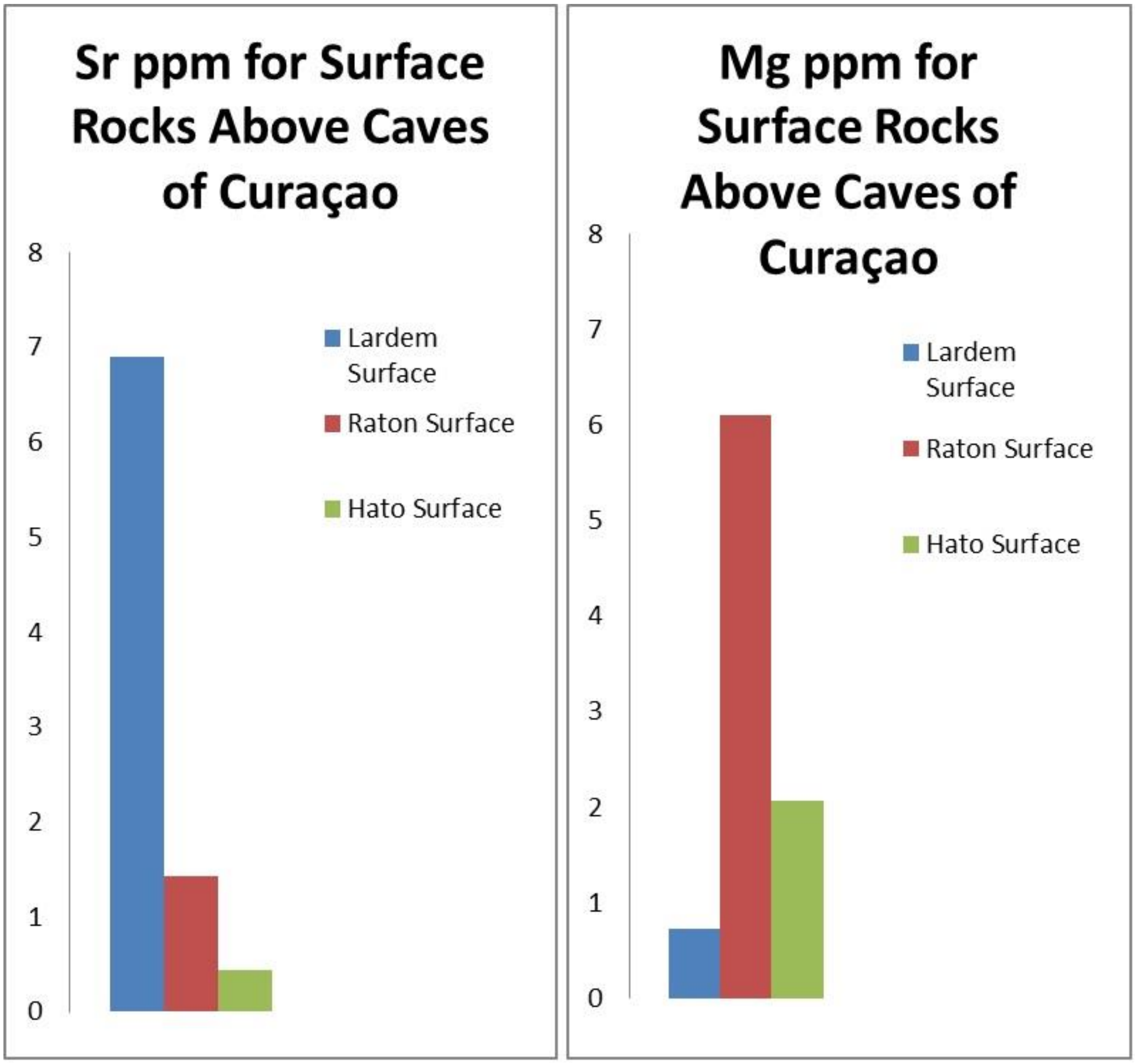

Figure 4.9 Sr and Mg ppm for Curaçao surface rocks

The averages of Sr and Mg ppm levels for surface rocks collected from above each of the three caves. Sr standard deviation of 0.026 and Mg standard deviation of 0.0255.

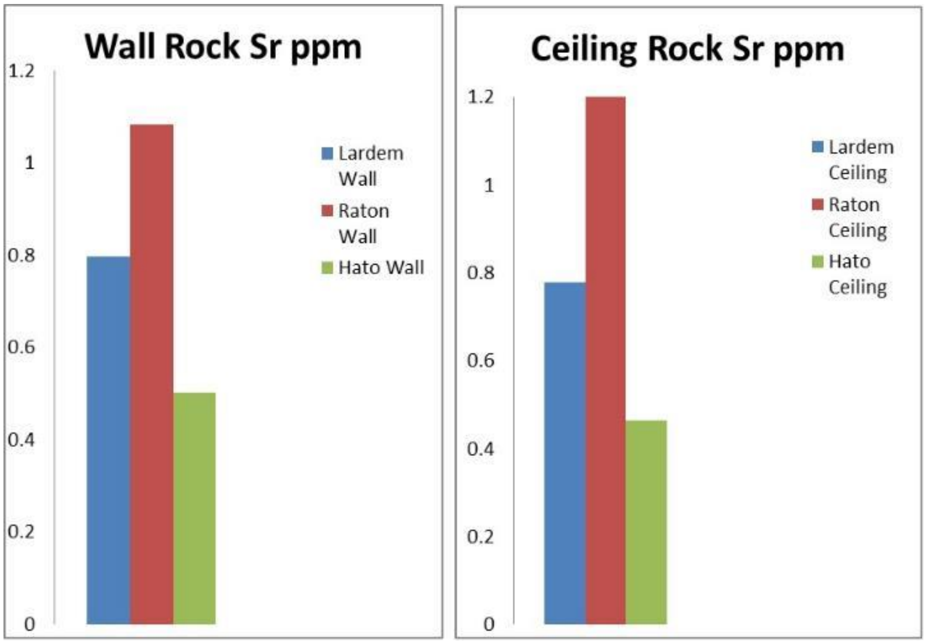

Figure 4.10 Sr ppm for wall and ceiling rock on Curaçao

Sr ppm for wall and ceiling rocks from within Curaçao caves. Standard deviation was 0.036.

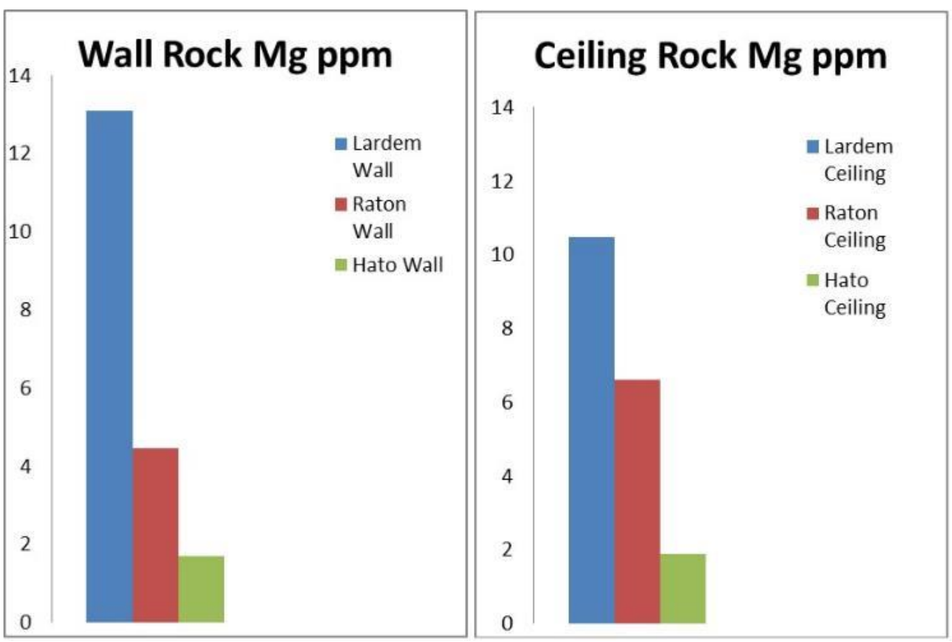

Figure 4.11 Mg ppm for wall and ceiling rock on Curaçao

Mg ppm for wall and ceiling rocks from within Curaçao caves. Standard deviation was 0.040.

Curaçao XRD Data

The XRD at I^2AT was used over the course of a few days to determine the mineralogy of the rock samples collected. The results from the rock powder samples from within Lardem Cave, Raton Cave and Hato Cave were all determined to be primarily calcite in mineralogy. The surface rocks collected from above Lardem Cave, located in the youngest, lowest carbonate terrace of the Curaçao study area, was found to contain a mix of 40% aragonite and 60% calcite (Figure 4.12). The surface rocks above Raton Cave and Hato Cave, located in the older, higher carbonate terraces, were both primarily calcite. All of the XRD sample results are located in appendix D.

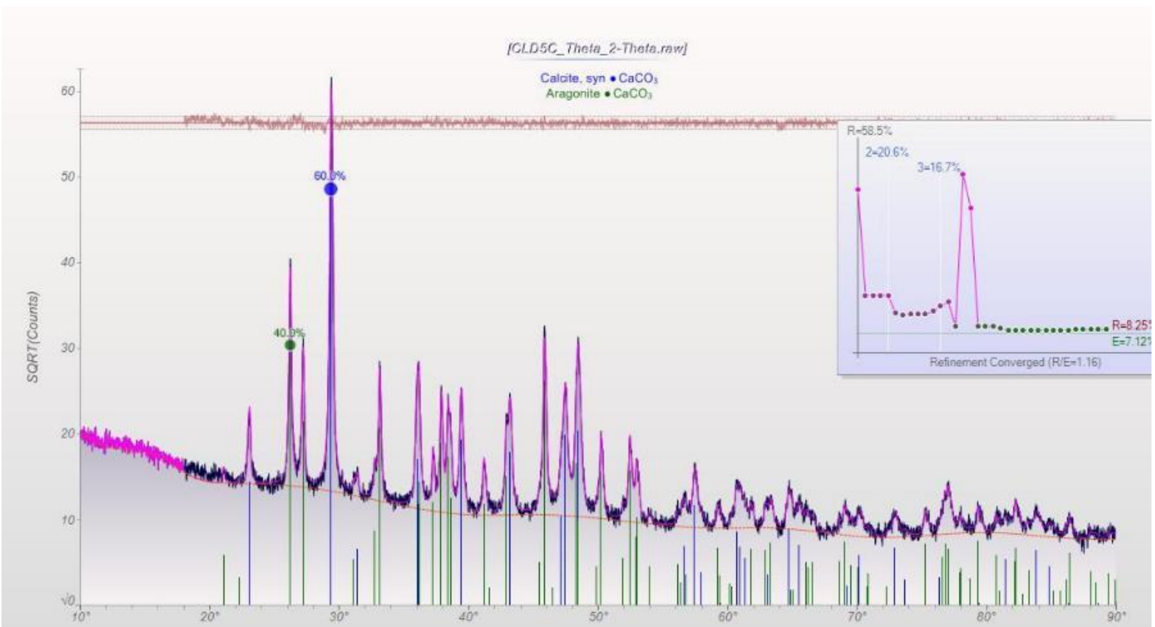

Figure 4.12 XRD results for Lardem Cave surface rock

The XRD results for the surface rock collected above Lardem Cave, located in the youngest carbonate terrace of Curaçao, indicating 40% aragonite and 60% calcite mineralogy.

Bahamian Stalagmites

The hypothesis for the Bahamian stalagmites was that for stalagmites located within rock units of similar age the stalagmite that grew in the driest climate at the same time as a stalagmite in the wettest climate would have a higher Sr level. The increased meteoric fluid flux of the furthest north study area, Abaco, should deplete the Sr levels faster than an island in the southernmost of the Bahamian study area, Long Island. A concern for this part of the study is having an accurate age for the host rock.

The Sr data for the stalagmite from San Salvador, SL4, had a very high Sr ppm in comparison to the stalagmites from Abaco, AH1 and AR1 (Figure 4.13). The samples closest to the top of this particular stalagmite were likely to be contaminated by the tidal influx in Light House cave. The Long Island stalagmite collected from Hamilton's Cave was lower in Sr concentration than both stalagmites collected from Abaco and the stalagmite collected from San Salvador. Not only was the Long Island stalagmite depleted of Sr it was also depleted of Mg (Figure 4.14).

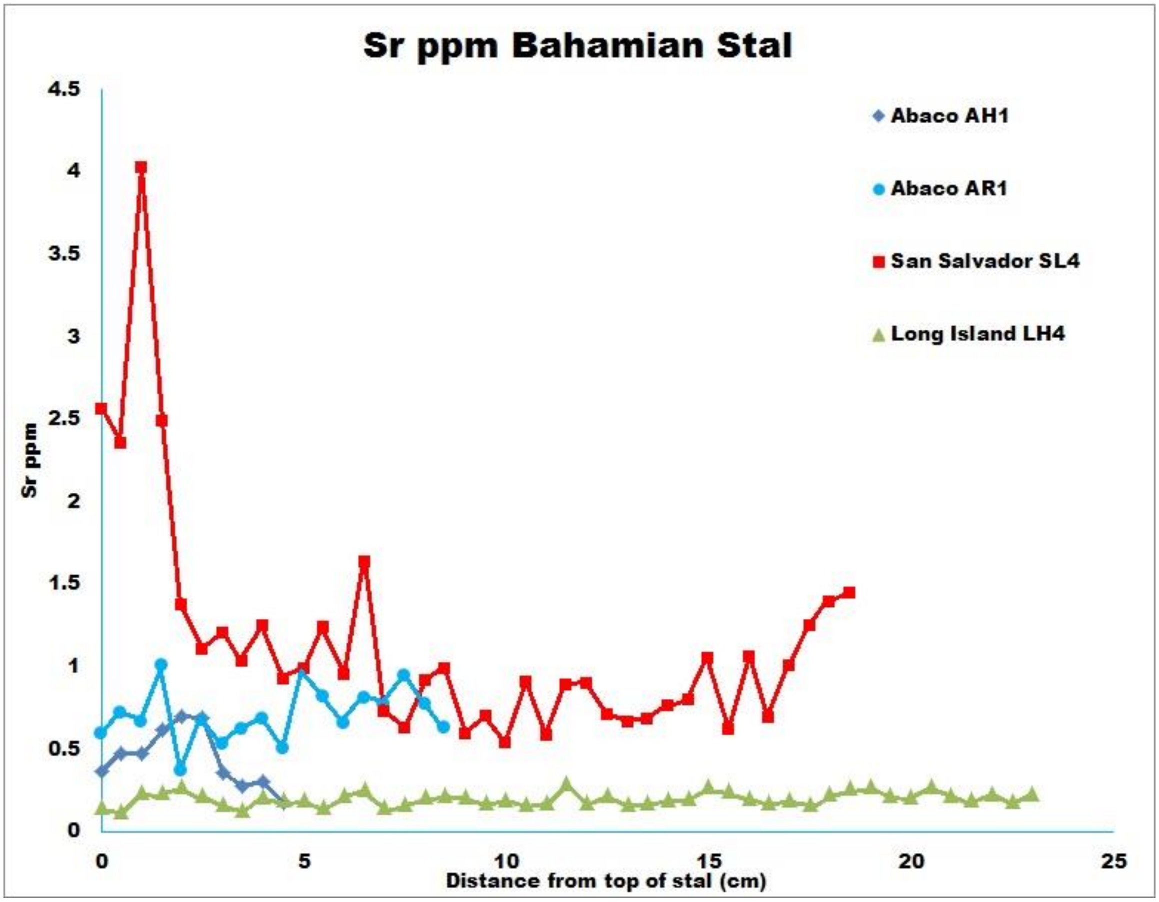

Figure 4.13 Sr ppm for Bahamian stalagmites

The Sr content of the stalagmites collected from the Bahamas. The San Salvador stalagmite was collected in an area of cave inundated during high tide. Abaco has the highest rate of rainfall and Long Island has the lowest.

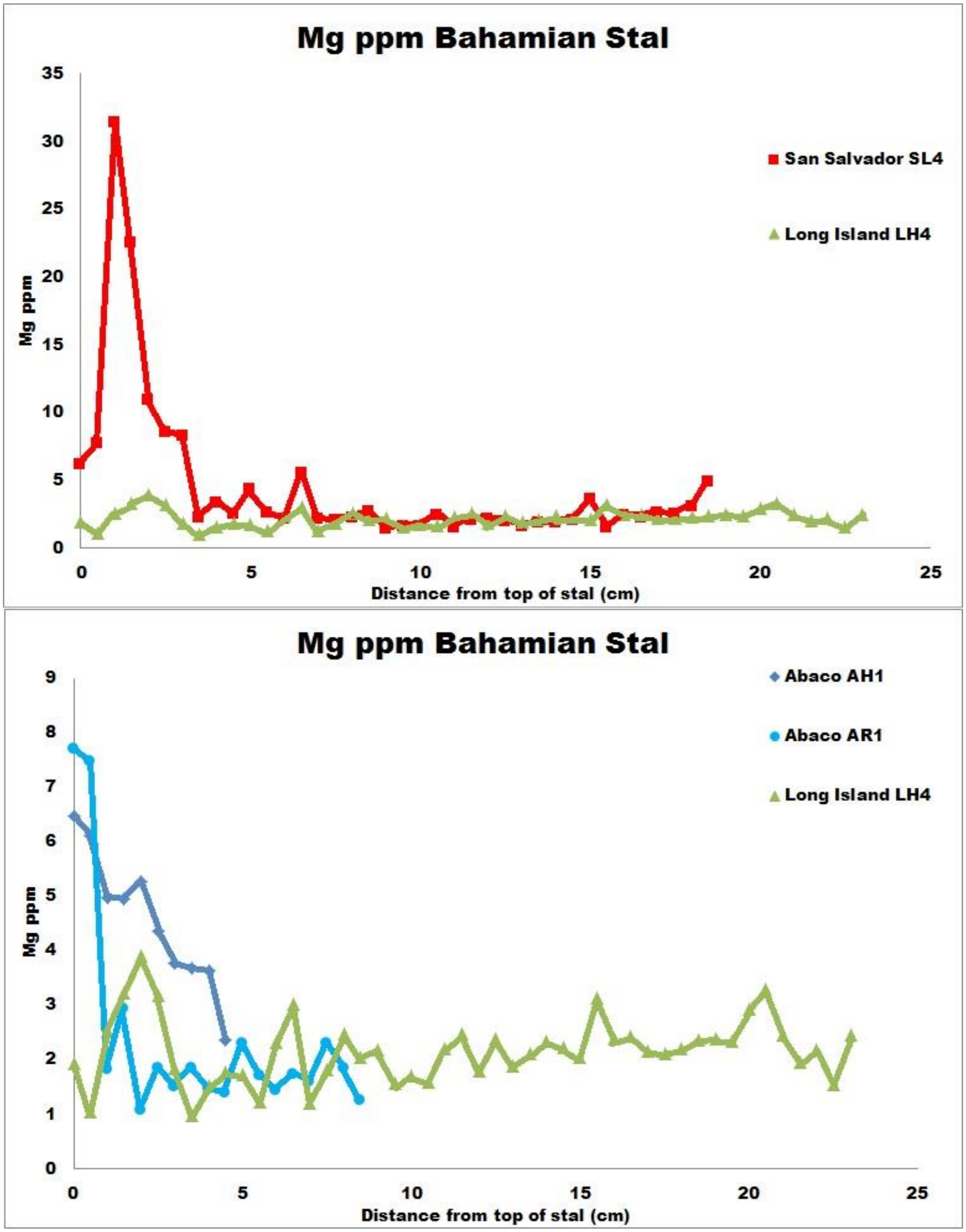

Figure 4.14 Mg ppm for Bahamian stalagmites

The top plot shows the data for the Long Island stalagmite and the San Salvador Stalagmite. The bottom plot shows the Long Island and Abaco stalagmite Mg data. Note that the San Salvador stalagmite was found in an area of Light House Cave that is inundated during high tide.

Bahamian Rock ICP-OES Data

The rocks of the Bahamian study areas are equally as chaotic as the stalagmite data. The rocks from within Hamilton's cave on Long Island were relatively low in Sr and Mg concentration. Abaco and San Salvador were as expected relative to one another. Abaco has a lower Sr concentration in the cave rocks than San Salvador, hypothetically due to the larger water flux on Abaco. The Mg concentration was inversely related in the cave rocks of Abaco and San Salvador. Abaco was low in Sr, but high in Mg relative to San Salvador (Figure 4.15 and 4.16).

The data for the cave rocks of Long Island are depleted of Sr or Mg. The surface rocks for Abaco were lower in concentration than San Salvador. Surface rocks from Long Island had a very high Sr concentration but relatively low Mg concentration (Figure 4.17 and 4.18). This is unusual because Hamilton's cave of Long Island is actually further from the coast than Hole in the Wall cave and Roadside cave of Abaco. Some additional data are needed to explain the anomaly with the Long Island specimens and XRD analysis is scheduled.

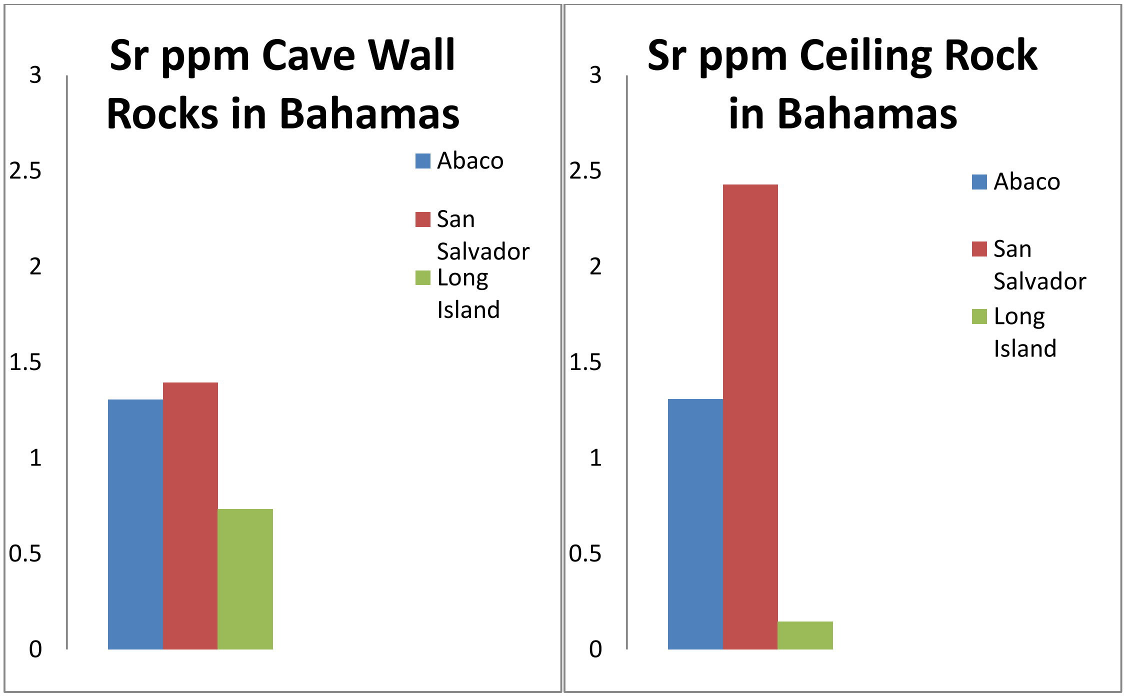

Figure 4.15 Sr ppm of Bahamian cave rocks

Abaco receives the greatest annual precipitation and Long Island the lowest.

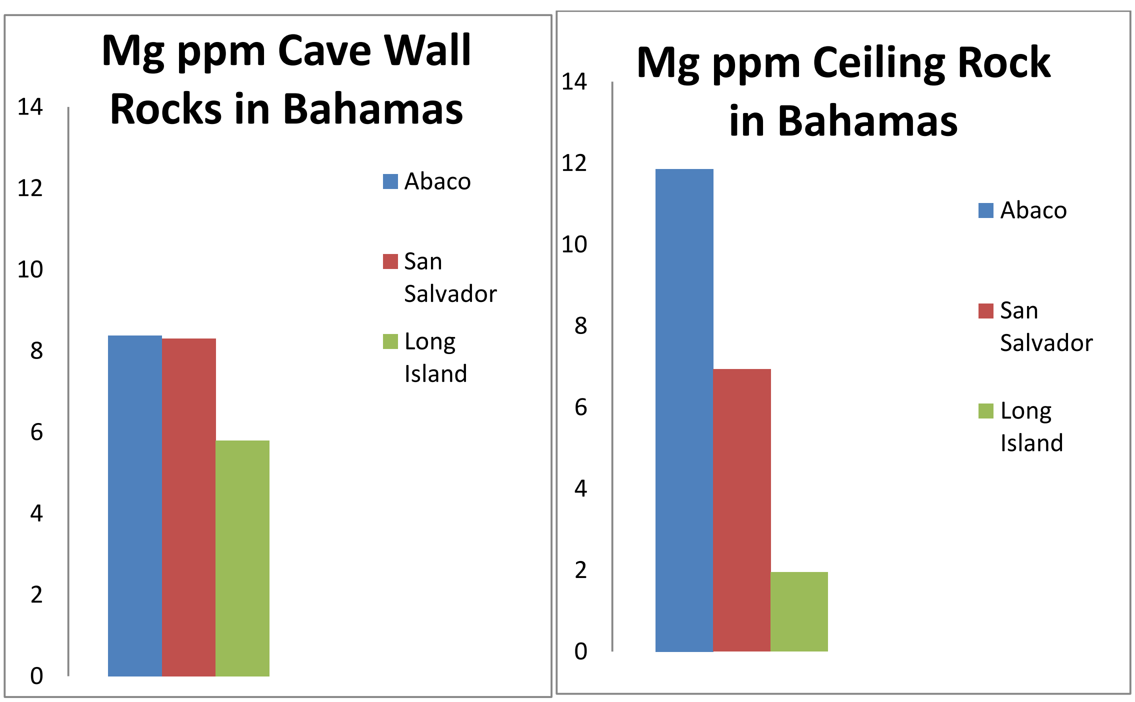

Figure 4.16 Mg ppm of Bahamian cave rocks

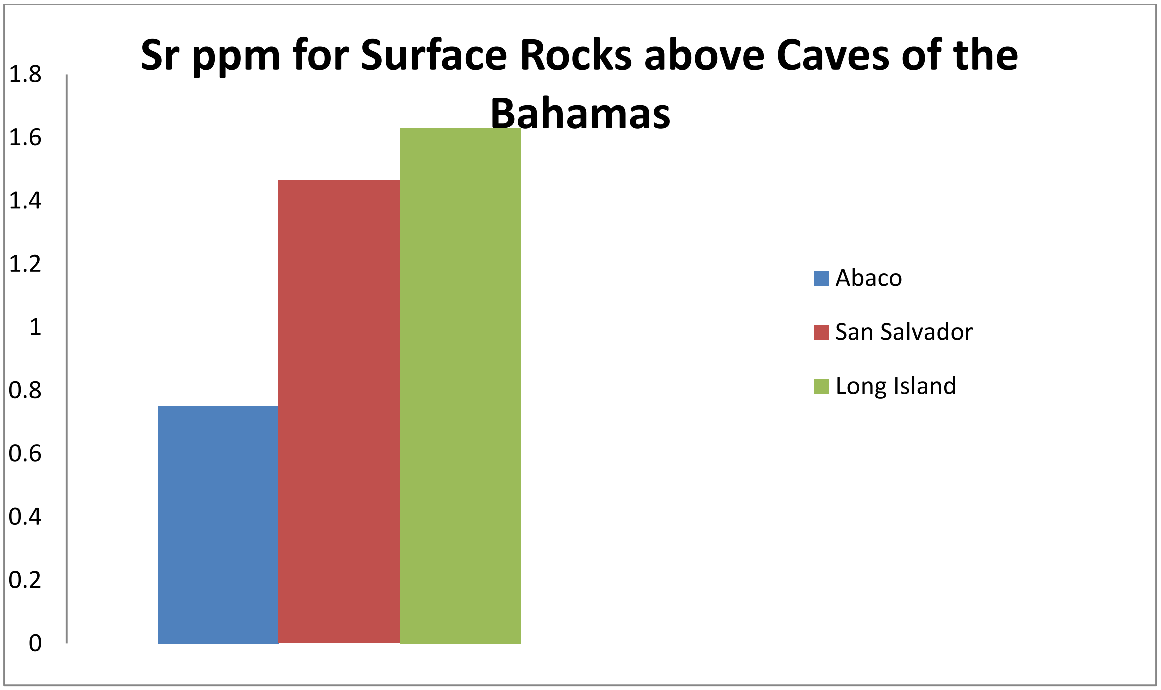

Figure 4.17 Sr ppm of Bahamian surface rocks

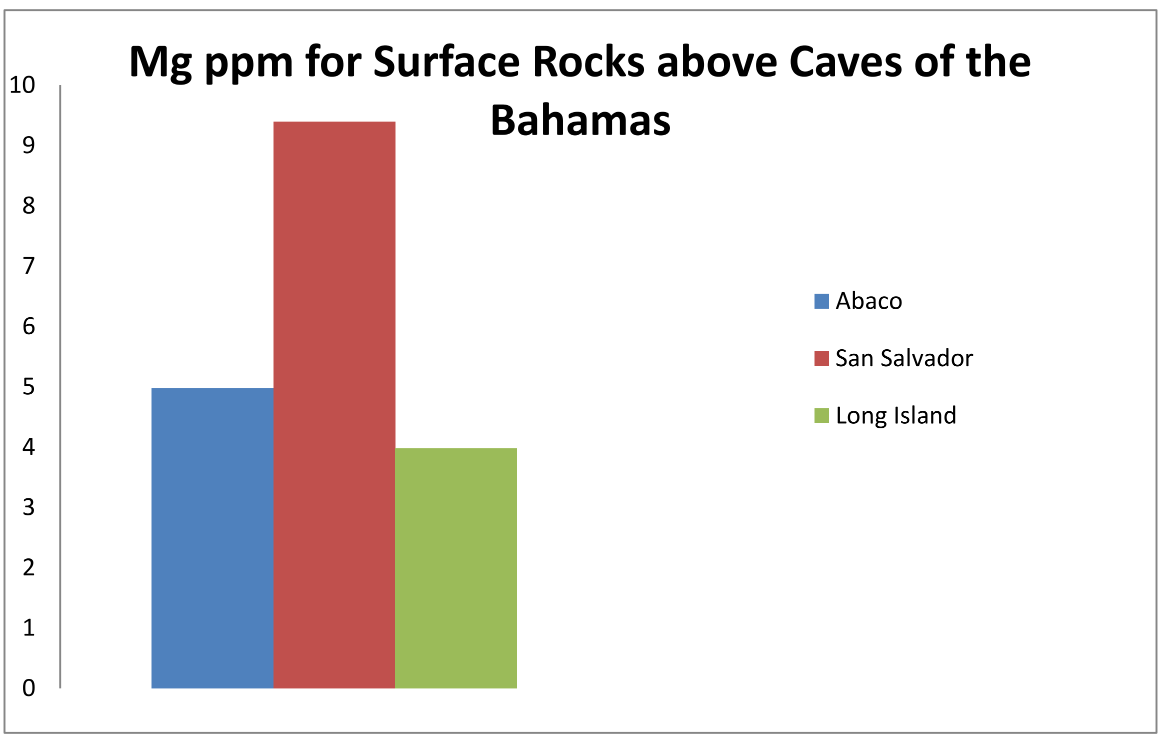

Figure 4.18 Mg ppm of Bahamian surface rocks

Bahamian Rock XRD Data

The powder from the rock samples produced interesting mineralogical data. The rocks from within the caves were calcite for the samples processed from Abaco and Long Island. The rock sample from within Light House cave on the island of San Salvador was determined to be 3% aragonite and 97% calcite (Figure 4.19). The rocks collected from above Hamilton's Cave on Lon g Island was also determined to be calcite. The surface rocks collected above the caves on Abaco and San Salvador were determined to be high-Mg calcite (Figure 4.20). This agrees with the allochems that were still present in the rocks at time of collection.

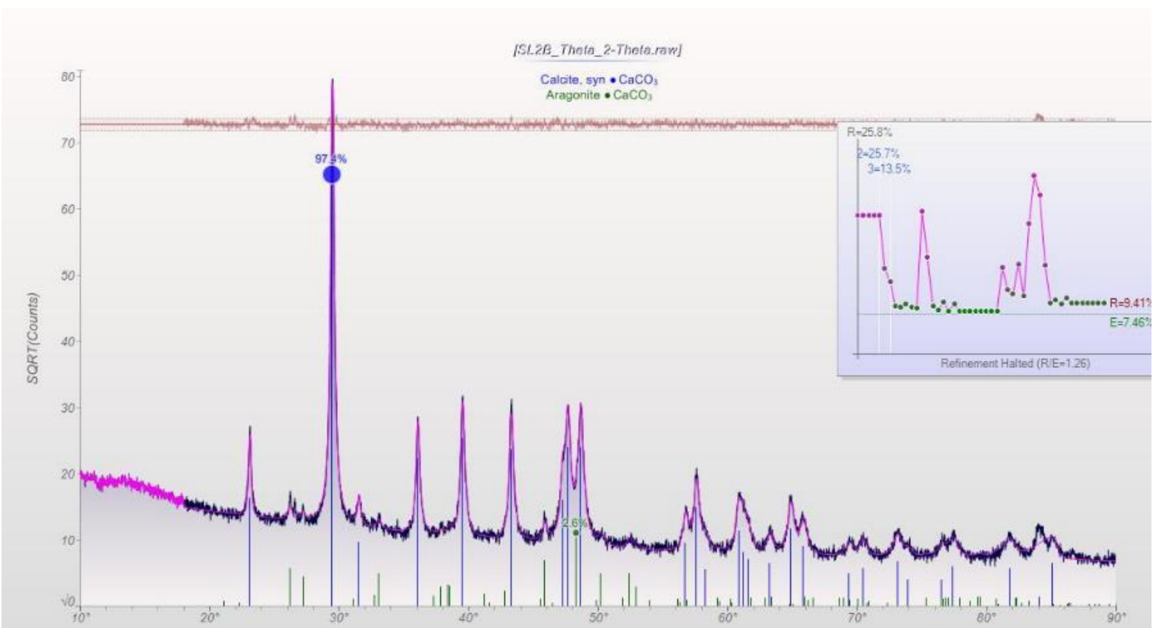

Figure 4.19 XRD results for Light House Cave rock

The XRD results from rock collected within Light House Cave on San Salvador, indicating about 3% aragonite and 97% calcite.

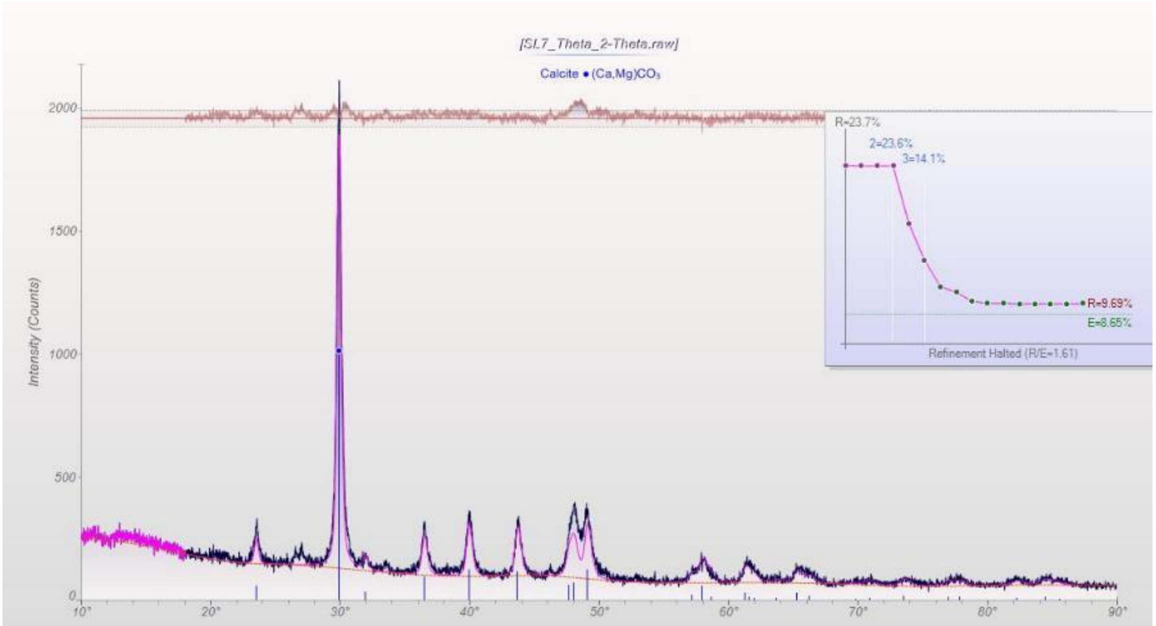

Figure 4.20 XRD results for San Salvador surface rock

The XRD results for the rock collected above San Salvador's Light House Cave indicating the mineralogy is high-Mg calcite.

CHAPTER V

DISCUSSION

Curaçao Data

The data from the stalagmites of Curaçao caves are in agreement with a higher Sr concentration for those located within younger rock units. The majority of the stalagmites also decrease in Sr/Ca ratios going up the growth axis. The top of the stalagmites overall have the lowest Sr/Ca while the bottom of the sampled stalagmites have the highest. The only exception is the stalagmite from Hato. The Sr concentrations for the Curaçao stalagmites is summarized with Figure 5.1.

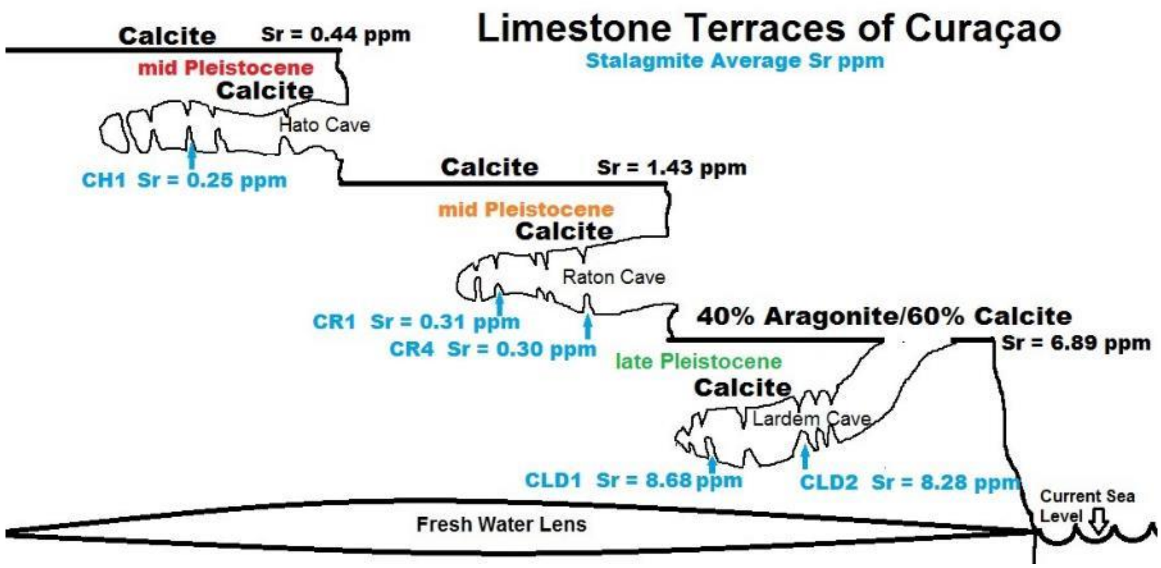

Figure 5.1 Sr ppm on Curaçao summary

A summary of the Sr concentrations in the stalagmites (an average of the entire stalagmite), the rock mineralogy within and above the caves, and the Sr averages for the rocks above the caves.

Lardem cave is located within lower terrace and is late Pleistocene in age (Hornbach et al., 2010). The stalagmites that precipitated in Lardem cave have the highest levels of Sr by far with values ranging from about 6.3 ppm and 11.1 ppm for CLD1 and 0.8 to 11.6 ppm for CLD2. They have averages of 8.7 ppm and 8.3 ppm respectively. The Sr/Ca values were an average of 0.034 and 0.017.

Raton cave is located within the middle terrace, older than the lower terrace and younger than the higher terrace where Hato cave is located. The stalagmites collected from within Raton cave have Sr values ranging from 0.16 ppm to 0.54 ppm for CR1 and 0.18 ppm to 0.44 ppm for CR4. These stalagmites both have an average of 0.31 ppm of Sr and an average Sr/Ca ratio of 0.001.

Hato cave is located in the higher terrace, the oldest of the three terraces looked at during this study. The Hato stalagmite sampled had Sr concentrations ranging from 0.09ppm to 1.24 ppm with an average of 0.31 ppm. The Sr/Ca ratio for the Hato stalagmite is an average of 0.002.

Overall, the distinction between the Lardem stalagmites and the Raton and Hato stalagmites is important. The Hato and Raton stalagmites are very close in Sr concentrations, but overall, a majority of Hato's Sr concentrations along the growth axis are much lower than Raton's stalagmites. As observed in Figure 4.4, there are three data points that are outliers from the rest of the data. When those three values are removed from the calculations for the Hato stalagmite, the average Sr concentration changes to 0.25 ppm and the Sr/Ca average to 0.01. The data for the Raton stalagmites are relatively close with no extreme outliers like the stalagmite from Hato.

It can be hypothesized that the reason the Hato stalagmite does not increase in Sr content in progressively older material could be due to when the stalagmite began to precipitate. If the Hato stalagmite began to precipitate after the cave rock had already been depleted of Sr if would not show much of a change in Sr levels over time. The Mg data help support this interpretation with the high levels of Mg present. Once the rock is flushed of Sr, the remaining Mg is the next element to be removed with water flux.

The Hato stalagmite has an average of 4.19 ppm of Mg while Raton has a collective average of 4.79 ppm of Mg and Lardem an Mg level of only 1.00 ppm. This would agree with the hypothesis that CH1 was a stalagmite that began forming after Hato was depleted not only of Sr but also of Mg. The rock data agree with this interpretation as the Hato cave rocks were found to have an average of only 0.48 ppm of Sr and 1.78 ppm of Mg. This compares to the values of 1.15 ppm Sr and 5.53 ppm Mg for Raton. What is rather interesting is the cave rock averages for Lardem are only 0.79 ppm Sr and 11.79 ppm Mg; however, the surface rock at Lardem had a Sr ppm of almost 7 ppm, indicating that a continuous supply of Sr could have been transiting the vadose zone of the host rock as the Sr within the host rock was depleted. While Raton and Hato caves receive sea spray as an aerosol, Lardem Cave, at 20 meters from a coastal sea cliff, is actually wet by sea spray. Hato is located at a greater elevation and would receive less sea spray than Raton.

There are some additional factors that may be taken into consideration. The thickness of the overlying carbonate rock unit on top of the cave could change the amount of Sr and Mg available for the meteoric water to pick up as it filters through the rock to the cave. Lardem cave's overlying rock units are rather thin. This could support the hypothesis of why the stalagmites are so high in Sr yet the cave rock itself seems to be comparatively low in Sr. There is no overlying soil above Lardem, only exposed epikarst terrain. This could be supported with further age dating to understand how soon the stalagmites began to grow once these caves were in the vadose zone.

The rock mineralogy does help support the hypothesis that aragonite is a major contributor to the Sr content of the stalagmites. The surface rocks above Lardem Cave contained 40% aragonite and the stalagmites from this cave had the highest concentration of Sr. The other rock specimens had voids that could be interpreted as aragonitic allochems that have dissolved. Depending upon the time of the stalagmite precipitation the Sr could have originated from the dissolution of these allochems that are now gone.

Bahamas Data

The samples from the Bahamas are very intricate and involve many processes that can be difficult to take all into account. There were certainly some observed similarities between the Curaçao and Bahamian samples. See Figure 5.2 for a summary of the Sr content in these stalagmites. The samples from Abaco and San Salvador compared in much the same way that Raton Cave and Lardem Cave compared on the island of Curaçao. When looking at the Abaco stalagmite values and the San Salvador stalagmite values it is easy to conclude that an environment with less water will have a higher amount of Sr still preserved in the rock units. It should be noted that the tidally-influenced cave environment of Light House cave on San Salvador could be the cause of the anomalous Sr and Mg values for the top of the stalagmite. Two stalagmites were collected from this cave, SL1 and SL4. Upon cutting of the stalagmites it was discovered that SL1 was hollow on the inside and SL4 was used for the San Salvador data. SL4 was a stalagmite that had been knocked over by what is suspected to be vandalism in the last 50 years.

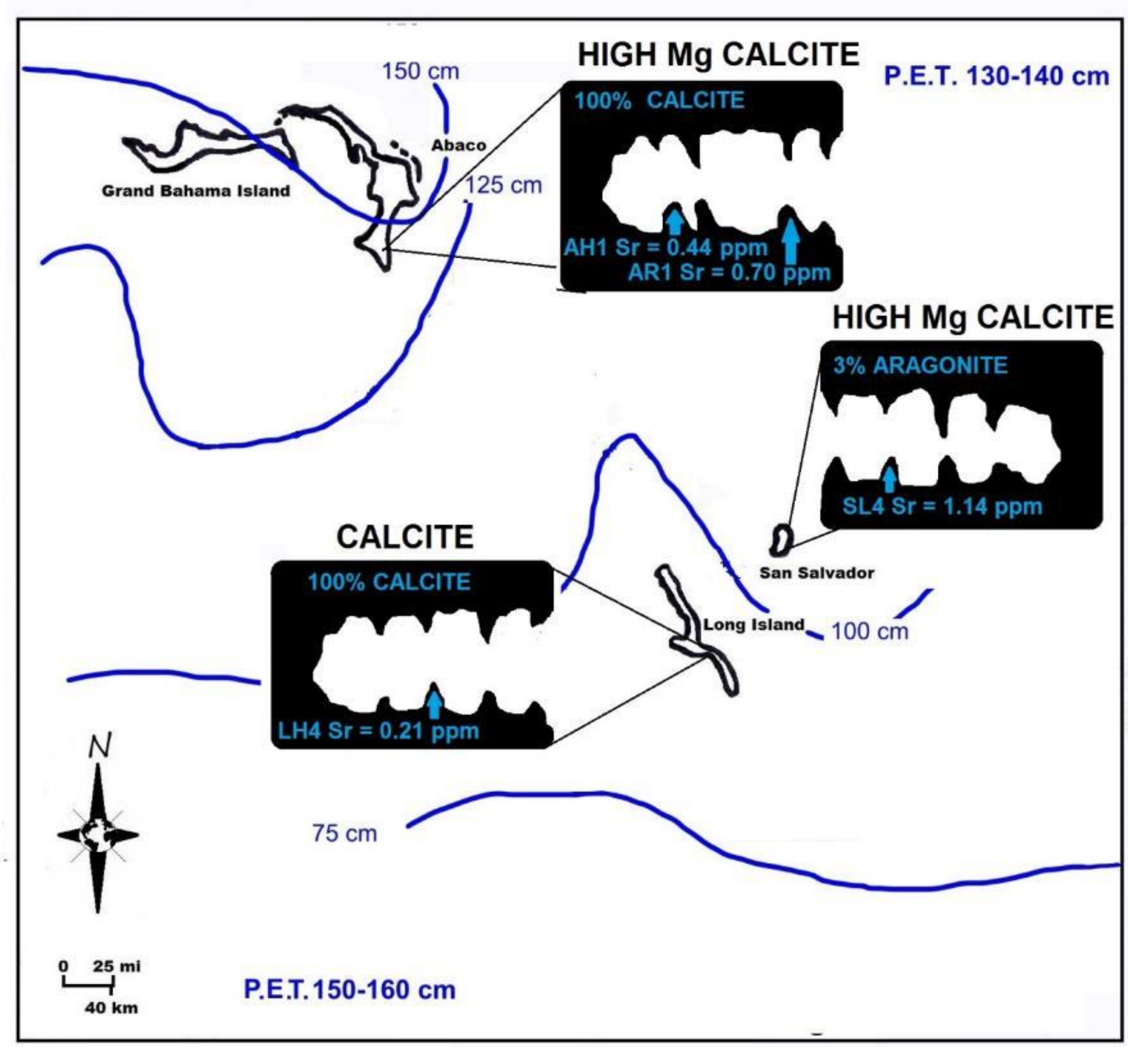

Figure 5.2 Sr ppm summary for the Bahamas

A summary of the Sr concentrations of the Bahamian stalagmites collected (the average Sr concentration for the entire stalagmite) and the mineralogy of the cave and surface rocks. The map showing the water budget of the Bahamas was obtained from Whittaker and Smart (1997).

The islands are distributed in three different zones of average annual precipitation. Relative to one another Abaco has the highest rate of precipitation and has an average Sr concentration of 0.44 ppm in the stalagmite collected within Hole in the Wall cave and 0.70 ppm in the stalagmite collected from nearby Roadside cave. This compares with a interior cave rock average of 1.31 ppm Sr.

Light House cave on the island of San Salvador had a much higher Sr content in the collected stalagmite SL4. The average for this stalagmite was 1.14 ppm. This is more than twice the average concentration than the average of the stalagmites collected from Abaco. The average for the interior cave rocks was 1.91 ppm Sr.

Hamilton's cave on Long Island had an average of only 0.21 ppm Sr. This island has the driest climate relative to the other two islands. The interior cave rocks of Hamilton's only had about 0.44 ppm of Sr so it is quite possible that Hamilton's has been flushed of Sr for quite some time and this stalagmite, which was actively growing when collected, grew long after the Sr had completely leached out of the bedrock.

It is possible that while these caves are in the same Bahamian units that Hamilton's could be located in an older portion of the Owl's Hole formation than the caves of Abaco and San Salvador. It is difficult to discern the Upper Owl's Hole formation from the Lower Owl's Hole formation (Figure 5.3). This would help explain the cave rock being depleted of the trace elements. The XRD results, identifying the cave rocks and surface rocks of Long Island to be calcite while the surface rocks of Abaco and San Salvador were high-Mg calcite, support this hypothesis. High-Mg calcite is easily dissolved and would not be expected to be found in older rock units. This could also be related to the size of the cave, and by proxy the amount of time the cave spent in the dissolutional mixing zone. Hamilton's is the largest cave in the Bahamas and it is possible that the amount of time under vadose conditions could have depleted the rock and completely inverted it to calcite. The only way to verify this would be for further investigation into the age of these rocks as relative to one another as well as further investigation into the mineralogy.

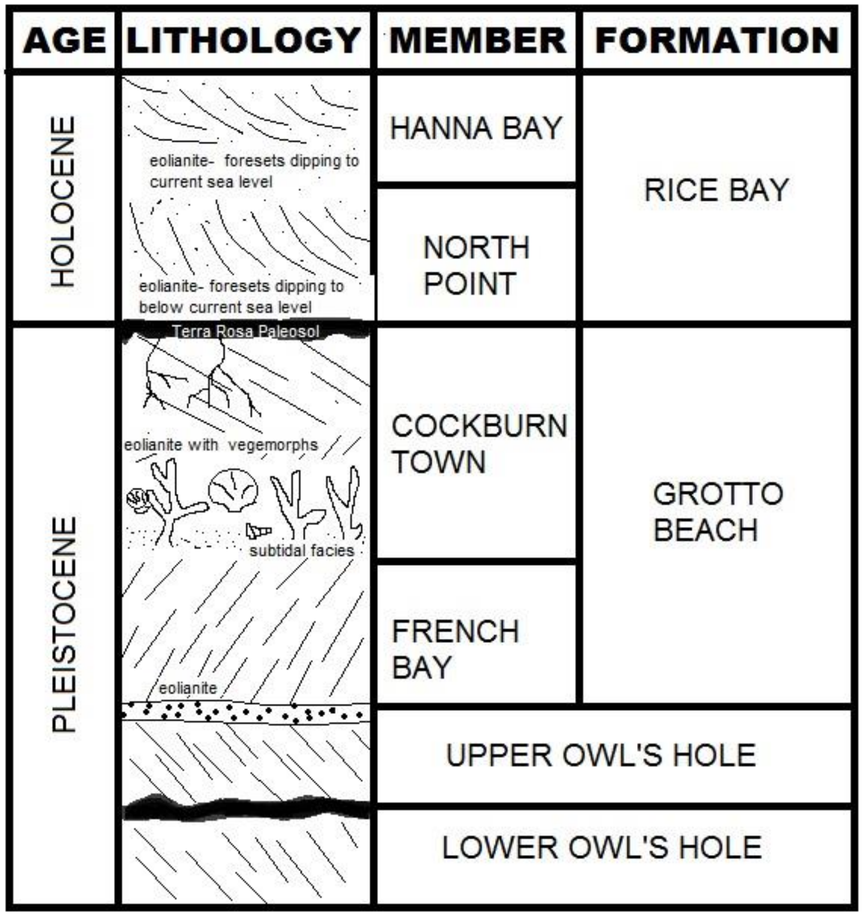

Figure 5.3 Stratigraphy of the Bahamas.

The Pleistocene calc-arenite eolianites of Upper Owl's Hole and Lower Owl's Hole can be difficult to distinguish unless found in large exposure with the paleosol separating the units. Modified from Mylroie and Carew (2013).

Another hypothesis includes the thickness of the overlying rock. Hamilton's cave of Long Island has a very thin rock ceiling that is spotted with many skylights (collapse features that breach the surface). It is possible that even with the relatively low precipitation that Long Island receives it would take a lot less time for the rocks to be inverted entirely from aragonite to calcite and thus causing the loss of the vast majority of the original Sr content. Both Lighthouse Cave on San Salvador and Hole in the Wall Cave on Abaco have thicker ceilings over the caves.

The concentration of Mg seems to align with the hypothesis that Hamilton's cave has undergone significant transition in mineralogy and geochemistry. The average Mg in the cave rocks of Hamilton's cave is only 3.87 ppm as compared to 9.84 ppm in Abaco's caves and 7.62 ppm in Light House cave of San Salvador. The stalagmite collected from Hamilton's cave has an average value of 2.18 ppm Mg.

The Mg concentrations in the stalagmites of Abaco and San Salvador also tend to be higher. Abaco's stalagmites have a collective average of 3.48 ppm of Mg while the stalagmite from San Salvador has an average of 4.45. Once again, age dating would be necessary to ascertain when the stalagmites were deposited in relation to the age of the cave rock. XRD analysis of the cave rocks would also help ascertain if the rocks were fully inverted to calcite.

Two assumptions remain to be tested. One is that the rocks for all three Bahamian islands are the same age. As has been previously demonstrated, the Owls Hole consists of eolianites from at least three sea level highstands (Kindler et al., 2010). If the Long Island cave data were from the oldest of those three units, and the San Salvador and Abaco cave data were from the youngest of those three units, then the pattern break with respect to Long Island could be explained. Another consideration is that there has been an assumption that the present day Holocene climate was the climate operational during the last glaciation(s). If the climatic bands had shifted, then the expected meteoric flux may well have been quite different than today. Long Island may have been wetter and Abaco drier.

If the Sr and Mg data are reliable, then they offer either a mechanism by which to date the age of the rocks, in a relative sense, or if the rocks are all the same age, possibly determine shifts in climate during the Mid to Late Quaternary. In any event, the data clearly demonstrate that eogenetic carbonate rocks create a trace element flux of Sr and Mg from the host rock that is much more complex than for teleogenetic rocks and their cave speleothems in continental interiors. The data also imply that sea spray and overlying rock thickness need to be taken into account when interpreting trace elements and their isotopes as recorded in cave speleothems.

CHAPTER VI

CONCLUSIONS

This study was seeking to find evidence of the Sr concentrations in speleothems deposited in eogenetic carbonate caves in relation to the relatively young and unchanged mineralogy of the rocks. It sought to answer three questions in regards to Sr concentrations in speleothems of these settings. The hypotheses were as follows.

1. The Sr content of Caribbean speleothems has a direct relationship with the age of the host rock at the time of speleothem precipitation.
2. Older speleothems contain less Sr than younger speleothems in the same climatic setting.
3. Eogenetic carbonates within climates of higher precipitation will lose Sr content faster than those in climates of lower precipitation and the speleothems deposited in the caves within these rocks will record this trend.

Hypothesis 1: The Sr content of Caribbean speleothems has a direct relationship with the age of the host rock at the time of speleothem precipitation.

The stalagmites collected from within the youngest cave rock unit on Curaçao had a significantly higher concentration of Sr than the stalagmites collected from the older carbonate terraces. The stalagmites in the caves of older rock units had lower Sr values indicating that the Sr had already leached out of the bedrock.

Hypothesis 2: Older speleothems contain less Sr than younger speleothems in the same climatic setting.

The stalagmites collected from Curaçao were all obviously from within the same climate with no variation in precipitation or temperature. The only difference in these stalagmites are the times at which they were deposited and the age of the rocks that hosted the cave they were deposited in. The Lardem stalagmite could not be older than 115 k years old, the end of the MIS 5e interglacial. Dating would be needed to ascertain if the age of the Hato and Raton stalagmites are younger than Lardem, but they did have the opportunity to begin depositing long before Lardem cave even existed. In any case the host rock is older. The Lardem stalagmite clearly has more Sr than the Raton and Hato stalagmite, but further investigation is necessary to determine the relative age of the two stalagmites from Raton and the stalagmite from Hato.

Hypothesis 3: Eogenetic carbonates within climates of higher precipitation will lose Sr content faster than those in climates of lower precipitation and the speleothems deposited in the caves within these rocks will record this trend.

The stalagmites from caves on the island of Abaco clearly show a lower Sr content than the stalagmite collected from the island of San Salvador. The cave rock and stalagmite from Long Island seemed to be leeched of Sr and could be explained by either a difference in age of the rock or the thickness of the rock unit where the cave is located, or perhaps a shift in glacial to interglacial climate.

Further Investigations

It would be necessary to further research the mineralogy and age of these specimens to support these hypotheses. While it can be stated that the stalagmites collected from within young rock units cannot be any older than the rock unit itself, it is not easily assumed that the stalagmites in older rock units formed before those in the younger rock units. Investigation into the mineralogy of the rocks within the cave and on the surface above the cave would aid in the hypothesis that meteoric fluid flux causes an inversion of aragonite to calcite and the loss of Sr in the process. This could not only result in higher Sr levels in the speleothem but also a precipitation of aragonitic stalagmites that transition to calcite as the Sr load in the drip water lowers. Preliminary investigation shows that the older speleothem layers in some specimens are likely aragonite while the younger layers are calcite but further investigation is needed to determine the full validity of this hypothesis.

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APPENDIX A

SPECIMEN COLLECTION INFORMATION

Specimen Details

Table A.1 Curaçao Specimen Details

Curaçao Specimen Collection Data-December 2012				
Sample ID	Cave	Date	Type	Description
C-LD-1	LarsDem	12/16/2012	Stalagmite	Small stalagmite collected near samples C-LD-2, C-LD-3 and C-LD-4. Approximately cm tall and cm wide. Actively growing apical tip.
C-LD-2	LarsDem	12/16/2012	Stalagmite	Large stalagmite that has broken into two pieces perpendicular to growth direction during removal. Top piece (a) measures approximately cm tall and cm wide and bottom piece (b) measures approximately cm tall and cm wide. Collected near C-LD-1, C-LD-3 and C-LD-4. Actively growing apical tip.
C-LD-3	LarsDem	12/16/2012	Wall Rock Sample	Wall rock sample colleted near C-LD-1, C-LD-2 and C-LD-4. Located closest to C-LD-2. Arrow indicates upright direction
C-LD-4	LarsDem	12/16/2012	Ceiling Rock Sample	Ceiling rock sample collected near C-LD-1, C-LD-2 and C-LD-3. Located closest to C-LD-1. Arrow indicates up direction.
C-LD-5	LarsDem	12/16/2012	Surface Rock Sample	Rock sample from surface directly above cave near the collection site. Arrow indicates up direction
C-R-1	Raton	12/16/2012	Stalagmite	Large stalagmite with two growth axies, one actively growing. Collected near C-R-2 and C-R-3. Easily removed from cave due to substrate below. Was separated into three pieces during transportation. Top portion (a) measures approximately cm tall and cm wide. In-situ pictures: In-Lab pictures:
C-R-2	Raton	12/16/2012	Wall Rock Sample	Wall rock sample collected near C-R-1 an C-R-3. Arrow indicates upright direction.
C-R-3	Raton	12/16/2012	Ceiling Rock Sample	Ceiling rock sample collected near C-R-1 and C-R-2. Arrow indicates upright direction.
C-R-4	Raton	12/16/2012	Stalagmite	Smaller stalagmite collected near samples C-R-5 and C-R-6. Active dripwater on apical tip. Approximately cm tall and cm wide.

Table A.1 (Continued)

C-R-5	Raton	12/16/2012	Wall Rock Sample	Wall rock sample located near C-R-4 and C-R-6. Arrow indicates upright direction
C-R-6	Raton	12/16/2012	Ceiling Rock Sample	Ceiling rock sample collected near C-R-4 and C-R-5. Arrow indicates upright direction.
C-R-7	Raton	12/16/2012	Surface Rock Sample	Rock sample from the surface on the cliff face outside of the cave entrance. Arrow indicates upright direction.
C-R-8	Raton	12/16/2012	Surface Rock Sample	Rock sample from the surface above the cave. Arrow indicates upright direction.
C-H-1	Hato	12/17/2012	Stalagmite	Large, darkly stained stalagmite collected near C-H-2 and C-H-3. Measures approximately cm tall and cm wide.
C-H-2	Hato	12/17/2012	Wall Rock Sample	Wall rock sample collected near C-H-1 and C-H-3. Arrow indicates upright direction.
C-H-3	Hato	12/17/2012	Ceiling Rock Sample	Ceiling rock sample collected near C-H-1 and C-H-2. Arrow indicates upright direction.
C-H-4	Hato	12/17/2012	Stalagmite	Small stalagmite collected near samples C-H-5 and C-H-6. Measures approximately cm tall and cm wide. Active dripwater on apical tip at time of collection.
C-H-5	Hato	12/17/2012	Wall Rock Sample	Wall rock sample collected near C-H-4 and C-H-6. Located further away from C-H-4 than C-H-6. Arrow indicates upright direction.
C-H-6	Hato	12/17/2012	Wall Rock Sample	Wall rock sample colleted near C-H-4 and C-H-5. Located closer to C-H-4 than C-H-5. Arrow indicates upright direction.
C-H-7	Hato	12/17/2012	Surface Rock Sample	Surface rock sample located above the cave approximately directly above C-H-4. Arrow indicates upright direction.
C-H-8	Hato	12/17/2012	Surface Rock Sample	Surface rock sample located above the cave approximately directly above C-H-1. Arrow indicates upright direction.

Table A.2 Bahamas Specimen Details

Bahamas Collection Data June 2013				
Sample ID	**Cave/Island**	**Date**	**Type**	
L-H-1	Hamiltons/ Long Island	6/15/2013	Stalagmite	Taller stal collected just to the North of L-H-4. Has two places of active precipitation- One on top and one growing on the side.
L-H-2	Hamiltons/ Long Island	6/15/2013	Wall rock Sample	Wall rock collected near L-H-1 & L-H-4, on wall just to NW of stal.
L-H-3a	Hamiltons/ Long Island	6/15/2013	Ceiling Rock Sample	Ceiling rock collected near L-H-1 & L-H-4. Bottom of this piece covered in flow stone.
L-H-3b	Hamiltons/ Long Island	6/15/2013	Ceiling Rock Sample	Smaller piece of ceiling rock collected with 3b, has a broken soda straw attached to the flowstone.
L-H-4	Hamiltons/ Long Island	6/15/2013	Stalagmite	Shorter stal collected just a few cm to the S of L-H-1.
L-H-5	Hamiltons/ Long Island	6/15/2013	Wall Rock Sample	Wall rock collected high on wall on opposite side of passage from stal and other cave interior specimens.
L-H-6	Hamiltons/ Long Island	6/15/2013	Surface Rock Sample	Surface rock sample, small, collected just E of L-H-7. Has some algae on surface.
L-H-7	Hamiltons/ Long Island	6/15/2013	Surface Rock Sample	Surface rock sample, large, collected just W of L-H-6. Mixed petrology, algae.
L-S-1	Salt Pond/ Long Island	6/15/2013	Stalagmite	Stal, attached to L-S-4 at base, broken but still in-situ. Base was removed from cave floor post-stal removal.

Table A.2 (Continued)

L-S-2	Salt Pond/ Long Island	6/15/2013	Wall Rock Sample	Wall rock sample abut 0.75 m to the NE of Stal collection site.
L-S-3	Salt Pond/ Long Island	6/15/2013	Ceiling Rock Sample	Ceiling rock sample ~ 2-3 m NW of stal collection site.
L-S-4	Salt Pond/ Long Island	6/15/2013	Stalagmite	Stal, base attached to L-S-1, Also broken but still in-situ.
L-S-5	Salt Pond/ Long Island	6/15/2013	Surface Rock Sample	Surface rock sample collected immediately above cave near collection site below.
L-S-6	Salt Pond/ Long Island	6/15/2013	Fossil specimen	West Indian Top Shell, located BENEATH the two stalagmites' base.
L-S-1/4	Salt Pond/ Long Island	6/15/2013	Stal Base	Base beneath L-S-1 and L-S-4 that connected the two stals at one time prior to fracture.
A-H-1	Hole In The Wall/Abaco	6/20/2013	Stalagmite	Small "button" stal collected in small passage "the yoga passage".
A-H-2	Hole In The Wall/Abaco	6/20/2013	Wall Rock Sample	Wall sample in the "yoga passage" near A-H-1
A-H-3	Hole In The Wall/Abaco	6/20/2013	Ceiling Rock Sample	Ceiling sample in the "yoga passage" near A-H-1 & A-H-2
A-H-4	Hole In The Wall/Abaco	6/20/2013	Stalagmite	Stal "Jr" located between the entrances in a stoopway.
A-H-5	Hole In The Wall/Abaco	6/20/2013	Wall Rock Sample	Wall sample near A-H-4.
A-H-6	Hole In The Wall/Abaco	6/20/2013	Ceiling Rock Sample	Ceiling sample located near A-H-4 & A-H-5
A-H-7	Hole In The Wall/Abaco	6/20/2013	Surface Rock Sample	Surface rock sample collected on S side of road.
A-H-8	Hole In The Wall/Abaco	6/20/2013	Surface Rock Sample	Surface rock sample collected on N side of road while battling mosquitos.
A-H-9	Hole In The Wall/Abaco	6/20/2013	Stalagmite	"Free" stal collected near A-H-4 sample site, near entrance.
A-H-10	Hole In The Wall/Abaco	6/20/2013	Wall/Ceiling Rock Sample	Rock sample collected near top of passage close to the A-H-9 collection site.

Table A.2 (Continued)

A-R-1	Roadside/ Abaco	6/20/2013	Stalagmite	Stal with actively precipitating apical tip.
A-R-2	Roadside/ Abaco	6/20/2013	Wall Rock Sample	Rock sample collected on "wall" (ceiling slopes down to floor, so kind of wall/ceiling rock sample)
A-R-3	Roadside/ Abaco	6/20/2013	Ceiling Rock Sample	Ceiling rock sample collected from overhang closer to A-R-1 than A-R-2 was.
S-L-1	Lighthouse/ San Salvador	6/28/2013	Stalagmite	Bulbous stal located in pocket behind a smaller stal near mapping station "C11" marked on wall. When removed noted the interior was hollow.
S-L-2	Lighthouse/ San Salvador	6/28/2013	Wall Rock Sample	Wall sample located near S-L-1.
S-L-3	Lighthouse/ San Salvador	6/28/2013	Ceiling Rock Sample	Ceiling Rock Sample located near S-L-1
S-L-4	Lighthouse/ San Salvador	6/28/2013	Stalagmite	"Hobo" stal found near the ladder entrance.
S-L-5	Lighthouse/ San Salvador	6/28/2013	Wall Rock Sample	Wall sample located near S-L-4.
S-L-6	Lighthouse/ San Salvador	6/28/2013	Ceiling Rock Sample	Ceiling rock sample located near S-L-4.
S-L-7	Lighthouse/ San Salvador	6/28/2013	Surface Rock Sample	Surface rock sample collected approx. above S-L-4
S-L-8	Lighthouse/ San Salvador	6/28/2013	Surface Rock Sample	Surface rock sample collected approx. above S-L-1

Table A.3 Cave Field Observations

Cave Descriptions	
Lardem Cave	The smallest of the three caves, LarsDem is very humid, flank-margin cave located near the coast with an entrance from ground. Cave is mostly crouching/crawling, and the active speleothems are in the Northern room. This cave is located in the youngest, and lowest elevation, carbonate rock unit of the three caves collection sites on Curacao.
Raton Cave	Raton is a humid flank margin cave with entrance in cliff. Cave is mostly walking passage with several areas of active speleothem development. This cave is located in a carbonate rock unit that is older than Larsdem cave but younger than Hato cave.
Hato Cave	The largest of the three caves that were collected from on Curaçao Hato is a commercial cave with tourist trails and lighting. Mostly walking passage with many areas of active speleothem development. Hato cave is located in the oldest rock unit collected from on the island of Curacao for the purposes of this study.
Hamilton's Cave	One of the largest caves located in the Bahamas. Located on Long Island this cave is an undeveloped show cave with many sky lights to the surface. The cave is located in the interior of Long Island and has several entrance points. The eolian foreset beds are clearly visible in the cave wall.
Salt Pond Cave	A cave located near the settlement of Salt Pond on Long Island, Bahamas. A cave with ceiling collapse located very near the coast and on private property. Cave is visited frequently. Hurricane flood lines are apparent and distinctive eolian foreset beds are easily identified in the cave wall.
Hole in the Wall Cave	This cave is located on the southern portion of Great Abaco Island near the Hole in the Wall Lighthouse. The cave has several entrances but not extensive skylight collapse features like Hamilton's or Salt Pond. Cave is located under a heavily vegetated terrain.
Roadside Cave	This is a small, recently discovered cave that opened up along a road not too far from Hole in the Wall Cave on the island of Abaco. The bottom is full of breakdown and has not yet been officially mapped.
Light House Cave	This cave is located on the interior of San Salvador near the Dixon Hill Lighthouse. It is partially flooded and is subject to tidal fluctuations. It has a permanent ladder installed and is visited often during educational stays at the Gerace Research Center.

APPENDIX B

THIN SECTION PHOTOGRAPHS FOR ROCK SPECIMENS

Curaçao Thin Sections

Pore spaces are filled with blue epoxy.

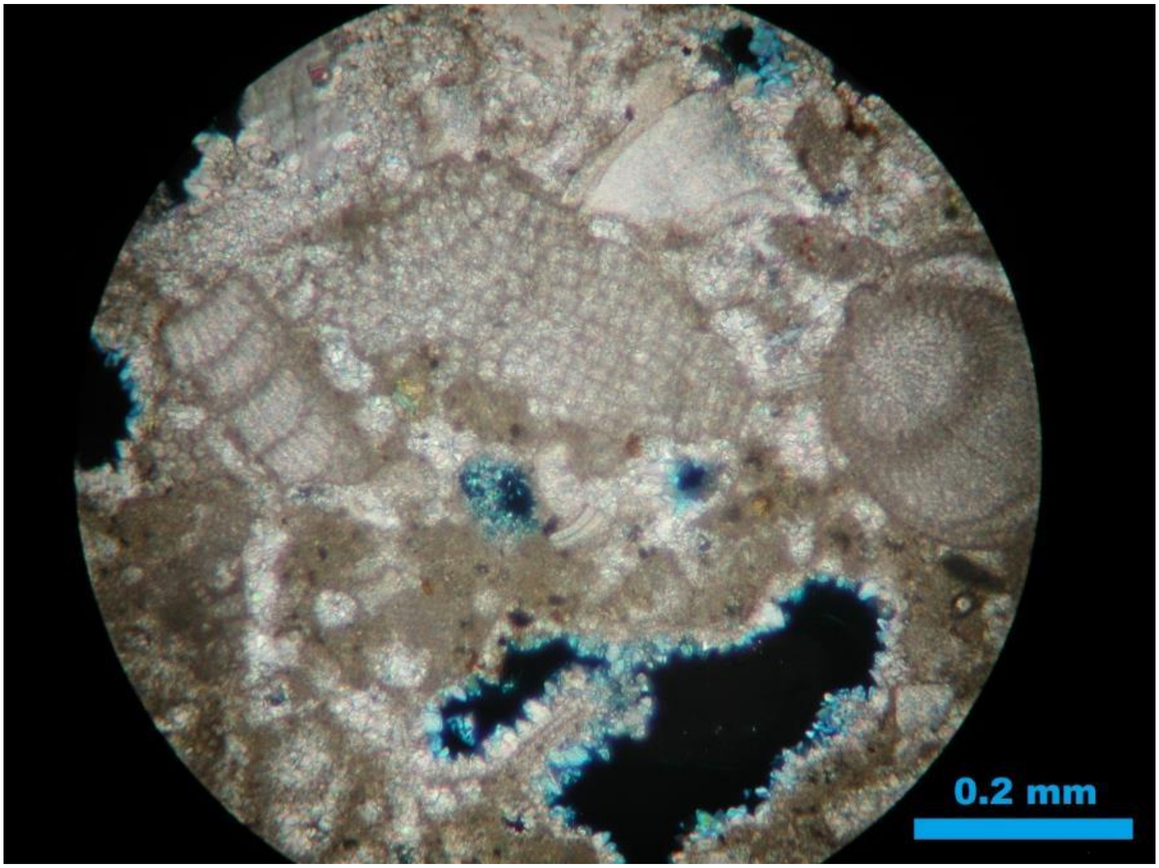

Figure B.1 Lardem Cave Wall Rock CLD3

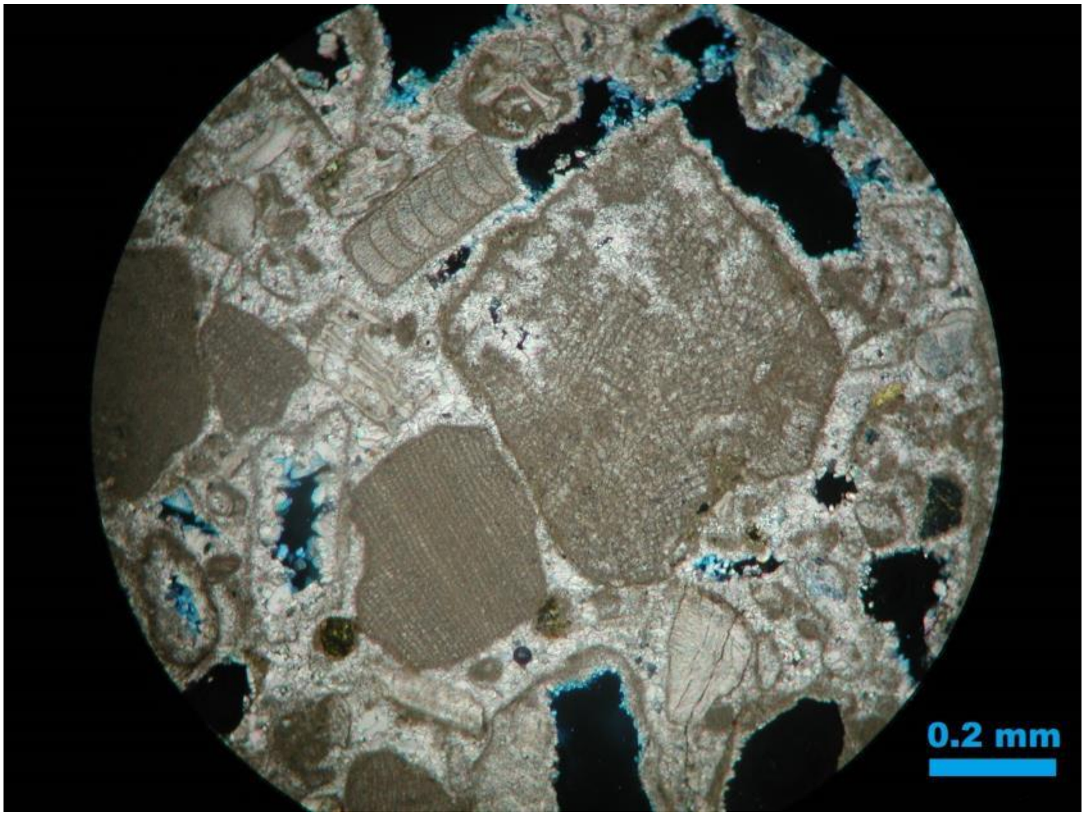

Figure B.2 Lardem Cave Ceiling Rock CLD4

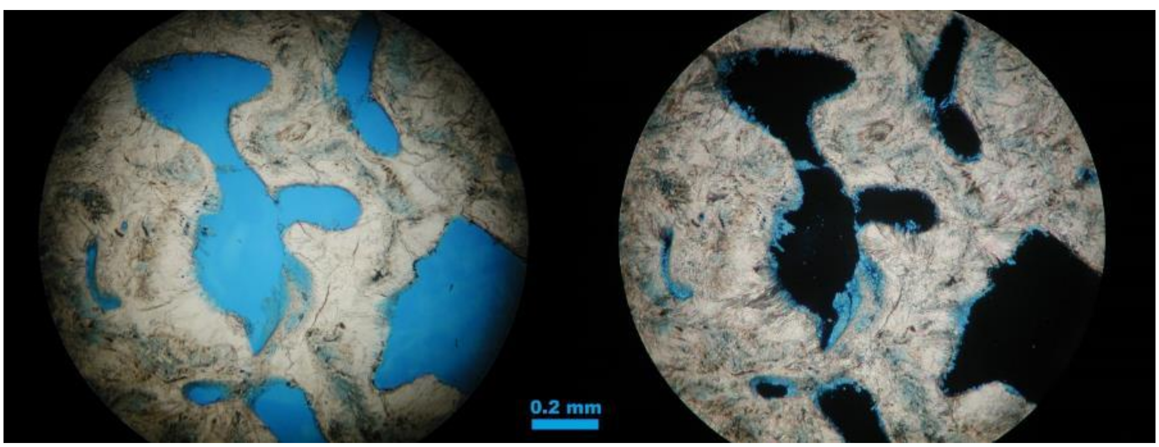

Figure B.3 Surface Rock above Lardem Cave CLD5

PPL (left) and XPL (right)

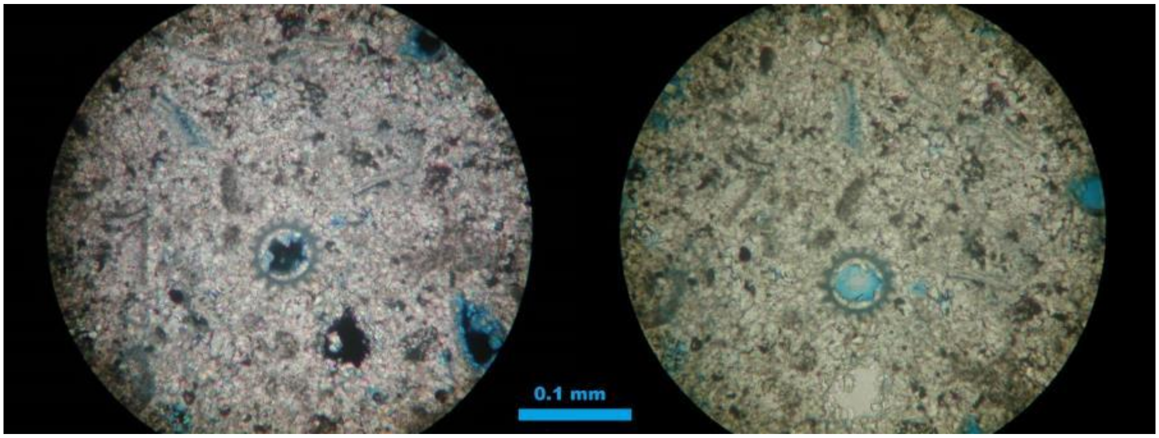

Figure B.4 Raton Cave wall rock CR2

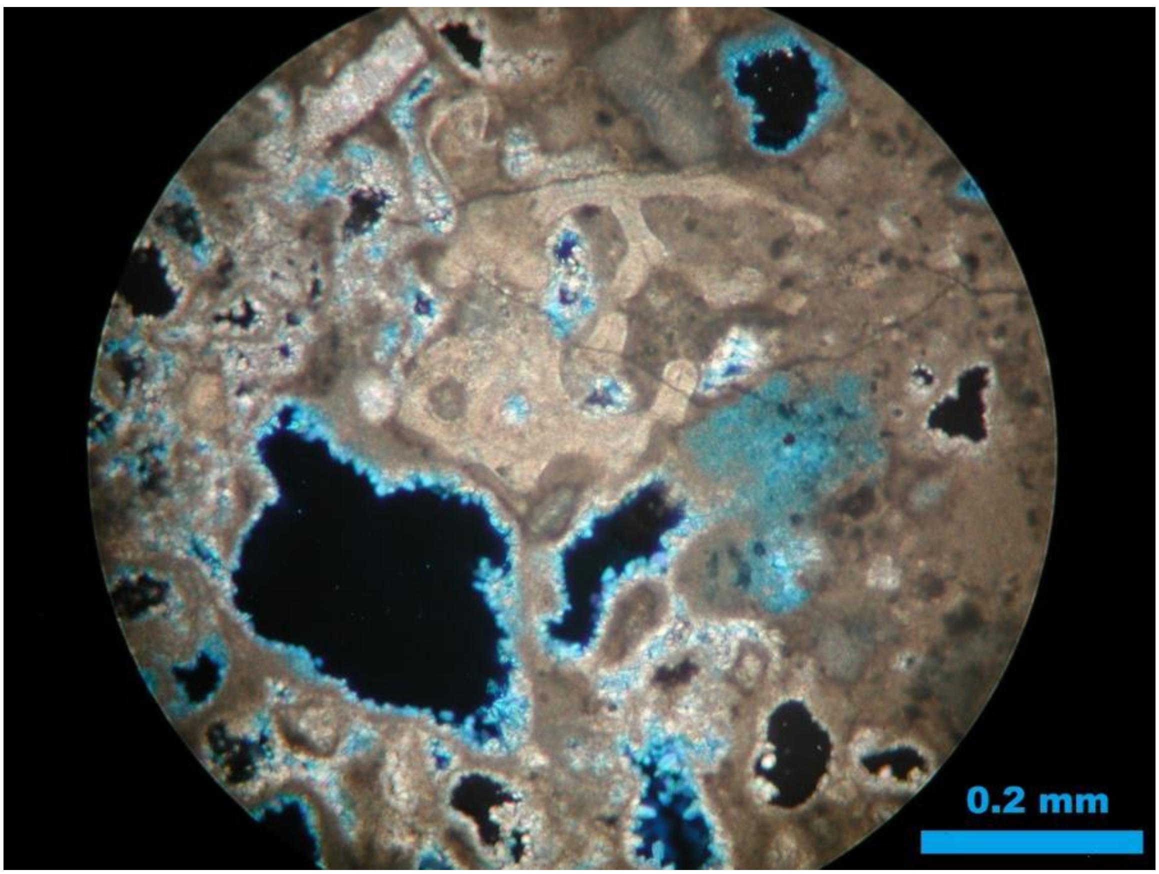

Figure B.5 Raton Cave ceiling rock CR3

Figure B.6 Raton Cave wall rock CR5

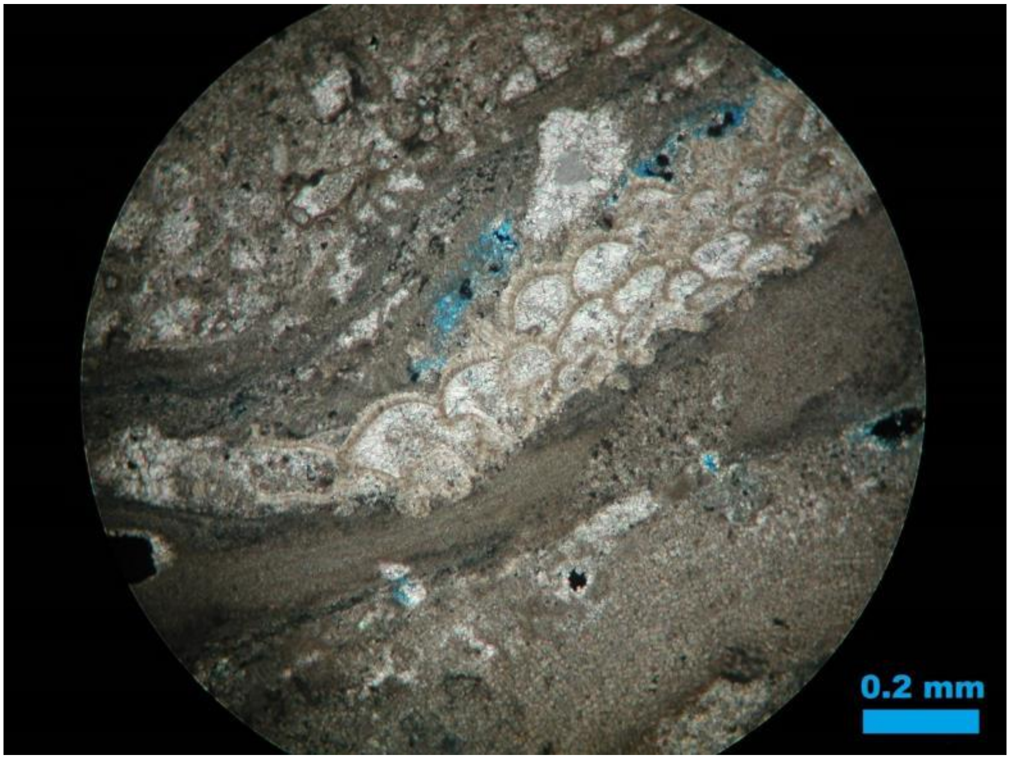

Figure B.7 Raton Cave ceiling rock CR6

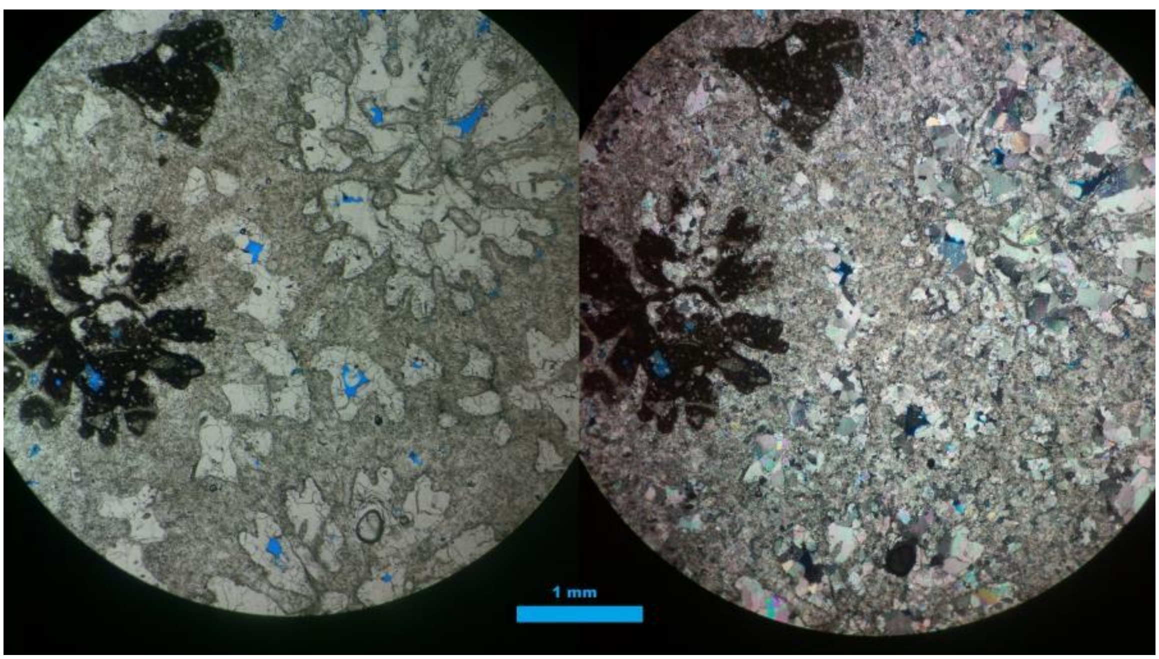

Figure B.8 Surface rock from above Raton Cave CR7

PPL (left) and XPL (right)

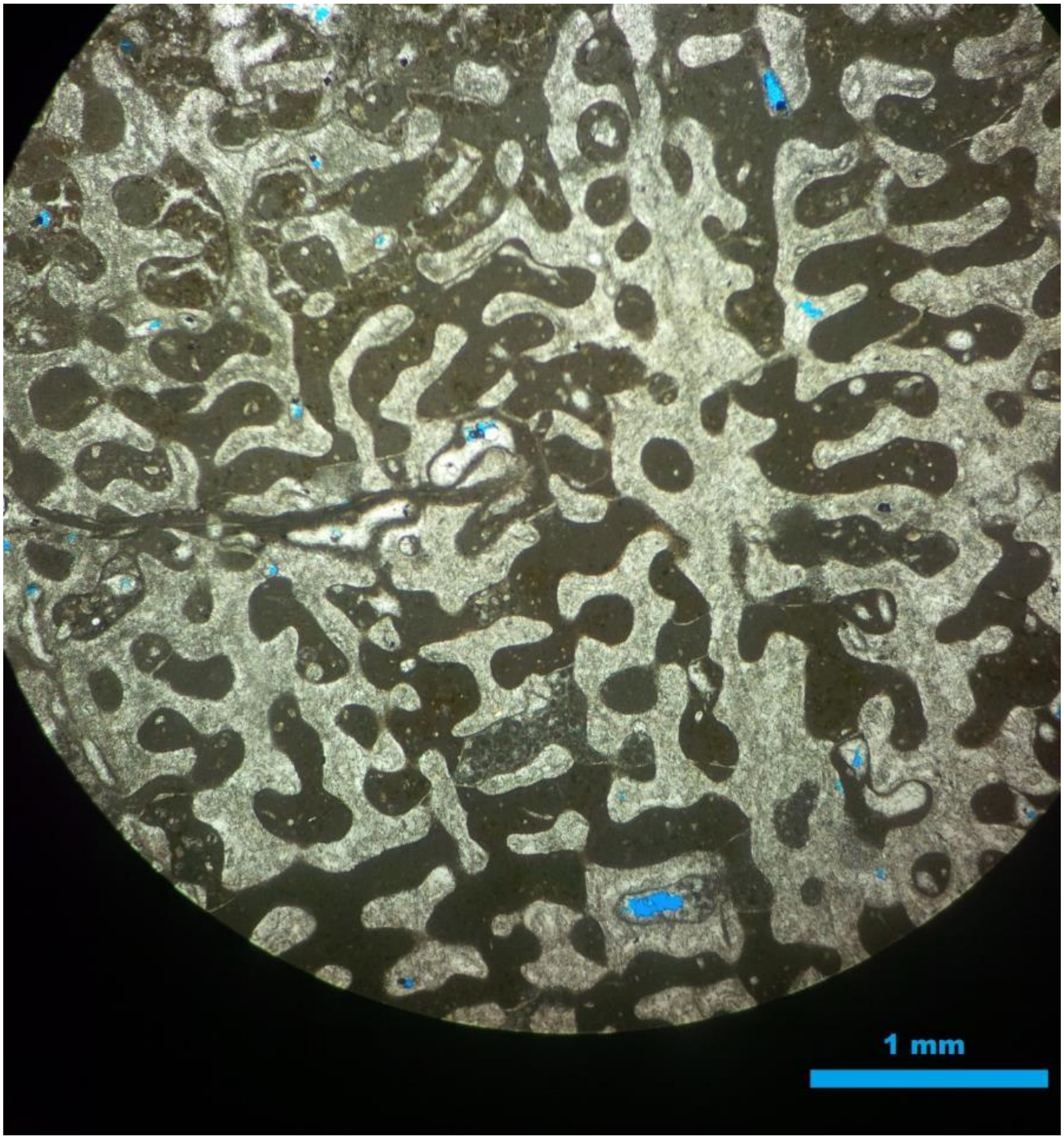

Figure B.9 Surface rock above Raton Cave CR8

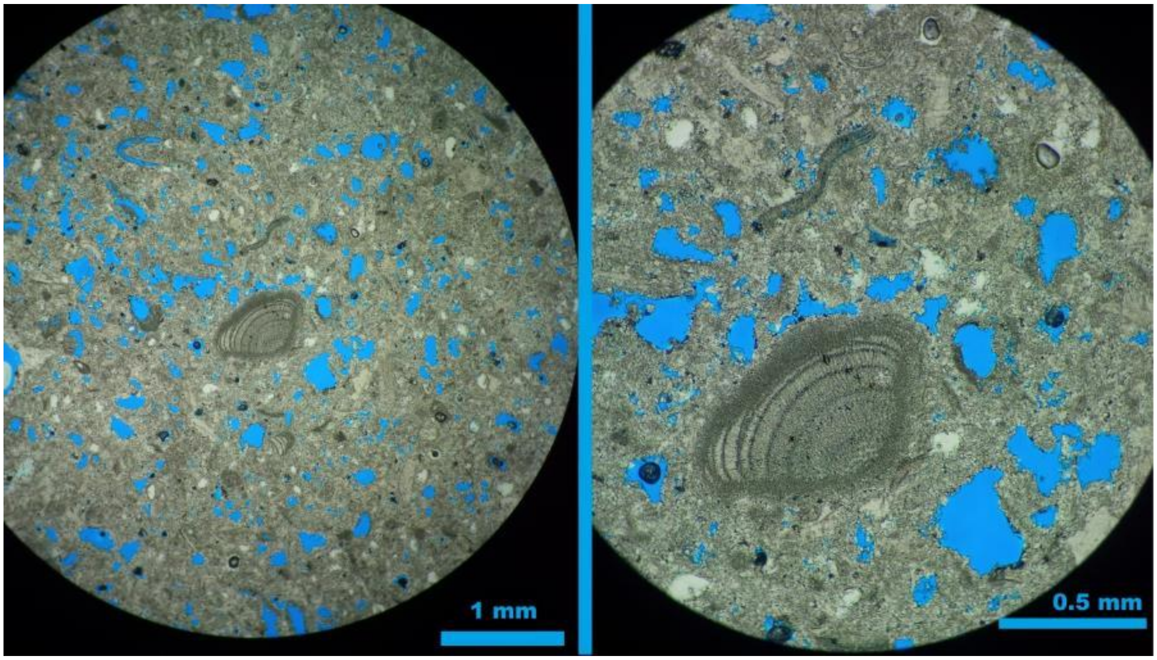

Figure B.10 Hato Cave wall rock CH2

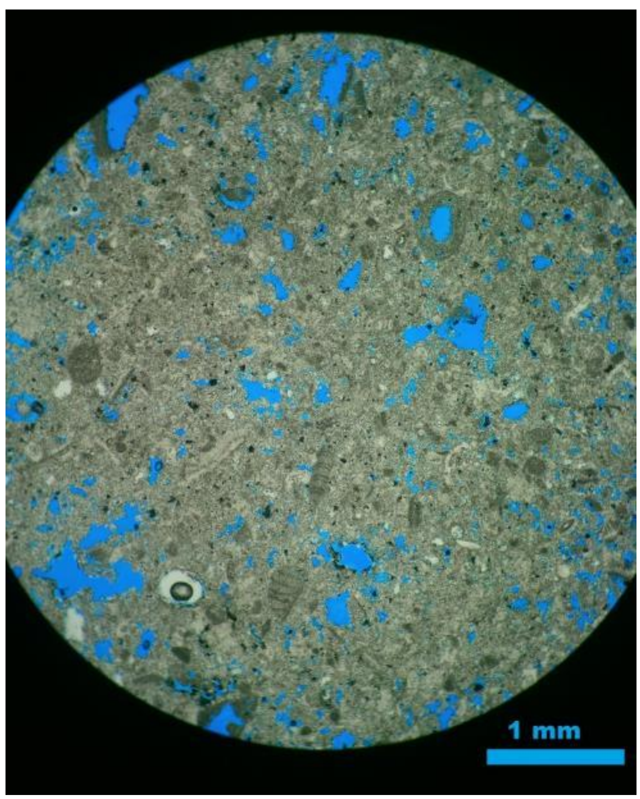

Figure B.11 Hato Cave ceiling rock CH3

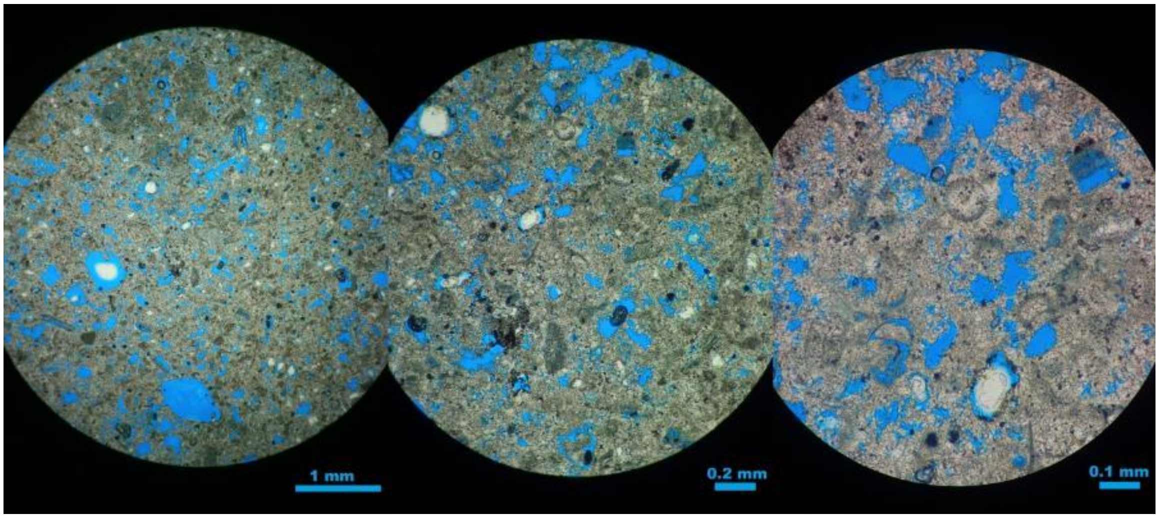

Figure B.12   Hato Cave wall rock CH5

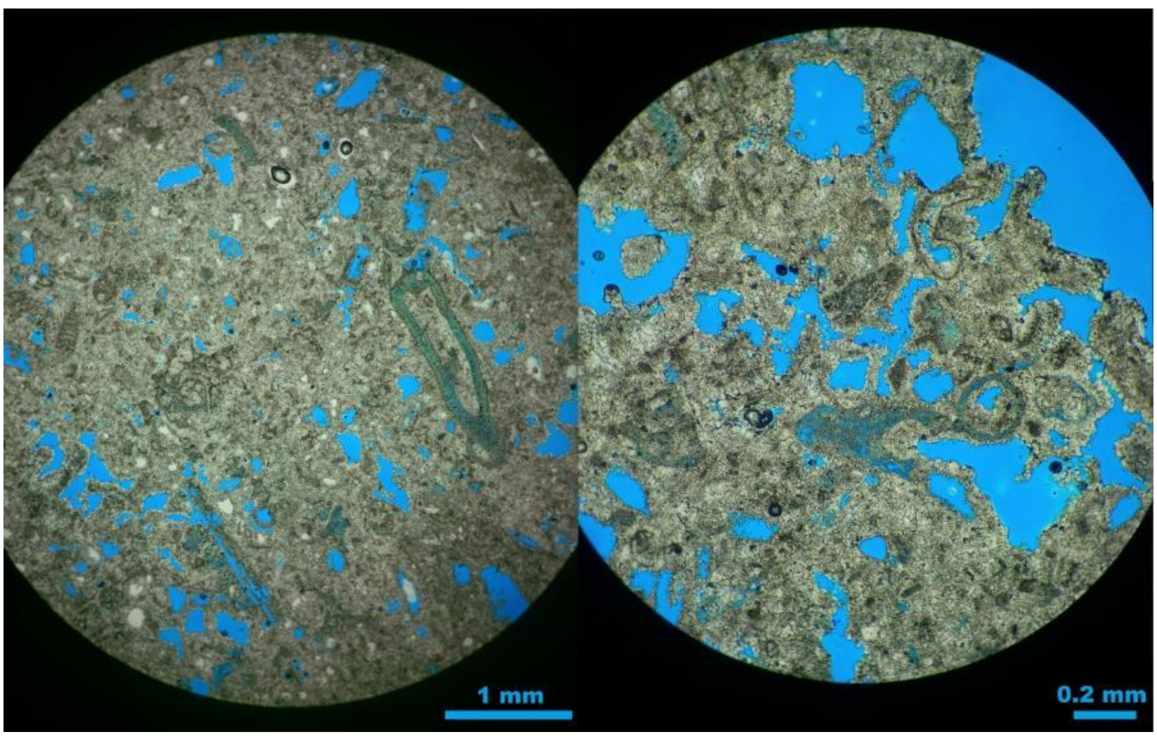

Figure B.13   Hato Cave ceiling rock CH6

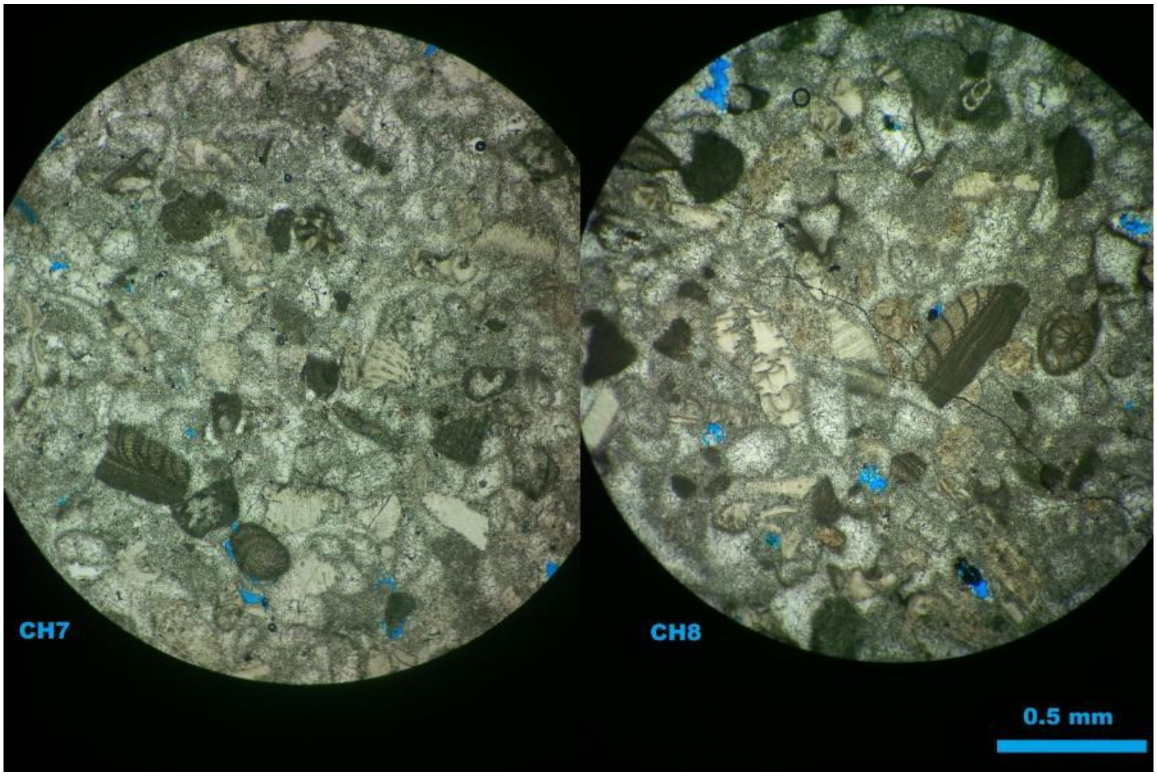

Figure B.14 Surface rock above Hato Cave CH7 and CH8

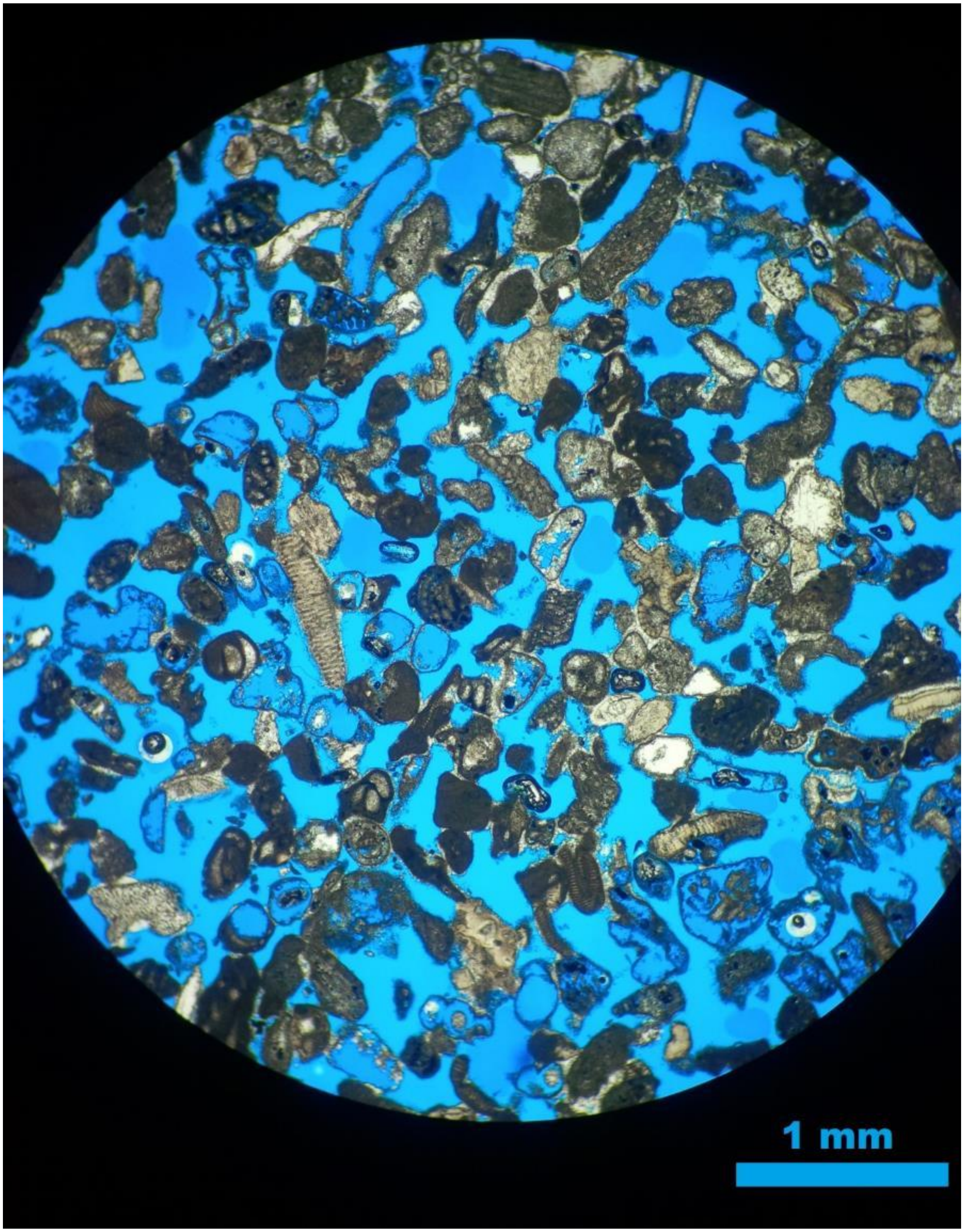

Figure B.15 Long Island's Hamilton's Cave wall rock LH2

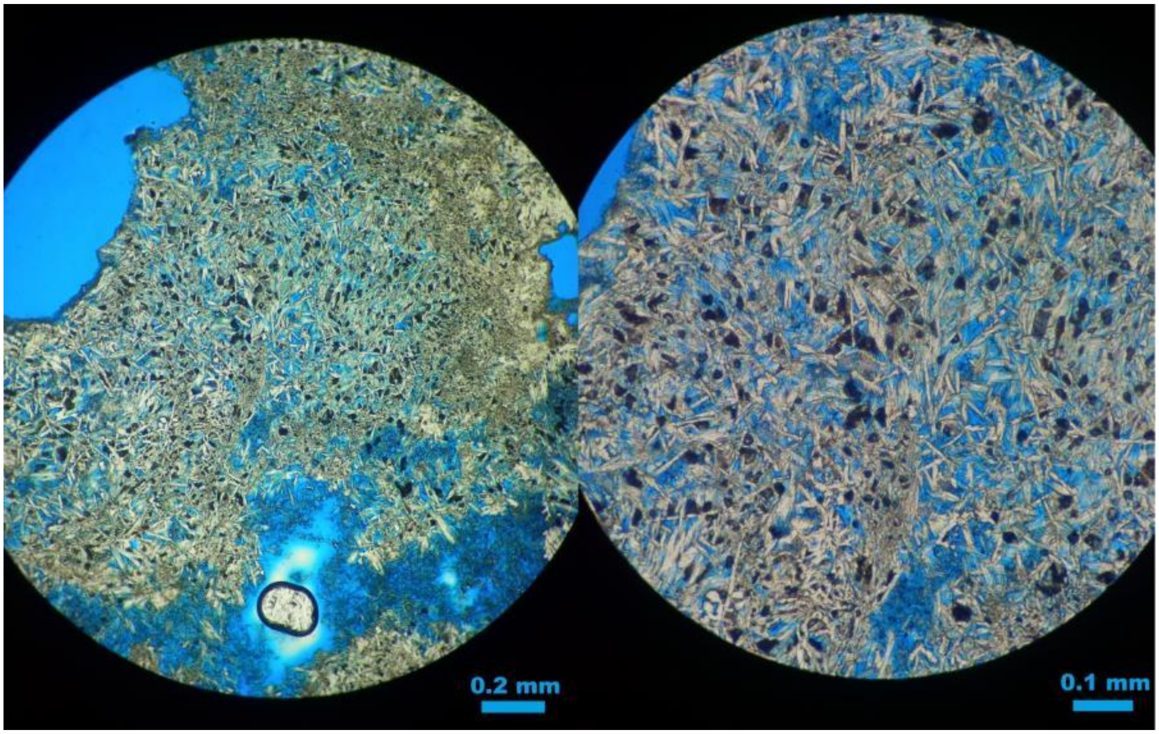

Figure B.16 Long Island's Hamilton's Cave ceiling rock LH3a

Flowstone.

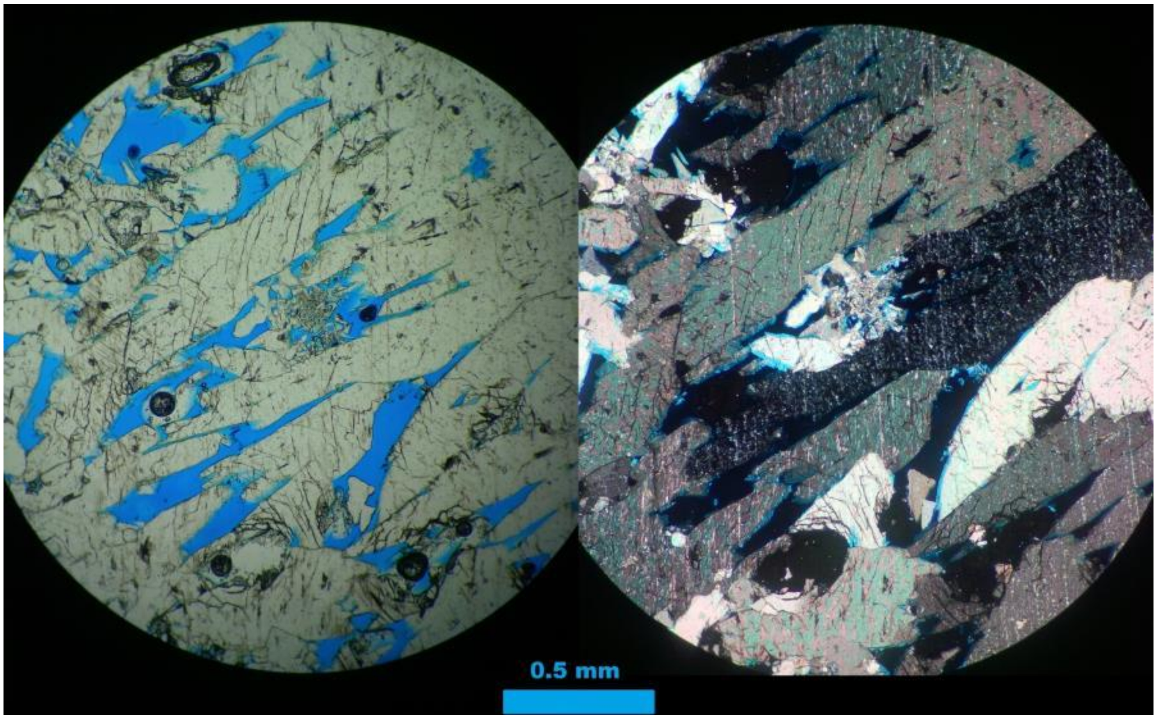

Figure B.17   Long Island's Hamilton's Cave ceiling rock LH3b

Flowstone.

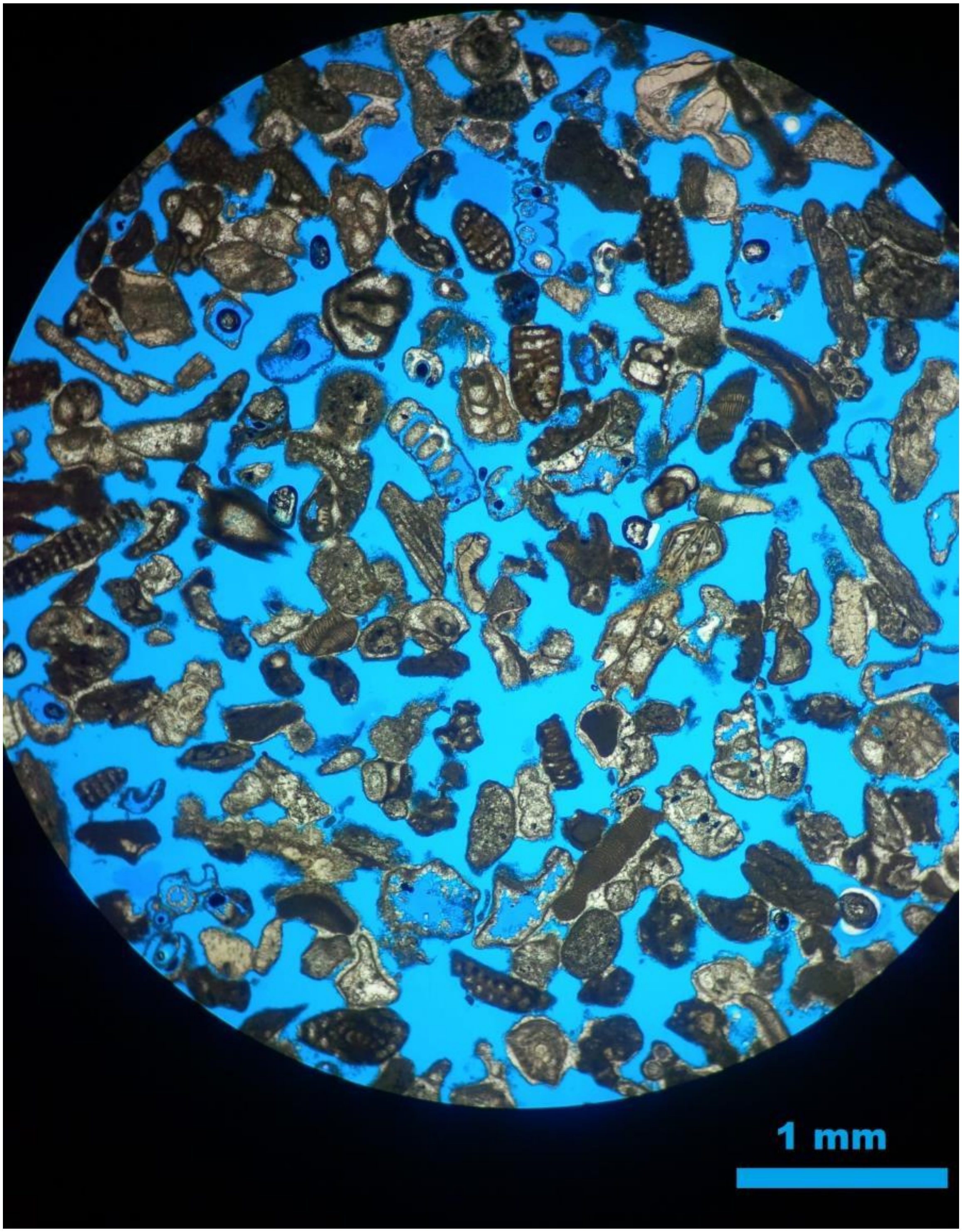

Figure B.18 Long Island's Hamilton's Cave wall rock LH5

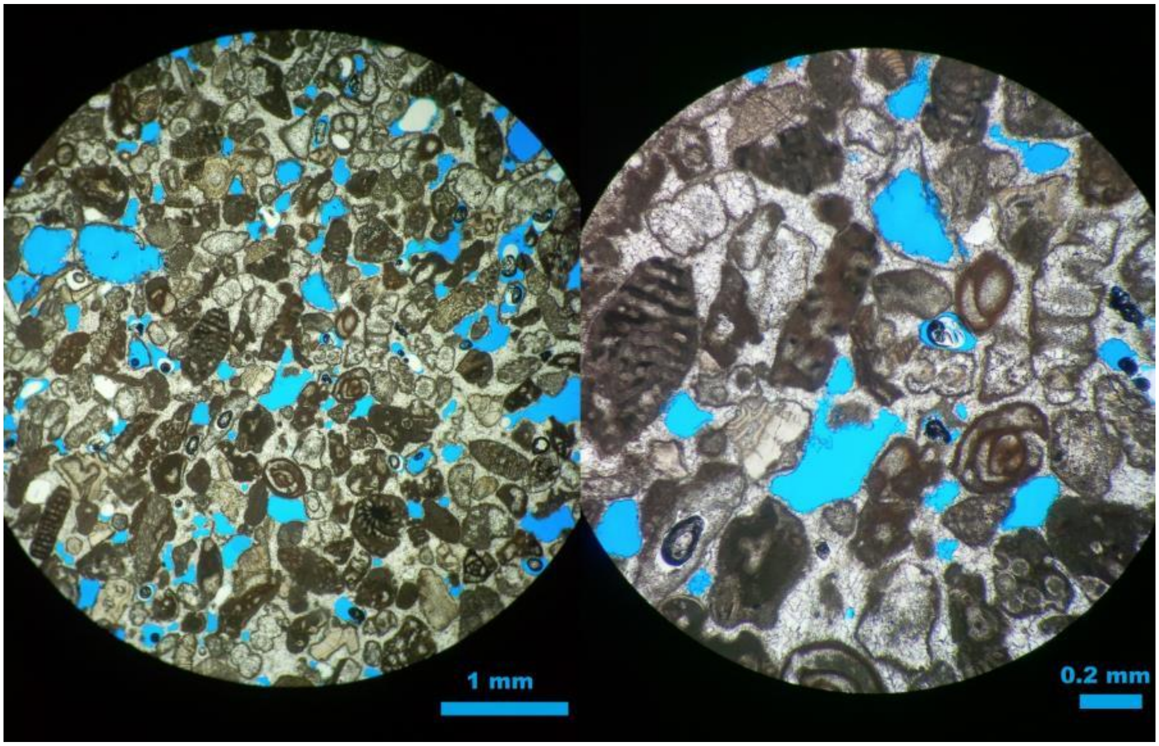

Figure B.19   Surface rock above Long Island's Hamilton's Cave LH6

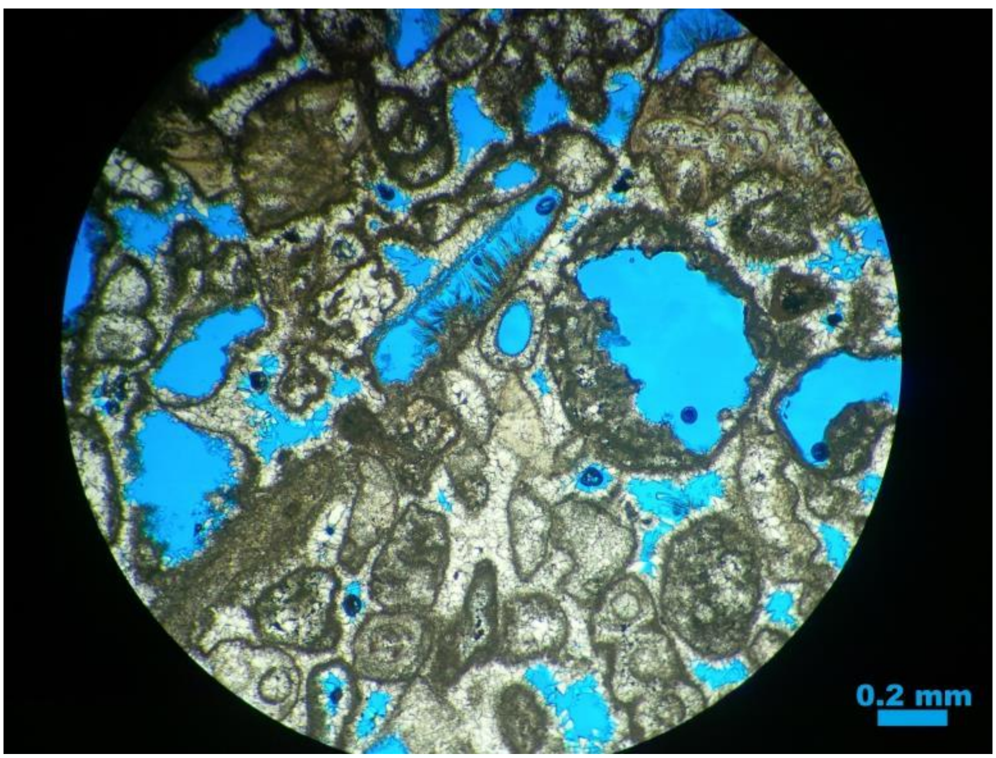

Figure B.20   Surface rock above Long Island's Hamilton's Cave LH7

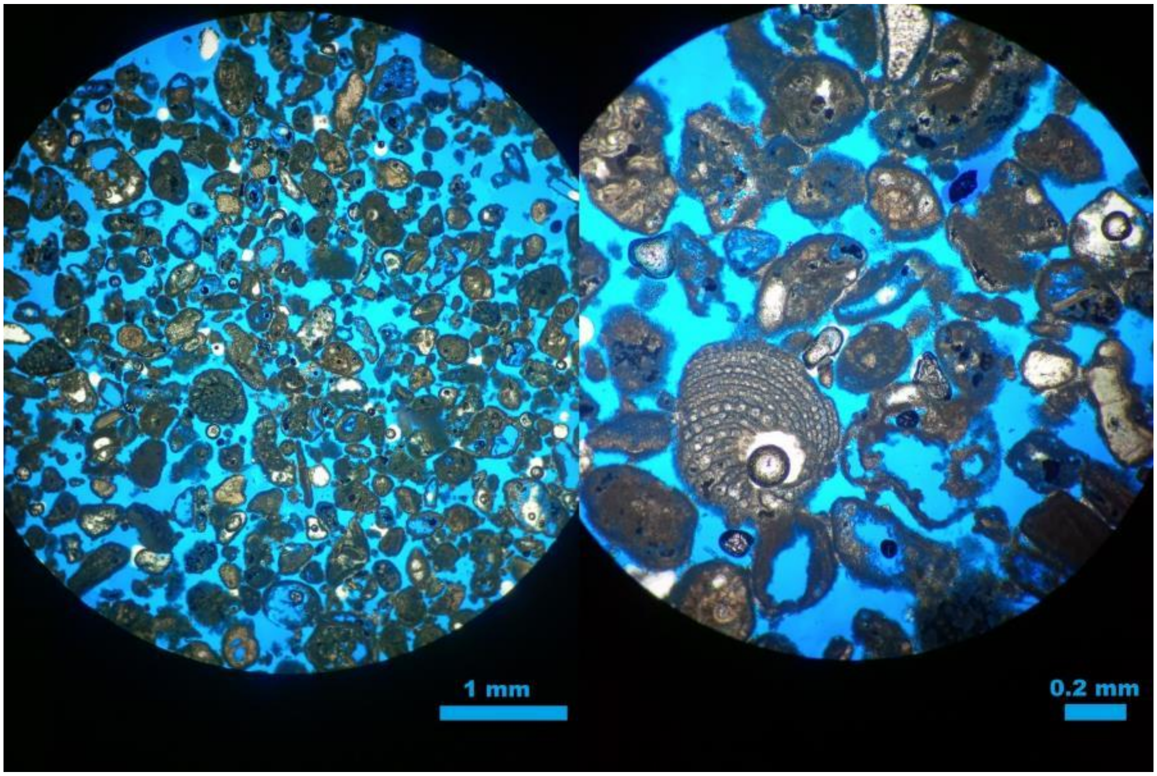

Figure B.21   Abaco's Hole in the Wall Cave wall rock AH2

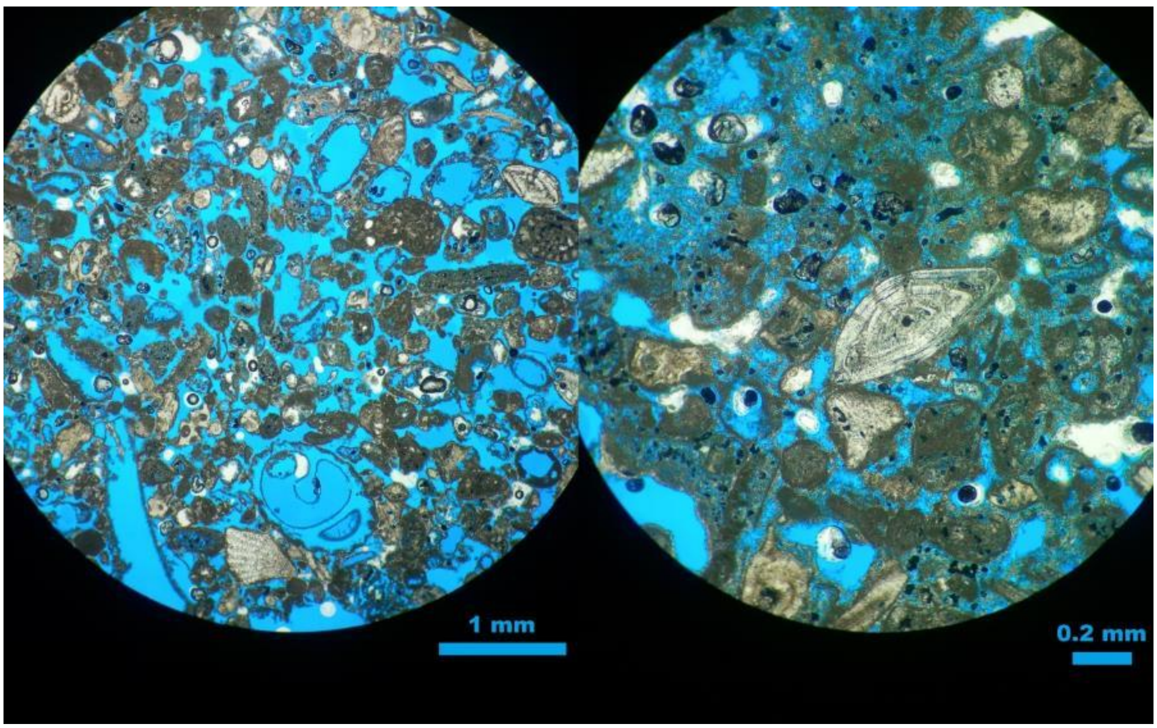

Figure B.22   Abaco's Hole in the Wall Cave ceiling rock AH3

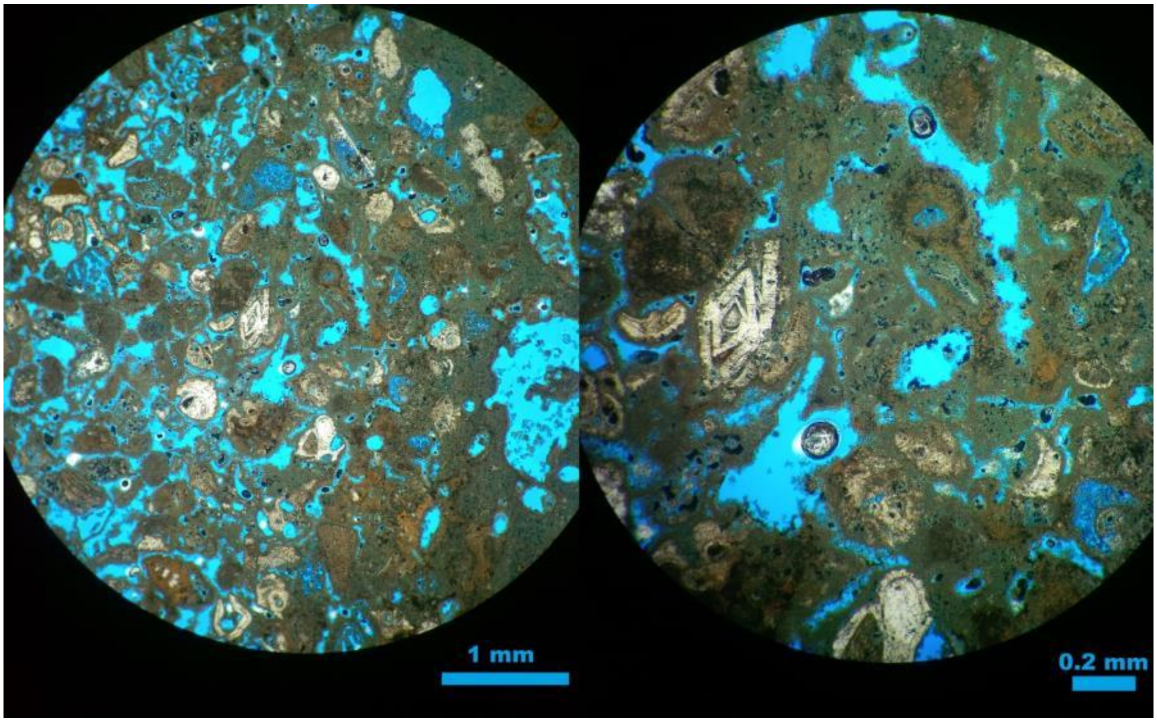

Figure B.23 Abaco's Hole in the Wall Cave wall rock AH5

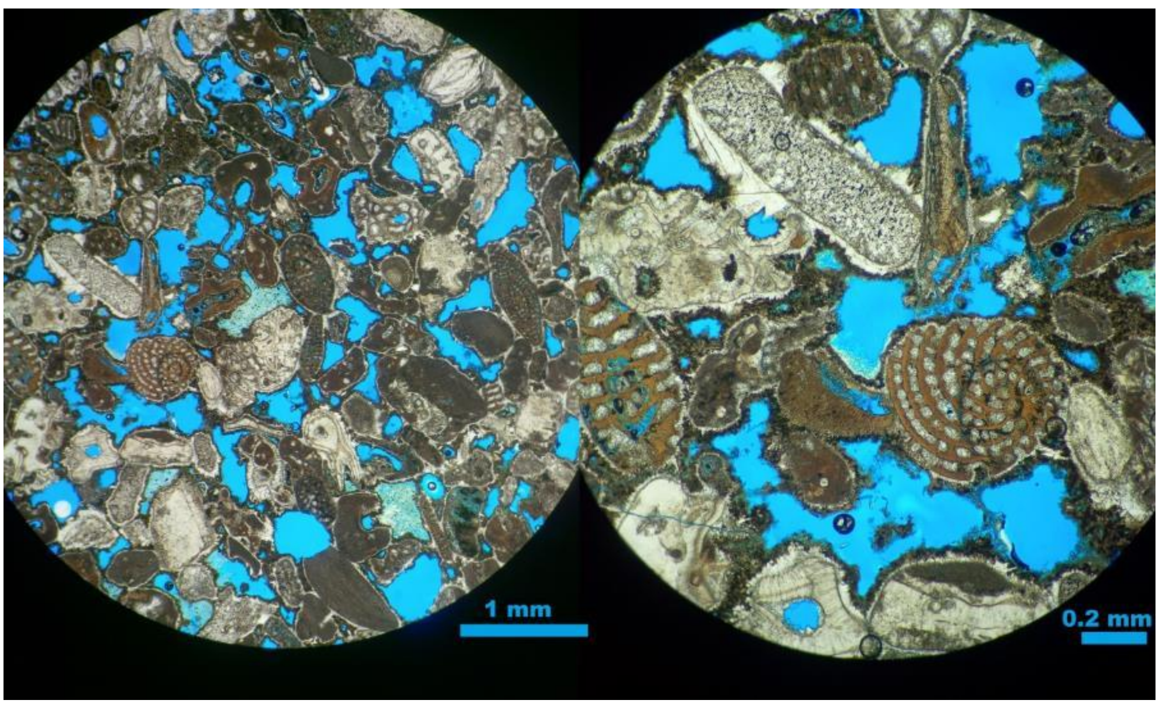

Figure B.24 Abaco's Hole in the Wall Cave ceiling rock AH6

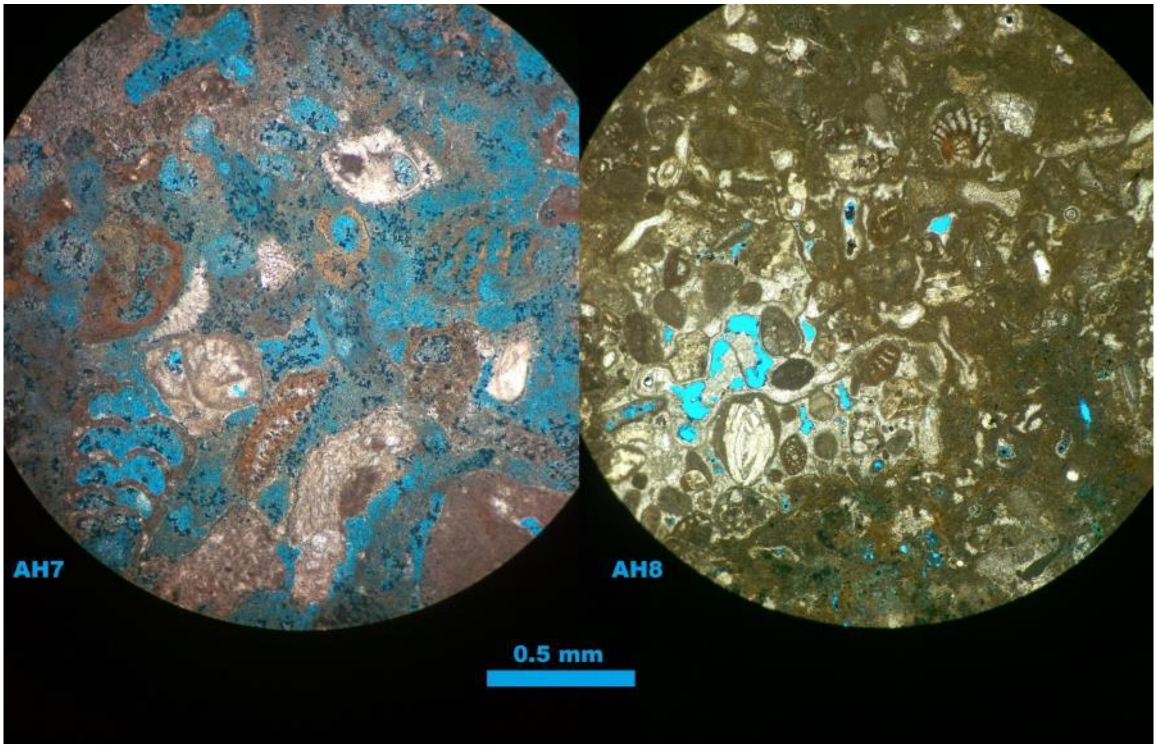

Figure B.25 Surface rock above Abaco's Hole in the Wall Cave AH7 and AH8

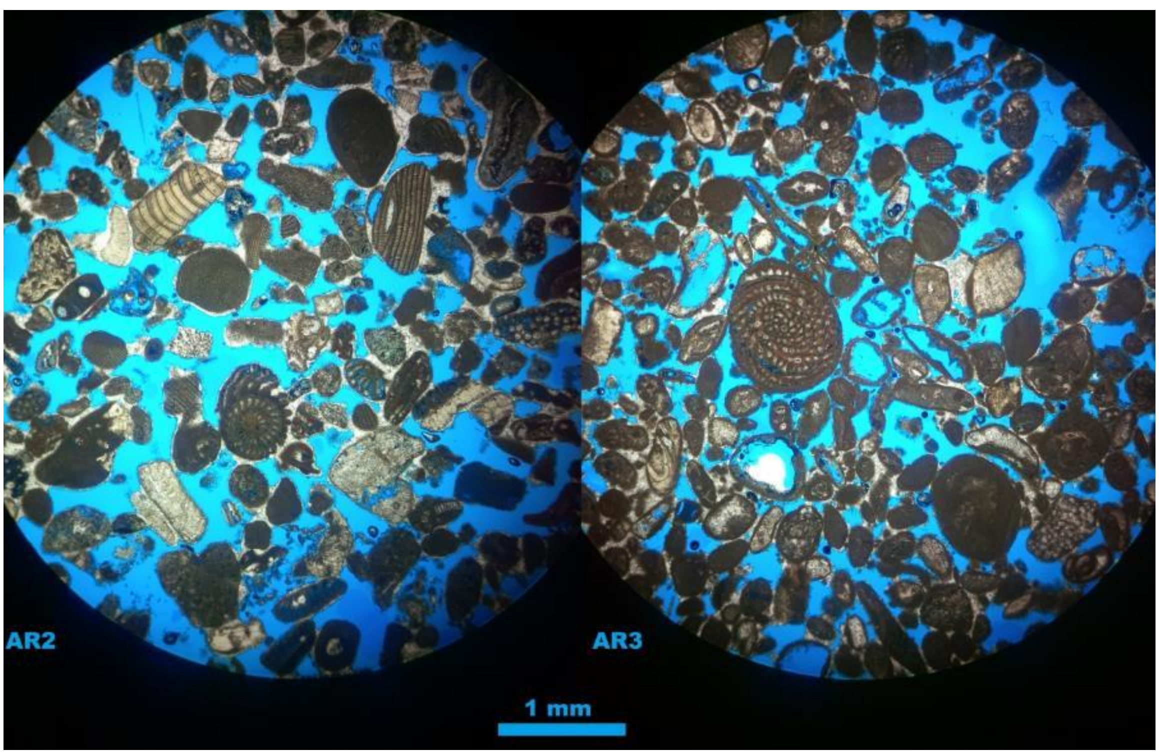

Figure B.26 Abaco's Roadside Cave wall and ceiling rock

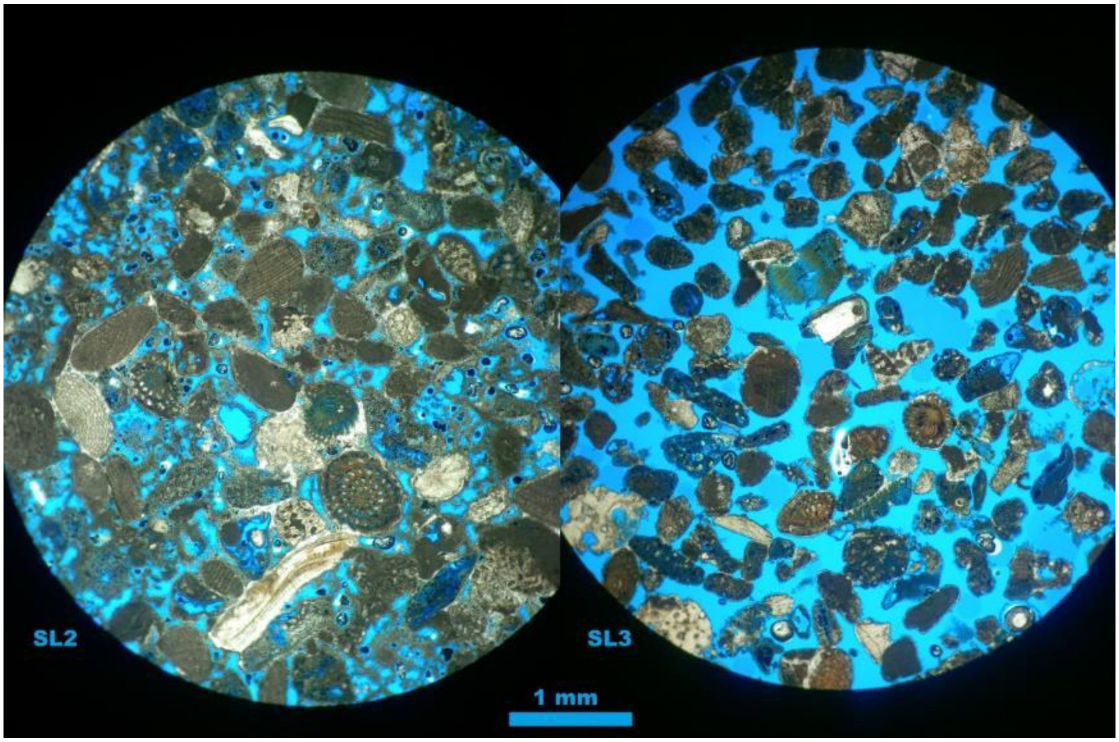

Figure B.27 San Salvador's Light House Cave wall and ceiling rock SL2 and SL3

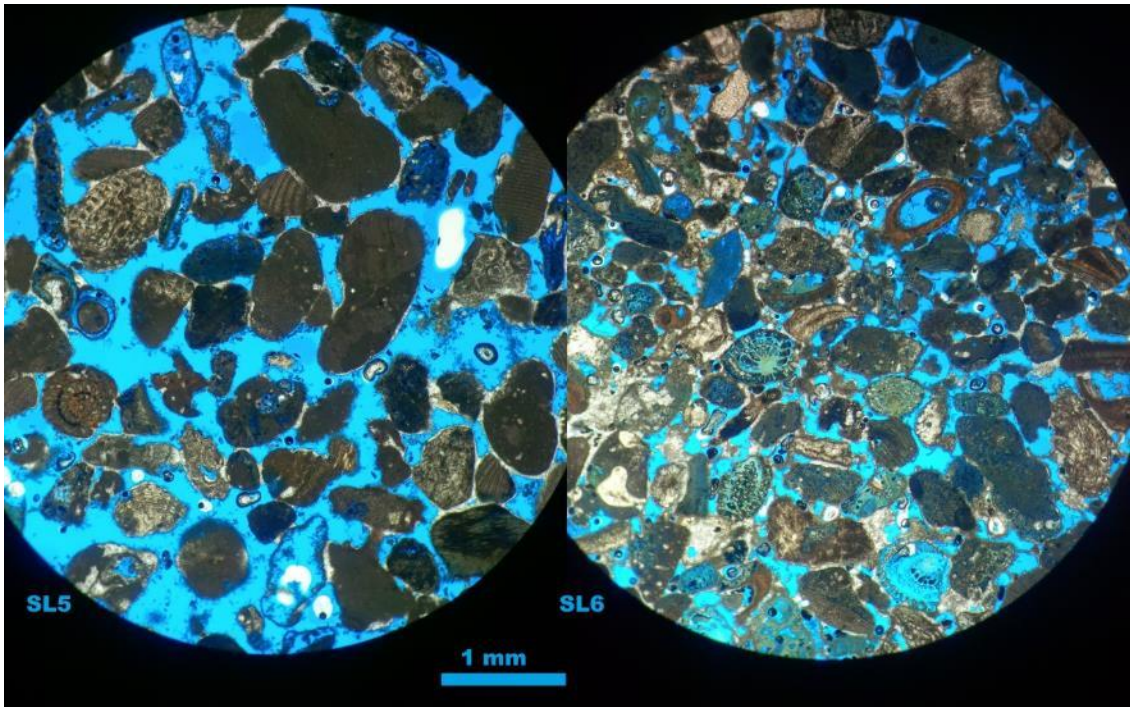

Figure B.28 San Salvador's Light House Cave wall and ceiling rock SL5 and SL6

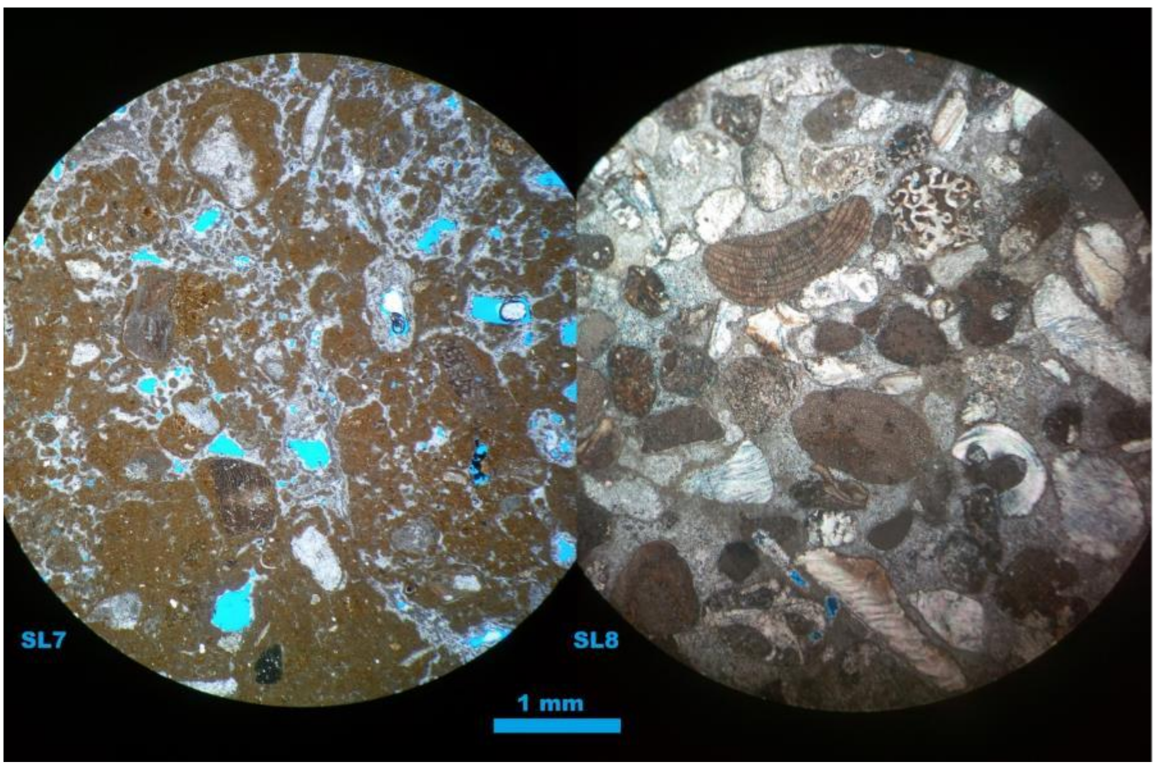

Figure B.29 Surface rocks above San Salvador's Light House Cave

APPENDIX C

ICP-OES DATA

Curaçao Stalagmite Data

Color coded (green=Sr, pink=Mg and blue=Ca)

Lardem Cave Stalagmite CLD1

Table C.1 Sr ppm CLD1

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CLD1-1	9.090417	0.0318164	0.349999	0.349999	9.090417	9.0904175
	9.257931	0.0529003	0.571406		0	
	9.405267	0.094013	0.999579		0	
CLD1-2	10.66	0.11	1.00	0.792124	0	11.0959365
	10.99	0.14	1.28		0	
	11.10	0.09	0.79		11.09594	
CLD1-3	9.00859	0.0876226	0.972657	0.698563	0	9.1806916
	9.180692	0.0641329	0.698563		9.180692	
	9.215927	0.1007564	1.093286		0	
CLD1-4	7.713091	0.0217787	0.282361	0.282361	7.713091	7.71309125
	7.952738	0.077453	0.973916		0	
	7.902256	0.0820353	1.038125		0	
CLD1-5	8.457581	0.063746	0.711191	0.711191	8.457581	8.45758073
	8.764022	0.1483611	1.692842		0	
	8.668097	0.1241775	1.43258		0	
CLD1-6	10.49	0.04	0.34	0.13847	0	10.7657741
	10.85	0.05	0.49		0	
	10.77	0.01	0.14		10.76577	
CLD1-7	8.873488	0.0599345	0.675433	0.644651	0	9.10049466
	9.194338	0.0673909	0.732961		0	
	9.100495	0.0586664	0.644651		9.100495	
CLD1-8	8.825717	0.0796228	0.902168	0.515621	0	9.1732084
	9.173208	0.047299	0.515621		9.173208	
	9.102683	0.0667397	0.733188		0	
CLD1-9	9.627845	0.046824	0.486339	0.141456	0	10.0270542
	10.04	0.09	0.89		0	
	10.03	0.01	0.14		10.02705	
CLD1-10	9.530655	0.0455537	0.477971	0.477971	9.530655	9.53065466
	9.904386	0.1037425	1.04744		0	
	9.818839	0.0544113	0.554152		0	
CLD1-11	7.313233	0.0514655	0.703731	0.703731	7.313233	7.3132329
	7.591443	0.0589626	0.776699		0	
	7.446242	0.119245	1.601412		0	
CLD1-12	8.256783	0.0093851	0.113665	0.113665	8.256783	8.25678307
	8.522399	0.0859861	1.008942		0	
	8.52737	0.0247855	0.290659		,0	

Table C.1 (Continued)

CLD1-13	6.098542	0.0590211	0.96779	0.418263	0	6.30115203
	6.301152	0.0263554	0.418263		6.301152	
	6.340485	0.0598456	0.943864		0	
CLD1-14	8.600497	0.0713529	0.829637	0.442593	0	8.8620347
	8.862035	0.0392228	0.442593		8.862035	
	8.766558	0.0995876	1.135995		0	
CLD1-15	7.730564	0.055985	0.724204	0.724204	7.730564	7.73056435
	8.069495	0.1130476	1.400925		0	
	7.911271	0.1200428	1.517365		0	
CLD1-16	7.246241	0.0336016	0.463711	0.463711	7.246241	7.24624052
	7.448131	0.0704395	0.945734		0	
	7.350016	0.0859488	1.169369		0	
CLD1-17	9.693127	0.0818834	0.844757	0.329159	0	9.93750641
	9.986377	0.2425538	2.428847		0	
	9.937506	0.0327102	0.329159		9.937506	
CLD1-18	10.18	0.03	0.27	0.267687	10.17884	10.1788407
	10.62	0.15	1.43		0	
	10.48	0.07	0.68		0	
CLD1-19	6.809285	0.0430723	0.632553	0.632553	6.809285	6.80928548
	7.07188	0.0583421	0.824987		0	
	7.014829	0.059678	0.85074		0	
CLD1-20	9.058815	0.0438611	0.484182	0.484182	9.058815	9.05881526
	9.481563	0.0529337	0.558281		0	
	9.413584	0.0754229	0.801214		0	
CLD1-21	7.399452	0.022487	0.303901	0.303901	7.399452	7.39945224
	7.773165	0.0784119	1.008751		0	
	7.726748	0.0943112	1.220581		0	
CLD1-22	6.771188	0.0153505	0.226704	0.226704	6.771188	6.77118814
	7.174177	0.026308	0.366704		0	
	7.001587	0.0992122	1.416996		0	
CLD1-23	9.030022	0.0670006	0.741975	0.741183	0	9.47236386
	9.550693	0.2020829	2.115898		0	
	9.472364	0.0702076	0.741183		9.472364	
CLD1-24	7.963172	0.0443907	0.55745	0.55745	7.963172	7.96317243
	8.226143	0.0443907	0.954875		0	
	8.218018	0.0563803	0.686057		0	
CLD1-25	9.659887	0.0650781	0.673695	0.673695	9.659887	9.65988725
	9.992192	0.0878117	0.878803		0	
	9.96097	0.0772843	0.775871		0	

Table C.2 Mg ppm CLD1

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
	0.261517	0.00160473	0.613626		0	
CLD1-1	0.2609	0.00123269	0.472477	0.472477	0.2609	0.2609
	0.268223	0.00386332	1.440337		0	
	0.103739	0.00074238	0.715623		0.103739	
CLD1-2	0.102935	0.00080257	0.779689	0.715623	0	0.103739
	0.10476	0.00183828	1.754764		0	
	0.107562	0.0008909	0.82826		0	
CLD1-3	0.108011	0.00105507	0.976813	0.710003	0	0.107827
	0.107827	0.00105507	0.710003		0.107827	
	0.091287	0.00052628	0.576511		0	
CLD1-4	0.091133	0.00069174	0.759042	0.341534	0	0.092546
	0.092546	0.00031607	0.341534		0.092546	
	0.611885	0.00435167	0.711191		0	
CLD1-5	0.619742	0.00142528	0.229979	0.229979	0.619742	0.619742
	0.623179	0.00406132	0.65171		0	
	2.84	0.01	0.37		2.842067	
CLD1-6	2.91365	0.01276089	0.437969	0.373516	0	2.842067
	2.937911	0.023015	0.78338		0	
	1.268026	0.0084689	0.66788		0	
CLD1-7	1.289807	0.00619525	0.480323	0.480323	1.289807	1.289807
	1.294305	0.00885771	0.68436		0	
	1.030088	0.00773076	0.750495		1.030088	
CLD1-8	1.052772	0.04729901	0.783535	0.750495	0	1.030088
	1.059684	0.01177893	1.111551		0	
	0.129621	0.00032662	0.251981		0.129621	
CLD1-9	0.132981	0.00047703	0.358722	0.251981	0	0.129621
	0.130292	0.00076946	0.590562		0	
	0.229958	0.00124519	0.541488		0	
CLD1-10	0.2357	0.00107352	0.455458	0.455458	0.2357	0.2357
	0.233639	0.23363928	0.580212		0	
	0.197557	0.00097702	0.494551		0	
CLD1-11	0.201662	0.00144748	0.717774	0.305863	0	0.197147
	0.197147	0.000603	0.305863		0.197147	
	1.164896	0.00236222	0.202784		0	
CLD1-12	1.19609	0.00237554	0.198609	0.198609	1.19609	1.19609
	1.19531	0.00485639	0.406287		0	
	0.245628	0.00241092	0.981534		0	
CLD1-13	0.251163	0.00206169	0.820858	0.56018	0	0.248374
	0.248374	0.00139134	0.56018		0.248374	

Table C.2 (Continued)

CLD1-14	0.25471	0.00270267	1.061079	0.59974	0	0.260662
	0.260662	0.00156329	0.59974		0.260662	
	0.258317	0.00329572	1.275842		0	
CLD1-15	0.200673	0.00158641	0.790544	0.183349	0	0.204322
	0.204322	0.00037462	0.183349		0.204322	
	0.205065	0.00272087	1.326832		0	
CLD1-16	0.078604	0.00027112	0.344915	0.293189	0	0.080644
	0.080644	0.00023644	0.293189		0.080644	
	0.079258	0.00290451	3.664626		0	
CLD1-17	0.108516	0.00131995	1.216363	0.855033	0	0.111299
	0.111299	0.00095164	0.855033		0.111299	
	0.110456	0.00115904	1.049326		0	
CLD1-18	0.063925	0.00018692	0.292406	0.292406	0.063925	0.063925
	0.065646	0.0004604	0.701327		0	
	0.064588	0.00053291	0.825095		0	
CLD1-19	0.044835	0.00026053	0.581084	0.47145	0	0.046429
	0.046429	0.00021889	0.47145		0.046429	
	0.044004	0.0021823	4.959325		0	
CLD1-20	0.062226	0.00049302	0.792301	0.698699	0	0.065086
	0.065086	0.00045476	0.698699		0.065086	
	0.062451	0.00185955	2.977632		0	
CLD1-21	0.051523	0.00024034	0.466472	0.447911	0	0.053471
	0.053471	0.0002395	0.447911		0.053471	
	0.051586	0.00154406	2.993181		0	
CLD1-22	0.045779	0.0001941	0.423997	0.423997	0.045779	0.045779
	0.047697	0.00057142	1.198016		0	
	0.045845	0.00229989	5.016638		0	
CLD1-23	0.067167	0.00032915	0.116465	0.116465	0.067167	0.070012
	0.070012	8.154E-05	0.116465		0.070012	
	0.067707	0.0007932	1.171522		0	
CLD1-24	0.049746	0.00045573	0.916104	0.378066	0	0.051398
	0.051398	0.00019432	0.378066		0.051398	
	0.04954	0.0032337	6.527508		0	
CLD1-25	0.068849	0.0004192	0.608868	0.576047	0	0.070433
	0.070433	0.00040573	0.576047		0.070433	
	0.069286	0.00160811	2.320962		0	

Table C.3 Ca ppm CLD1

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CLD1-1	4.870138	0.1117391	2.2943726	1.426116 6	0	5.153233	515.323307
	5.153233	0.0734911	1.4261166		5.1532		

Table C.3 (Continued)

	5.724496	0.1693646	2.9585949		0		
CLD1-2	5.979778	0.1016127	1.6992727	1.6992727	5.9798	5.979778	597.977825
	4.702684	0.0936994	1.9924675		0		
CLD1-3	4.910059	0.0660745	1.3456977	1.3456977	4.9101	4.910059	491.005894
	4.087421	0.1806423	4.4194689		0		
CLD1-4	4.276621	0.071016	1.6605628	1.6605628	4.2766	4.276621	427.662081
	4.63766	0.1339227	2.8877216		0		
CLD1-5	4.834302	0.0801029	1.6569691	1.6569691	4.8343	4.834302	483.430208
	5.793946	0.1911427	3.299007		0		
CLD1-6	6.190124	0.0564932	0.9126345	0.9126345	6.1901	6.190124	619.012377
	4.638059	0.1213416	2.6162142		0		
CLD1-7	4.870767	0.1030184	2.1150349	2.1150349	4.8708	4.870767	487.076704
	5.657928	0.1583235	2.7982597		0		
CLD1-8	5.940299	0.1232344	2.0745485	2.0745485	5.9403	5.940299	594.029889
	6.212451	0.1304529	2.0998629		0		
CLD1-9	6.555299	0.0784212	1.196303	1.196303	6.5553	6.555299	655.529928
	5.949706	0.1732508	2.9119221		0		
CLD1-10	6.151936	0.0766847	1.2465133	1.2465133	6.1519	6.151936	615.193576
	4.344772	0.1410678	3.2468392		0		
CLD1-11	4.567653	0.0564144	1.2350846	1.2350846	4.5677	4.567653	456.765327
	5.759289	0.1995377	3.464624		0		
CLD1-12	5.991328	0.0330361	0.5513983	0.5513983	5.9913	5.991328	599.13285

Table C.3 (Continued)

	3.82101	0.1380074	3.6118042		0		
CLD1-13	4.007134	0.0808218	2.0169478	2.0169478	4.0071	4.007134	400.713389
	5.432827	0.1418346	2.6106952		0		
CLD1-14	5.689366	0.0975787	1.7151058	1.7151058	5.6894	5.689366	568.936643
	0.295071	0.0023761	0.805258		0		
CLD1-15	0.288765	0.0023082	0.7993374	0.7993374	0.2888	0.288765	28.8764642
	2.76301	0.0391194	1.4158268		0		
CLD1-16	2.700969	0.0220798	0.8174769	0.8174769	2.701	2.700969	270.096939
	2.799155	0.0330519	1.1807824		0		
CLD1-17	2.789081	0.0262101	0.9397403	0.9397403	2.7891	2.789081	278.908106
	2.821534	0.0447926	1.587526		0		
CLD1-18	2.832695	0.0422947	1.4930911	1.4930911	2.8327	2.832695	283.269486
	1.923547	0.0139564	0.7255567		0		
CLD1-19	1.884996	0.0124117	0.6584471	0.6584471	1.885	1.884996	188.499634
	2.563814	0.0383399	1.4954228		0		
CLD1-20	2.566835	0.0142415	0.5548258	0.5548258	2.5668	2.566835	256.683542
	2.250919	0.0300618	1.3355343		0		
CLD1-21	2.210554	0.0052457	0.2373035	0.2373035	2.2106	2.210554	221.0554
	2.01813	0.0353376	1.751009		0		
CLD1-22	1.991485	0.0336576	1.6900745	1.6900745	1.9915	1.991485	199.148535
	2.686297	0.0098228	0.3656615		2.6863		
CLD1-23	2.65246	0.0328262	1.2375771	0.3656615	0	2.686297	268.629738
	2.176807	0.0189706	0.8714857		0		
CLD1-24	2.146952	0.000613	0.0285525	0.0285525	2.147	2.146952	214.695169
	2.65162	0.0350193	1.3206772		2.6516		
CLD1-25	2.652006	0.0508994	1.9192782	1.3206772	0	2.65162	265.161982

Lardem Stalagmite CLD2

Table C.4 Sr ppm CLD2

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CLD2-1	8.347271	0.026032	0.311864	0.311864	8.347271	8.34727082
	8.182352	0.037726	0.878803		0	
	8.420093	0.105249	0.775871		0	
CLD2-2	12.83	0.09	0.73	0.731103	12.82631	12.8263138
	12.62	0.16	1.29		0	
	12.91	0.10	0.78		0	
CLD2-3	5.677549	0.023925	0.421405	0.110708	0	5.80938615
	5.575979	0.032443	0.581831		0	
	5.809386	0.006431	0.110708		5.809386	
CLD2-4	9.396775	0.097275	1.035198	0.359906	0	9.02804526
	9.028045	0.032493	0.359906		9.028045	
	9.429396	0.153786	1.630919		0	
CLD2-5	9.666794	0.040511	0.419074	0.319284	0	9.74042922
	9.116957	0.02927	0.321051		0	
	9.740429	0.0311	0.319284		9.740429	
CLD2-6	7.716338	0.02645	0.342778	0.342778	7.716338	7.71633812
	7.275592	0.055643	0.764796		0	
	7.776906	0.038521	0.495325		0	
CLD2-7	8.742537	0.014763	0.168861	0.168861	8.742537	8.74253655
	8.26464	0.040633	0.491645		0	
	8.878587	0.037445	0.421749		0	
CLD2-8	0.819141	0.010319	1.259702	0.350459	0	0.78681863
	0.786819	0.002757	0.350459		0.786819	
	0.82719	0.003256	0.393639		0	
CLD2-9	11.91	0.01	0.11	0.107355	11.91114	11.9111356
	11.18	0.11	1.00		0	
	11.98	0.11	0.94		0	
CLD2-10	13.25	0.07	0.57	0.565739	13.25304	13.2530437
	12.47	0.14	1.14		0	
	13.30	0.11	0.86		0	
CLD2-11	4.760115	0.019891	0.417863	0.278626	0	4.82340607
	4.522289	0.022601	0.499778		0	
	4.823406	0.013439	0.278626		4.823406	
CLD2-12	2.457929	0.010952	0.445558	0.207521	0	2.36694292
	2.366943	0.004912	0.207521		2.366943	
	2.48592	0.009807	0.394499		,0	

Table C.4 (Continued)

CLD2-13	9.169206	0.015301	0.166874	0.166874	9.169206	9.16920595
	8.634695	0.130191	1.50776		0	
	9.176187	0.073772	0.80395		0	
CLD2-14	8.609456	0.019639	0.228108	0.228108	8.609456	8.60945572
	8.146084	0.035886	0.44053		0	
	8.662398	0.101731	1.174394		0	
CLD2-15	7.401394	0.061414	0.829763	0.611743	0	7.07963483
	7.079635	0.043309	0.611743		7.079635	
	7.46033	0.068379	0.91657		0	
CLD2-16	6.988301	0.029116	0.416633	0.282308	0	7.13167279
	6.687221	0.10811	1.616672		0	
	7.131673	0.020133	0.282308		7.131673	
CLD2-17	6.622552	0.079152	1.195195	1.192763	0	6.73891415
	6.227801	0.076308	1.225288		0	
	6.738914	0.080379	1.192763		6.738914	
CLD2-18	5.716821	0.034534	0.604081	0.378929	0	5.80374719
	5.388316	0.037391	0.693931		0	
	5.803747	0.021992	0.378929		5.803747	
CLD2-19	4.742228	0.015165	0.319796	0.319796	4.742228	4.74222765
	4.474668	0.025145	0.561934		0	
	4.813527	0.016396	0.340616		0	
CLD2-20	4.665871	0.00648	0.263285	0.136732	0	4.73912804
	4.41239	0.044217	1.002102		0	
	4.739128	0.00648	0.136732		4.739128	
CLD2-21	4.790202	0.01309	0.273264	0.273264	4.790202	4.79020181
	4.535655	0.027781	0.612494		0	
	4.845968	0.023389	0.482655		0	
CLD2-22	6.086198	0.023625	0.388166	0.388166	6.086198	6.08619792
	5.774618	0.064684	1.120151		0	
	6.203956	0.027185	0.438181		0	
CLD2-23	6.941605	0.032967	0.474913	0.271771	0	6.95052101
	6.528226	0.018154	0.278077		0	
	6.950521	0.018889	0.271771		6.950521	
CLD2-24	8.771383	0.016198	0.184672	0.184672	8.771383	8.77138278
	8.241748	0.099933	1.212525		0	
	8.754455	0.108652	1.241105		0	

Table C.4 (Continued)

CLD2-25	10.16	0.08	0.82	0.479552	0	9.47277885
	9.472779	0.045427	0.479552		9.472779	
	10.18	0.05	0.50		0	
CLD2-26	10.43	0.08	0.72	0.724343	10.43165	10.4316518
	9.742762	0.145202	1.490363		0	
	10.46	0.12	1.18		0	
CLD2-27	6.744147	0.035316	0.523659	0.416147	0	6.84364891
	6.327537	0.039254	0.620361		0	
	6.843649	0.02848	0.416147		6.843649	
CLD2-28	11.02	0.09	0.80	0.231192	0	10.4329977
	10.43	0.02	0.23		10.433	
	11.13	0.07	0.63		0	
CLD2-29	6.850154	0.016759	0.244648	0.244648	6.850154	6.85015433
	6.480651	0.074254	1.145782		0	
	6.911283	0.064689	0.935992		0	
CLD2-30	9.409231	0.012326	0.130998	0.130998	9.409231	9.40923117
	8.840142	0.158421	1.792069		0	
	9.480161	0.026894	0.28369		0	
CLD2-31	8.637471	0.027789	0.321727	0.321727	8.637471	8.63747135
	8.117395	0.027789	0.625714		0	
	8.629483	0.160719	1.862436		0	
CLD2-32	10.76	0.04	0.33	0.332092	10.76133	10.761333
	10.23	0.15	1.43		0	
	10.92	0.09	0.81		0	
CLD2-33	9.362888	0.00568	0.060666	0.060666	9.362888	9.36288759
	8.84748	0.071882	0.060666		8.84748	
	9.374721	0.031165	0.332441		0	
CLD2-34	7.68962	0.019955	0.259509	0.259509	7.68962	7.68961966
	7.283343	0.083928	1.152322		0	
	7.724706	0.081051	1.049247		0	
CLD2-35	15.62	0.06	0.40	0.402464	15.62231	15.6223072
	14.89	0.27	1.81		0	
	15.92	0.12	0.76		0	
CLD2-36	11.65	0.01	0.11	0.113843	11.65108	11.6510762
	11.09	0.11	0.99		0	
	11.70	0.09	0.79		0	

Table C.4 (Continued)

CLD2-37	8.671381	0.046804	0.539754	0.539754	8.671381	8.67138149
	8.237073	0.045838	0.556483		0	
	8.811234	0.120337	1.365718		0	
CLD2-38	7.354529	0.034382	0.467488	0.467488	7.354529	7.35452897
	6.989359	0.102395	1.465018		0	
	7.413031	0.056585	0.763317		0	
CLD2-39	8.779702	0.001741	0.019827	0.019827	8.779702	8.77970167
	8.365622	0.105002	1.255166		0	
	8.818438	0.079926	0.906351		0	
CLD2-40	10.45	0.07	0.64	0.117316	0	9.92761738
	9.927617	0.011647	0.117316		9.927617	
	10.60	0.04	0.37		0	
CLD2-41	8.790791	0.020983	0.238689	0.238689	8.790791	8.79079116
	8.358525	0.119673	1.431752		0	
	8.916118	0.038944	0.436784		0	
CLD2-42	10.78	0.02	0.15	0.146779	10.78175	10.7817463
	10.30	0.03	0.27		0	
	10.91	0.09	0.79		0	
CLD2-43	10.20	0.04	0.39	0.392082	10.20033	10.200333
	9.668056	0.04386	0.453659		0	
	10.23	0.08	0.82		0	
CLD2-44	9.093202	0.025539	0.280855	0.280855	9.093202	9.09320203
	8.652861	0.069749	0.806082		0	
	9.129796	0.07547	0.826635		0	
CLD2-45	5.977771	0.017756	0.29704	0.116715	0	6.05641199
	5.717205	0.050527	0.883772		0	
	6.056412	0.007069	0.116715		6.056412	

Table C.5 Mg ppm CLD2

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CLD2-1	3.1880654	0.012766302	0.4004404	0.341097	0	3.305929
	3.166257	0.011043295	0.3487808		0	
	3.3059287	0.011276425	0.3410971		3.305929	
CLD2-2	1.8191228	0.013099924	0.7201231	0.593276	0	1.804164
	1.8041644	0.010703668	0.5932757		1.804164	
	1.9042282	0.01465535	0.7696215		0	
CLD2-3	11.15	0.02	0.21	0.200177	0	11.23108
	11.23	0.02	0.20		11.23108	
	11.76	0.05	0.42		0	
CLD2-4	0.2633743	0.002734805	1.0383721	0.44744	0	0.274204
	0.260807	0.002877636	1.1033583		0	
	0.2742044	0.0012269	0.4474399		0.274204	

Table C.5 (Continued)

CLD2-5	0.1894173	0.000607208	0.320566	0.320566	0.189417	0.189417
	0.1882165	0.001326392	0.7047159		0	
	0.1995601	0.00134044	0.6716974		0	
CLD2-6	0.1299871	0.000349145	0.2685994	0.145395	0	0.128619
	0.1286188	0.000187005	0.1453951		0.128619	
	0.1358572	0.001070368	0.787863		0	
CLD2-7	1.9186285	0.002556216	0.1332314	0.133231	1.918628	1.918628
	1.903557	0.005681394	0.298462		0	
	2.0140201	0.004080928	0.202626		0	
CLD2-8	13.92	0.08	0.59	0.25592	0	14.99116
	14.25	0.04	0.31		0	
	14.99	0.04	0.26		14.99116	
CLD2-9	1.5323142	0.004805309	0.3135982	0.313598	1.532314	1.532314
	1.5166143	0.004966307	0.3274601		0	
	1.6226472	0.010540244	0.6495709		0	
CLD2-10	0.4532791	0.00133593	0.2947257	0.294726	0.453279	0.453279
	0.4463089	0.002933114	0.6571936		0	
	0.4730352	0.002893991	0.6117918		0	
CLD2-11	4.5458139	0.016461284	0.3621196	0.36212	4.545814	4.545814
	4.4882914	0.016426025	0.365975		0	
	4.7771726	0.017369796	0.3635999		0	
CLD2-12	7.5324731	0.022160615	0.2942011	0.275151	0	7.476414
	7.4764145	0.020571422	0.2751509		7.476414	
	7.9316965	0.026008249	0.3279027		0	
CLD2-13	0.7175885	0.002609162	0.3636015	0.286348	0	0.753823
	0.7026664	0.002857017	0.4065965		0	
	0.7538234	0.00215856	0.2863482		0.753823	
CLD2-14	0.199831	0.001009568	0.505211	0.505211	0.199831	0.199831
	0.1952708	0.001311074	0.6714129		0	
	0.2092373	0.001816646	0.868223		0	
CLD2-15	3.0667856	0.021713789	0.7080309	0.205967	0	3.237589
	3.0199542	0.020852542	0.690492		0	
	3.2375885	0.006668365	0.205967		3.237589	
CLD2-16	2.5643438	0.01270805	0.4955673	0.429634	0	2.514672
	2.5146718	0.010803892	0.4296343		2.514672	
	2.7111527	0.016447344	0.606655		0	
CLD2-17	1.1201593	0.008949812	0.7989767	0.798977	1.120159	1.120159
	1.0970337	0.010159476	0.9260861		0	
	1.1772008	0.01403586	1.192308		0	
CLD2-18	1.1180817	0.003695225	0.3304969	0.290055	0	1.094764
	1.0947644	0.00317542	0.2900551		1.094764	
	1.1728021	0.004690605	0.3999486		0	
CLD2-19	4.9086174	0.011457267	0.2334113	0.230956	0	4.840398
	4.8403982	0.011179172	0.2309556		4.840398	
	5.1947707	0.013396796	0.25789		0	

Table C.5 (Continued)

CLD2-20	2.9958859	0.006823446	0.2277605	0.038053	0	3.156078
	2.9404299	0.003783601	0.1286751		0	
	3.1560779	0.00120099	0.0380532		3.156078	
CLD2-21	2.1578708	0.009161844	0.424578	0.275769	0	2.114853
	2.1148532	0.005832116	0.2757693		2.114853	
	2.2607071	0.00767123	0.3393288		0	
CLD2-22	1.6609875	0.006092841	0.3668204	0.175219	0	1.751941
	1.6274911	0.007647296	0.4698825		0	
	1.7519414	0.003069735	0.1752191		1.751941	
CLD2-23	0.6966008	0.002314811	0.332301	0.073462	0	0.73169
	0.6808102	0.002662134	0.3910244		0	
	0.7316896	0.000537517	0.0734624		0.73169	
CLD2-24	0.0708159	9.83431E-05	0.1388714	0.138871	0.070816	0.070816
	0.0694698	0.000113656	0.1636052		0	
	0.0755042	0.000399423	0.5290075		0	
CLD2-25	0.1389391	0.000743739	0.5352985	0.535299	0.138939	0.138939
	0.1352707	0.000919771	0.6799487		0	
	0.1467856	0.003113713	2.1212658		0	
CLD2-26	0.0975477	0.000683325	0.7005034	0.425366	0	0.095612
	0.0956123	0.000406702	0.4253657		0.095612	
	0.1050556	0.000710426	0.6762383		0	
CLD2-27	0.0730848	0.00042899	0.5869761	0.586976	0.073085	0.073085
	0.0711526	0.00054781	0.7699085		0	
	0.0763633	0.001019818	1.3354828		0	
CLD2-28	0.1032763	0.000763987	0.7397508	0.739751	0.103276	0.103276
	0.1002215	0.000917535	0.9155077		0	
	0.1088155	0.001348773	1.2395043		0	
CLD2-29	0.058995	0.000166702	0.2825694	0.282569	0.058995	0.058995
	0.0580175	0.000235344	0.4056438		0	
	0.063386	0.000995858	1.5711012		0	
CLD2-30	0.1462089	0.00047469	0.3246655	0.298767	0	0.143044
	0.1430443	0.000427369	0.2987668		0.143044	
	0.1534119	0.000657604	0.4286522		0	
CLD2-31	0.0895298	0.000350048	0.3909844	0.275299	0	0.087301
	0.0873007	0.000240338	0.2752989		0.087301	
	0.0936503	0.001164649	1.2436147		0	
CLD2-32	0.074263	0.000530472	0.7143161	0.430175	0	0.072887
	0.0728868	0.000313541	0.430175		0.072887	
	0.0806984	0.000613707	0.7604948		0	
CLD2-33	0.0577681	8.18988E-05	0.1417716	0.141772	0.057768	0.057768
	0.0562419	0.000224717	0.3995547		0	
	0.0607554	0.001691715	2.7844674		0	

Table C.5 (Continued)

CLD2-34	0.060691	0.000213873	0.3523969		0.060691	
	0.0598311	0.000500959	0.837289	0.352397	0	0.060691
	0.063967	0.000412228	0.6444391		0	
CLD2-35	0.0988657	0.000660593	0.6681721		0	
	0.0974515	0.000304018	0.3119689	0.259013	0	0.106662
	0.1066623	0.00027627	0.2590132		0.106662	
CLD2-36	0.1067818	0.000228892	0.2143549		0	
	0.1053593	9.08153E-05	0.0861958	0.086196	0.105359	0.105359
	0.1126675	0.000564533	0.5010613		0	
CLD2-37	0.0735372	0.000287478	0.3909294		0.073537	
	0.0720739	0.000436145	0.6051364	0.390929	0	0.073537
	0.0758789	0.000700514	0.9232007		0	
CLD2-38	0.0489693	0.000129502	0.2644549		0.048969	
	0.0481301	0.000262619	0.5456445	0.264455	0	0.048969
	0.0520732	0.001526341	2.931146		0	
CLD2-39	0.1026253	0.000103953	0.1012937		0.102625	
	0.1019413	0.000156147	0.1531738	0.101294	0	0.102625
	0.1073639	0.001165887	1.0859212		0	
CLD2-40	0.0899205	0.000430618	0.4788877		0.08992	
	0.0888342	0.0006323	0.7117758	0.478888	0	0.08992
	0.0957774	0.000557936	0.5825341		0	
CLD2-41	0.192202	0.000873957	0.4547074		0.192202	
	0.1894852	0.001089756	0.575114	0.454707	0	0.192202
	0.2002153	0.001732173	0.8651552		0	
CLD2-42	0.2201665	0.000487398	0.2213769		0	
	0.2179829	0.000678659	0.3113361	0.204842	0	0.229787
	0.2297869	0.0004707	0.2048422		0.229787	
CLD2-43	1.0072161	0.003273529	0.3250076		0	
	0.9991366	0.003186669	0.3189423	0.197252	0	1.046847
	1.0468474	0.00206493	0.1972522		1.046847	
CLD2-44	0.1213082	0.000701301	0.5781151		0	
	0.120455	0.000198152	0.1645029	0.164503	0.120455	0.120455
	0.1275722	0.000927953	0.7273949		0	
CLD2-45	0.0565213	0.000382546	0.676817		0	
	0.0559717	0.000161305	0.2881906	0.288191	0.055972	0.055972
	0.0593904	0.000723994	1.2190424		0	

Table C.6 Ca ppm CLD2

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CLD2-1	3.346998	0.025407	0.759092	0.759092	3.346998	3.346998	334.699806
	3.313377	0.032188	0.971445		0		
CLD2-2	4.869304	0.065343	1.341928	1.2074	0	5.111991	511.19906
	5.111991	0.061722	1.2074		5.111991		
CLD2-3	4.313345	0.132962	3.082573	1.22109	0	4.40878	440.878008
	4.40878	0.053835	1.22109		4.40878		
CLD2-4	4.521101	0.090848	2.009427	0.741863	0	4.740576	474.057567
	4.740576	0.035169	0.741863		4.740576		
CLD2-5	4.521488	0.110835	2.451298	1.008124	0	4.702867	470.28665
	4.702867	0.047411	1.008124		4.702867		
CLD2-6	3.68962	0.058837	1.594651	1.594651	3.68962	3.68962	368.962043
	3.71198	0.090644	2.44192		0		
CLD2-7	4.55456	0.166485	3.655348	2.147852	0	4.733881	473.388122
	4.733881	0.101677	2.147852		4.733881		
CLD2-8	3.345615	0.058917	1.76101	1.466629	0	3.318197	331.819695
	3.318197	0.048666	1.466629		3.318197		
CLD2-9	6.046232	0.13207	2.184339	0.579698	0	6.26828	626.827961
	6.26828	0.036337	0.579698		6.26828		
CLD2-10	5.990824	0.176181	2.940849	0.873202	0	6.290057	629.005664
	6.290057	0.054925	0.873202		6.290057		
CLD2-11	3.507759	0.052014	1.482831	1.482831	3.507759	3.507759	350.775856
	3.482737	0.063539	1.824404		0		
CLD2-12	3.592625	0.070674	1.967186	1.967186	3.592625	3.592625	359.262509
	3.563777	0.073869	2.072786		0		

Table C.6 (Continued)

CLD2-13	-0.00958	0.000783	8.171192	8.171192	-0.00958	0	0
	-0.00882	0.001168	13.24		0		
CLD2-14	4.782184	0.184681	3.861854	1.886962	0	4.988629	498.862887
	4.988629	0.094134	1.886962		4.988629		
CLD2-15	5.11805	0.144829	2.829774	1.218444	0	5.3228	532.280009
	5.3228	0.064855	1.218444		5.3228		
CLD2-16	5.068344	0.145622	2.873172	1.442086	0	5.268365	526.836548
	5.268365	0.075974	1.442086		5.268365		
CLD2-17	4.135358	0.147624	3.569794	1.688432	0	4.340081	434.008087
	4.340081	0.073279	1.688432		4.340081		
CLD2-18	3.67877	0.068027	1.849187	1.830703	0	3.655693	365.56929
	3.655693	0.066925	1.830703		3.655693		
CLD2-19	4.034504	0.139389	3.454919	2.064147	0	4.209939	420.99389
	4.209939	0.086899	2.064147		4.209939		
CLD2-20	3.685271	0.063494	1.722923	1.722923	3.685271	3.685271	368.527097
	3.74225	0.103102	2.755093		0		
CLD2-21	-0.00976	0.001278	13.10	12.68157	0	0	0
	-0.00883	0.00112	12.68		-0.00883		
CLD2-22	3.930181	0.105053	2.672983	2.672983	3.930181	3.930181	393.01807
	4.01739	0.123415	3.072024		0		
CLD2-23	4.259759	0.131733	3.092506	1.946619	0	4.447656	444.765649
	4.447656	0.086579	1.946619		4.447656		
CLD2-24	5.060148	0.129886	2.566843	1.748383	0	5.244229	524.422895
	5.244229	0.091689	1.748383		5.244229		

Table C.6 (Continued)

CLD2-25	5.535598	0.182427	3.295519	1.353388	0	5.739282	573.928221
	5.739282	0.077675	1.353388		5.739282		
CLD2-26	5.456026	0.118136	2.165245	0.926593	0	5.670444	567.044426
	5.670444	0.052542	0.926593		5.670444		
CLD2-27	3.685045	0.067052	1.819578	1.819578	3.685045	3.685045	368.504502
	3.661778	0.071225	1.945102		0		
CLD2-28	6.59278	0.198335	3.008373	1.109563	0	6.84251	684.250968
	6.84251	0.075922	1.109563		6.84251		
CLD2-29	3.985923	0.102331	2.567313	1.010377	0	4.167251	416.725083
	4.167251	0.042105	1.010377		4.167251		
CLD2-30	5.328272	0.175041	3.285138	1.064326	0	5.636498	563.649784
	5.636498	0.059991	1.064326		5.636498		
CLD2-31	3.731249	0.091569	2.454107	1.988226	0	3.752311	375.231072
	3.752311	0.074604	1.988226		3.752311		
CLD2-32	5.949114	0.202147	3.397943	1.316648	0	6.164307	616.430684
	6.164307	0.081162	1.316648		6.164307		
CLD2-33	5.365095	0.196416	3.660999	1.078433	0	5.59892	559.892018
	5.59892	0.060381	1.078433		5.59892		
CLD2-34	4.645144	0.154458	3.325142	0.410614	0	4.834892	483.48917
	4.834892	0.019853	0.410614		4.834892		
CLD2-35	9.287748	0.273052	2.939917	2.021027	0	9.579375	957.937519
	9.579375	0.193602	2.021027		9.579375		
CLD2-36	6.750362	0.109501	1.622143	0.933224	0	6.979118	697.911828
	6.979118	0.065131	0.933224		6.979118		

Table C.6 (Continued)

CLD2-37	5.056002	0.173002	3.421716	1.745255	0	5.293552	529.355182
	5.293552	0.092386	1.745255		5.293552		
CLD2-38	4.188571	0.191661	4.57581	0.59603	0	4.383706	438.370569
	4.383706	0.026128	0.59603		4.383706		
CLD2-39	4.997751	0.132109	2.643366	1.929343	0	5.264512	526.451244
	5.264512	0.10157	1.929343		5.264512		
CLD2-40	6.140967	0.205859	3.352229	1.116822	0	6.412406	641.240625
	6.412406	0.071615	1.116822		6.412406		
CLD2-41	5.081179	0.063142	1.24266	0.25609	0	5.234861	523.486074
	5.234861	0.013406	0.25609		5.234861		
CLD2-42	6.066966	0.139414	2.297914	1.611439	0	6.319047	631.904737
	6.319047	0.101828	1.611439		6.319047		
CLD2-43	5.832762	0.176066	3.018577	1.594223	0	6.020383	602.038348
	6.020383	0.095978	1.594223		6.020383		
CLD2-44	5.067048	0.249944	4.932732	0.807281	0	5.195744	519.574379
	5.195744	0.041944	0.807281		5.195744		
CLD2-45	1.921054	0.027575	1.435398	1.435398	1.921054	1.921054	192.105365
	1.884398	0.029468	1.563805		0		

Raton Stalagmite CR1

Table C.7 Sr ppm CR1

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CR1-1	0.155302	0.000885467	0.570157	0.570157	0.155302	0.1553023
	0.167377	0.001260119	0.752862		0	
	0.165805	0.001006857	0.607255		0	
CR1-2	0.271958	0.004054441	1.490835	0.982692	0	0.2808631
	0.283247	0.002964076	1.046462		0	
	0.280863	0.002760021	0.982692		0.280863	
CR1-3	0.244823	0.002039154	0.83291	0.83291	0.244823	0.2448229
	0.255007	0.0021657	0.849272		0	
	0.253283	0.002295615	0.906345		0	
CR1-4	-0.00077	0.005359523	697.5909	10.52889	0	0
	0	0.000162003	244.2164		0	
	-0.00092	9.72822E-05	10.53		-0.00092	
CR1-5	0.292455	0.008754198	2.993353	1.211377	0	0.2999832
	0.299983	0.003633928	1.211377		0.299983	
	0.29897	0.003703362	1.238708		0	
CR1-6	0.280985	0.003093927	1.101099	0.335875	0	0.2880417
	0.29019	0.354359944	0.35436		0	
	0.288042	0.335874953	0.335875		0.288042	
CR1-7	0.201398	0.003941976	1.957311	0.68368	0	0.2065113
	0.206511	0.001411876	0.68368		0.206511	
	0.204969	0.001550029	0.756227		0	
CR1-8	0.178148	0.004022508	2.257959	0.883339	0	0.1882846
	0.188285	0.001663192	0.883339		0.188285	
	0.186834	0.001678834	0.898569		0	
CR1-9	0.288826	0.002597207	0.89923	0.225716	0	0.3023079
	0.302308	0.000682359	0.225716		0.302308	
	0.300623	0.00115043	0.382682		0	
CR1-10	0.190812	0.008865879	4.646396	0.76183	0	0.2029257
	0.202926	0.001545948	0.76183		0.202926	
	0.202122	0.001752596	0.867097		0	

Table C.7 (Continued)

CR1-11	0.265724	0.001926495	0.724999	0.724999	0.265724	0.2657239
	0.270125	0.003462633	1.281865		0	
	0.268492	0.003004073	1.118871		0	
CR1-12	0.282377	0.007815951	2.767916	0.227128	0	0.295061
	0.295061	0.000670165	0.227128		0.295061	
	0.293424	0.001210226	0.41245		0	
CR1-13	0.362169	0.008178505	2.258199	1.231857	0	0.3737223
	0.375573	0.005024954	1.337942		0	
	0.373722	0.004603726	1.231857		0.373722	
CR1-14	0.509801	0.010718268	2.102443	1.019314	0	0.5376327
	0.537633	0.005480167	1.019314		0.537633	
	0.533535	0.005490348	1.029051		0	
CR1-15	0.314321	0.00874685	2.782774	1.394182	0	0.3277318
	0.327732	0.004569178	1.394182		0.327732	
	0.326039	0.005160362	1.582741		0	
CR1-16	0.478551	0.00723013	1.510837	0.681835	0	0.5002868
	0.502705	0.003847758	0.76541		0	
	0.500287	0.00341113	0.681835		0.500287	
CR1-17	0.28153	0.001390784	0.494009	0.494009	0.28153	0.28153
	0.292314	0.003481812	1.191122		0	
	0.291687	0.003002109	1.029223		0	
CR1-18	0.388182	0.002689979	0.692969	0.228301	0	0.3994305
	0.401281	0.001046735	0.260848		0	
	0.39943	0.000911905	0.228301		0.39943	
CR1-19	0.395594	0.0052165	1.318651	0.60113	0	0.4169416
	0.416942	0.002506362	0.60113		0.416942	
	0.413721	0.002963404	0.716281		0	
CR1-20	0.418023	0.007109566	1.70076	0.443094	0	0.4348856
	0.434886	0.001926954	0.443094		0.434886	
	0.433929	0.002421468	0.558033		0	
CR1-21	0.401856	0.00927341	2.307643	0.428295	0	0.4202383
	0.420238	0.001799858	0.428295		0.420238	
	0.418319	0.002438937	0.583033		0	

Table C.8 Mg ppm CR1

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CR1-1	2.515716	0.012934	0.514135	0.514135	2.515716	2.515716
	2.626576	0.017573	0.669027		0	
	2.572063	0.017443	0.662859		0	
CR1-2	4.468908	0.037476	0.838602	0.838602	4.468908	4.468908
	4.697092	0.051079	1.087464		0	
	4.608766	0.049494	1.049967		0	
CR1-3	4.164974	0.039346	0.944697	0.836799	0	4.351122
	4.351122	0.03641	0.836799		4.351122	
	4.275931	0.040113	0.916476		0	
CR1-4	0.000828	0.000753	90.99	82.11688	0	0.000974
	0.000974	0.0008	82.12		0.000974	
	0.000111	0.002558	817.7407		0	
CR1-5	5.61975	0.081353	1.447627	1.138043	0	5.868101
	5.868101	0.066782	1.138043		5.868101	
	5.736089	0.088669	1.498019		0	
CR1-6	5.156059	0.020457	0.396752	0.36558	0	5.403716
	5.403716	0.019755	0.36558		5.403716	
	5.270897	0.035649	0.65569		0	
CR1-7	3.325698	0.014874	0.447259	0.385087	0	3.48342
	3.48342	0.013414	0.385087		3.48342	
	3.396463	0.015082	0.431232		0	
CR1-8	2.765919	0.021732	0.785724	0.630909	0	2.895334
	2.895334	0.018267	0.630909		2.895334	
	2.823021	0.027492	0.948503		0	
CR1-9	3.822351	0.031385	0.821079	0.404812	0	4.002146
	4.002146	0.016201	0.404812		4.002146	
	3.953142	0.024984	0.61972		0	
CR1-10	2.8634	0.024777	0.865311	0.728871	0	2.920094
	2.987259	0.028804	0.96423		0	
	2.920094	0.02183	0.728871		2.920094	

Table C.8 (Continued)

CR1-11	3.683327	0.044261	1.201664	0.867622	0	3.851458
	3.851458	0.033416	0.867622		3.851458	
	3.773657	0.037616	0.97117		0	
CR1-12	4.101111	0.014135	0.344655	0.18385	0	4.306961
	4.306961	0.007918	0.18385		4.306961	
	4.2167	0.021517	0.497624		0	
CR1-13	5.570697	0.047694	0.856162	0.856162	5.570697	5.570697
	5.867841	0.072656	1.238214		0	
	5.724016	0.058152	0.991988		0	
CR1-14	8.482534	0.087721	1.034141	1.034141	8.482534	8.482534
	9.014786	0.094828	1.051913		0	
	8.847135	0.096651	1.071104		0	
CR1-15	5.392268	0.067632	1.254246	1.192902	0	5.562423
	5.682702	0.074669	1.313976		0	
	5.562423	0.067669	1.192902		5.562423	
CR1-16	7.675345	0.047391	0.617449	0.617449	7.675345	7.675345
	8.142676	0.053214	0.653517		0	
	7.955009	0.05468	0.671342		0	
CR1-17	4.591242	0.031509	0.686287	0.686287	4.591242	4.591242
	4.814043	0.056011	1.163498		0	
	4.676555	0.052817	1.098831		0	
CR1-18	6.19181	0.01869	0.301848	0.057365	0	6.324784
	6.522582	0.012967	0.198797		0	
	6.324784	0.003734	0.057365		6.324784	
CR1-19	6.701592	0.052167	0.778424	0.768111	0	6.879404
	7.081523	0.057704	0.814851		0	
	6.879404	0.054296	0.768111		6.879404	
CR1-20	6.26483	0.037556	0.599469	0.217465	0	6.574666
	6.574666	0.014298	0.217465		6.574666	
	6.404154	0.03944	0.596969		0	
CR1-21	5.697322	0.021503	0.377418	0.211132	0	5.8337
	5.984327	0.028773	0.480809		0	
	5.8337	0.01266	0.211132		5.8337	

Table C.9 Ca ppm CR1

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CR1-1	1.574438	0.02708583	1.72035	0.227416	0	1.578251873	157.825187
	1.578252	0.0035892	0.22742		1.57825		
CR1-2	2.679552	0.04930838	1.84017	0.947139	0	2.654127226	265.412723
	2.654127	0.02513827	0.94714		2.65413		
CR1-3	2.332292	0.01384327	0.59355	0.593548	2.33229	2.33229247	233.229247
	2.288826	0.03591514	1.56915		0		
CR1-4	1.817953	0.02654042	1.45991	1.340807	0	1.814661573	181.466157
	1.814662	0.02433111	1.34081		1.81466		
CR1-5	2.578467	0.07214647	2.79804	1.69773	0	2.57080627	257.080627
	2.570806	0.04364535	1.69773		2.57081		
CR1-6	2.31222	0.04041383	1.74784	1.659487	0	2.266669584	226.666958
	2.26667	0.03761508	1.65949		2.26667		
CR1-7	2.069599	0.0155059	0.74922	0.216383	0	2.036448455	203.644846
	2.036448	0.00440652	0.21638		2.03645		
CR1-8	1.885535	0.00916516	0.48608	0.486078	1.88553	1.885534691	188.553469
	1.880652	0.02373418	1.26202		0		
CR1-9	2.703866	0.02784476	1.02981	1.029813	2.70387	2.70386583	270.386583
	2.696501	0.02891681	1.07238		0		
CR1-10	1.905667	0.04181597	2.1943	1.131691	0	1.874095539	187.409554
	1.874096	0.02120896	1.13169		1.8741		

Table C.9 (Continued)

CR1-11	2.432998	0.00904334	0.3717	0.371695	2.433	2.432998282	243.299828
	2.403451	0.01920564	0.79909		0		
CR1-12	2.531802	0.09196294	3.63231	0.956601	0	2.524995076	252.499508
	2.524995	0.02415412	0.9566		2.525		
CR1-13	1.918518	0.04302971	2.24286	1.162934	0	1.933967488	193.396749
	1.933967	0.02249077	1.16293		1.93397		
CR1-14	2.920563	0.04614912	1.58014	1.16323	0	2.918449036	291.844904
	2.918449	0.03394826	1.16323		2.91845		
CR1-15	1.919018	0.02093337	1.09084	1.090837	1.91902	1.919018408	191.901841
	1.89494	0.02454762	1.29543		0		
CR1-16	2.855477	0.06495853	2.27488	0.890029	0	2.84294058	284.294058
	2.842941	0.02530299	0.89003		2.84294		
CR1-17	1.70602	0.02402043	1.40798	0.327743	0	1.731486619	173.148662
	1.731487	0.00567483	0.32774		1.73149		
CR1-18	2.124956	0.04737693	2.22955	1.845186	0	2.117084947	211.708495
	2.117085	0.03906416	1.84519		2.11708		
CR1-19	2.40518	0.03120068	1.29723	1.297228	2.40518	2.405180342	240.518034
	2.380704	0.04961751	2.08415		0		
CR1-20	2.373883	0.03072643	1.29435	1.294354	2.37388	2.37388265	237.388265
	2.375617	0.03828441	1.61156		0		
CR1-21	2.278631	0.0179447	0.78752	0.787521	2.27863	2.278631296	227.86313
	2.276104	0.0323221	1.42006		0		

Raton Stalagmite CR4

Table C.10 Sr ppm CR4

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CR4-1	0.338312	0.0084104	2.486		0	
	0.352933	0.0025557	0.7241	0.636907	0	0.351921032
	0.351921	0.0022414	0.6369		0.3519	
CR4-2	0.208622	0.0082298	3.9449		0	
	0.219195	0.0017761	0.8103	0.772971	0	0.21751795
	0.217518	0.0016814	0.773		0.2175	
CR4-3	0.272355	0.0084207	3.0918		0	
	0.280955	0.0022819	0.8122	0.560747	0	0.278924162
	0.278924	0.0015641	0.5607		0.2789	
CR4-4	0.361598	0.0074183	2.0515		0	
	0.377175	0.0040418	1.0716	0.955759	0	0.375753937
	0.375754	0.0035913	0.9558		0.3758	
CR4-5	0.175811	0.0031415	1.7869		0	
	0.179283	0.0003835	0.2139	0.19092	0	0.178759586
	0.17876	0.0003413	0.1909		0.1788	
CR4-6	0.275204	0.0027627	1.0039		0	
	0.288813	0.0030451	1.0544	0.978036	0	0.286245283
	0.286245	0.0027996	0.978		0.2862	
CR4-7	0.273129	0.0040095	1.468		0	
	0.28844	0.0023615	0.8187	0.818715	0.2884	0.28843988
	0.286144	0.0024052	0.8405		0	
CR4-8	0.352004	0.0106893	3.0367		0	
	0.370296	0.0044053	1.1897	1.100978	0	0.367911454
	0.367911	0.0040506	1.101		0.3679	
CR4-9	0.356899	0.0017335	0.4857		0.3569	
	0.375355	0.0024415	0.6505	0.485702	0	0.356898986
	0.373982	0.0019191	0.5132		0	
CR4-10	0.26051	0.0058498	2.2455		0	
	0.273723	0.0011303	0.4129	0.412943	0.2737	0.273723445
	0.271918	0.0011925	0.4385		0	
CR4-11	0.314239	0.0082436	2.6234		0	
	0.330986	0.0005292	0.1599	0.159881	0.331	0.330986111
	0.329506	0.0006969	0.2115		0	
CR4-12	0.289892	0.0055572	1.917		0	
	0.305624	0.0021758	0.7119	0.584805	0	0.303792095
	0.303792	0.0017766	0.5848		0.3038	
CR4-13	0.295563	0.0023492	0.7948		0	
	0.315641	0.0016051	0.5085	0.4891	0	0.314235457
	0.314235	0.0015369	0.4891		0.3142	

Table C.10 (Continued)

CR4-14	0.233887	0.0068833	2.943	0.57305	0	0.245112687
	0.245113	0.0014046	0.5731		0.2451	
	0.243539	0.0021411	0.8792		0	
CR4-15	0.24991	0.0045424	1.8176	0.550091	0	0.263682587
	0.265307	0.0016949	0.6388		0	
	0.263683	0.0014505	0.5501		0.2637	
CR4-16	0.207379	0.0003061	0.1476	0.147602	0.2074	0.207379216
	0.215876	0.0012453	0.5769		0	
	0.214253	0.001222	0.5704		0	
CR4-17	0.262314	0.00311	1.1856	1.036458	0	0.272778397
	0.274681	0.0033924	1.235		0	
	0.272778	0.0028272	1.0365		0.2728	
CR4-18	0.245293	0.0012812	0.5223	0.522324	0.2453	0.245293
	0.256358	0.0018365	0.7164		0	
	0.254838	0.0022562	0.8853		0	
CR4-19	0.274523	0.0049759	1.8126	0.407702	0	0.289428072
	0.292023	0.0015282	0.5233		0	
	0.289428	0.00118	0.4077		0.2894	
CR4-20	0.235172	0.0058771	2.4991	0.44793	0	0.245968788
	0.245969	0.0011018	0.4479		0.246	
	0.243976	0.0014861	0.6091		0	
CR4-21	0.336062	0.0042014	1.2502	0.438468	0	0.348396838
	0.351416	0.0016452	0.4682		0	
	0.348397	0.0015276	0.4385		0.3484	
CR4-22	0.416542	0.0049905	1.1981	0.251815	0	0.438493338
	0.442038	0.0014706	0.3327		0	
	0.438493	0.0011042	0.2518		0.4385	
CR4-23	0.362419	0.0022282	0.6148	0.614804	0.3624	0.36241931
	0.381538	0.0033412	0.8757		0	
	0.378773	0.0038152	1.0072		0	
CR4-24	0.361308	0.0082232	2.276	0.938751	0	0.379530911
	0.379531	0.0035629	0.9388		0.3795	
	0.376524	0.0040906	1.0864		0	
CR4-25	0.3569	0.0089	2.4889	0.276434	0	0.369252519
	0.369253	0.0010207	0.2764		0.3693	
	0.366904	0.0010635	0.2899		0	
CR4-26	0.231136	0.0056303	2.4359	0.99269	0	0.240154016
	0.240154	0.002384	0.9927		0.2402	
	0.239008	0.002417	1.0113		0	
CR4-27	0.37343	0.0020045	0.5368	0.180271	0	0.38531514
	0.387491	0.0009238	0.2384		0	
	0.385315	0.0006946	0.1803		0.3853	

Table C.11 Mg ppm CR4

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CR4-1	6.831353	0.053638	0.78517		0	
	7.205085	0.045358	0.629534	0.478328	0	7.029932
	7.029932	0.033626	0.478328		7.029932	
CR4-2	4.351383	0.027789	0.638629		0	
	4.580556	0.028057	0.612522	0.612522	4.580556	4.580556
	4.470875	0.030013	0.671291		0	
CR4-3	3.600775	0.009875	0.27425		3.600775	
	3.76491	0.026654	0.707959	0.27425	0	3.600775
	3.71764	0.010707	0.288016		0	
CR4-4	4.844633	0.040426	0.834454		0	
	5.081725	0.0372	0.732033	0.732033	5.081725	5.081725
	5.001521	0.057257	1.144799		0	
CR4-5	2.326502	0.009222	0.396373		0	
	2.423034	0.003977	0.164132	0.164132	2.423034	2.423034
	2.358691	0.008329	0.35313		0	
CR4-6	3.546207	0.026867	0.757615		3.546207	
	3.735008	0.040411	1.081957	0.757615	0	3.546207
	3.647452	0.03348	0.917893		0	
CR4-7	4.570244	0.027907	0.61062		4.570244	
	4.800463	0.035387	0.737158	0.61062	0	4.570244
	4.738369	0.03088	0.651695		0	
CR4-8	6.080915	0.073133	1.202665		0	
	6.442179	0.065042	1.009634	1.009634	6.442179	6.442179
	6.323665	0.075396	1.192276		0	
CR4-9	5.268394	0.021904	0.415755		5.268394	
	5.55724	0.024714	0.444713	0.415755	0	5.268394
	5.431085	0.041079	0.756369		0	
CR4-10	4.211267	0.011283	0.267929		4.211267	
	4.438799	0.028123	0.633561	0.267929	0	4.211267
	4.306975	0.018678	0.433669		0	
CR4-11	6.158166	0.004316	0.07008		6.158166	
	6.483831	0.014879	0.229485	0.07008	0	6.158166
	6.313291	0.013294	0.210568		0	
CR4-12	5.296073	0.042783	0.807822		0	
	5.57498	0.030686	0.550418	0.550418	5.57498	5.57498
	5.460117	0.034975	0.640553		0	
CR4-13	5.297124	0.041862	0.790272		0	
	5.561381	0.025347	0.455763	0.455763	5.561381	5.561381
	5.469721	0.048286	0.882787		0	

Table C.11 (Continued)

CR4-14	3.520603	0.033393	0.948509	0.710495	0	3.691033
	3.691033	0.026225	0.710495		3.691033	
	3.610542	0.025955	0.718876		0	
CR4-15	3.918145	0.019421	0.495681	0.495681	3.918145	3.918145
	4.116374	0.029921	0.726879		0	
	4.020822	0.029113	0.724048		0	
CR4-16	3.320495	0.027874	0.839444	0.697985	0	3.48255
	3.48255	0.024308	0.697985		3.48255	
	3.391863	0.028947	0.853421		0	
CR4-17	3.535499	0.034927	0.987907	0.987907	3.535499	3.535499
	3.716801	0.040818	1.098194		0	
	3.646835	0.054487	1.494083		0	
CR4-18	3.292338	0.032117	0.975493	0.862569	0	3.458058
	3.458058	0.029828	0.862569		3.458058	
	3.393964	0.029749	0.87653		0	
CR4-19	4.342412	0.015025	0.346012	0.346012	4.342412	4.342412
	4.594034	0.024813	0.540118		0	
	4.464353	0.020142	0.451177		0	
CR4-20	3.511868	0.028884	0.822477	0.413804	0	3.711543
	3.711543	0.015359	0.413804		3.711543	
	3.623176	0.036145	0.997592		0	
CR4-21	5.160391	0.036553	0.708342	0.281037	0	5.478136
	5.478136	0.015396	0.281037		5.478136	
	5.35396	0.028037	0.523676		0	
CR4-22	7.130636	0.025361	0.355668	0.355668	7.130636	7.130636
	7.59806	0.027183	0.357767		0	
	7.410208	0.046417	0.626395		0	
CR4-23	4.91209	0.051328	1.044925	0.84251	0	5.08902
	5.20966	0.064466	1.237431		0	
	5.08902	0.042875	0.84251		5.08902	
CR4-24	5.258168	0.067952	1.292309	0.62671	0	5.594473
	5.594473	0.035061	0.62671		5.594473	
	5.463904	0.078683	1.44006		0	
CR4-25	5.687815	0.022395	0.393734	0.139716	0	5.893376
	5.998473	0.025177	0.419727		0	
	5.893376	0.008234	0.139716		5.893376	
CR4-26	3.182963	0.027383	0.860298	0.860298	3.182963	3.182963
	3.336033	0.037929	1.136953		0	
	3.27159	0.033916	1.036683		0	
CR4-27	5.339288	0.010577	0.198089	0.085792	0	5.524329

	5.65395	0.01694	0.299616		0	
	5.524329	0.004739	0.085792		5.524329	

Table C.12 Ca ppm CR4

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CR4-1	2.145691	0.039351486	1.833977		0		
	2.144568	0.014628571	0.682122	0.682122	2.144568	2.144567665	214.4567665
CR4-2	1.754844	0.049775605	2.83647		0		
	1.777293	0.017955918	1.010296	1.010296	1.777293	1.777292916	177.7292916
CR4-3	2.163105	0.033502386	1.54881		0		
	2.152666	0.026336868	1.223454	1.223454	2.152666	2.152665794	215.2665794
CR4-4	3.002946	0.048236565	1.606308		0		
	2.977211	0.045708088	1.535265	1.535265	2.977211	2.977211327	297.7211327
CR4-5	1.474121	0.014135592	0.958917		1.474121		
	1.483863	0.015218181	1.025578	0.958917	0	1.474121186	147.4121186
CR4-6	2.2864	0.03178599	1.39022		0		
	2.298858	0.013894543	0.604411	0.604411	2.298858	2.298858112	229.8858112
CR4-7	2.239989	0.012567733	0.561062		2.239989		
	2.223414	0.017306904	0.778393	0.561062	0	2.239989321	223.9989321
CR4-8	2.732203	0.07005749	2.564139		0		
	2.736957	0.024604098	0.898958	0.898958	2.736957	2.736957224	273.6957224
CR4-9	2.350237	0.019770932	0.841231		2.350237		
	2.397364	0.033042879	1.378301	0.841231	0	2.350237399	235.0237399
CR4-10	2.068198	0.015081077	0.729189		2.068198		
	2.071128	0.021109864	1.019245	0.729189	0	2.068197545	206.8197545
CR4-11	2.521787	0.023173325	0.918925		2.521787		
	2.506075	0.050660127	2.021492	0.918925	0	2.521786547	252.1786547
CR4-12	2.444651	0.052621436	2.152513		0		
	2.432729	0.032007467	1.315702	1.315702	2.432729	2.432728829	243.2728829
CR4-13	2.305048	0.042590024	1.847685		2.305048		
	2.265364	0.062333142	2.751573	1.847685	0	2.30504822	230.504822

Table C.12 (Continued)

CR4-14	1.810304	0.011384885	0.628894	0.543939	0	1.805881826	180.5881826
	1.805882	0.009822891	0.543939		1.805882		
CR4-15	1.91624	0.042395717	2.212443	0.954638	0	1.936204143	193.6204143
	1.936204	0.018483737	0.954638		1.936204		
CR4-16	1.357559	0.030056209	2.213989	0.448104	0	1.363354656	136.3354656
	1.363355	0.006109248	0.448104		1.363355		
CR4-17	2.296751	0.025579757	1.113737	1.113737	2.296751	2.296751086	229.6751086
	2.351504	0.046943291	1.996309		0		
CR4-18	2.135172	0.029053685	1.360719	0.131116	0	2.130681931	213.0681931
	2.130682	0.00279367	0.131116		2.130682		
CR4-19	2.011585	0.031522708	1.567058	0.990053	0	2.042865369	204.2865369
	2.042865	0.020225443	0.990053		2.042865		
CR4-20	1.763269	0.029855612	1.693196	0.507432	0	1.783848914	178.3848914
	1.783849	0.009051815	0.507432		1.783849		
CR4-21	2.168703	0.016813673	0.775287	0.738469	0	2.156499834	215.6499834
	2.1565	0.01592508	0.738469		2.1565		
CR4-22	2.68629	0.046398083	1.727218	0.725352	0	2.665722476	266.5722476
	2.665722	0.019335868	0.725352		2.665722		
CR4-23	2.388647	0.020705755	0.86684	0.86684	2.388647	2.388646695	238.8646695
	2.422821	0.058814903	2.427538		0		
CR4-24	2.673111	0.026072418	0.975359	0.890922	0	2.677112159	267.7112159
	2.677112	0.023850973	0.890922		2.677112		
CR4-25	2.310936	0.034646928	1.499259	0.310531	0	2.302767027	230.2767027
	2.302767	0.007150806	0.310531		2.302767		
CR4-26	1.52137	0.016351713	1.074802	0.540118	0	1.537891882	153.7891882
	1.537892	0.008306434	0.540118		1.537892		
CR4-27	1.942361	0.017683382	0.910407	0.676916	0	1.93518739	193.518739
	1.935187	0.013099597	0.676916		1.935187		

Hato Stalagmite CH1

Table C.13 Sr ppm CH1

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CH1-1	0.086493	0.002255	2.607039	0.415117	0	0.089045
	0.089045	0.00037	0.415117		0.089045	
	0.088187	0.000667	0.756658		0	
CH1-2	0.105894	0.002405	2.271516	0.565912	0	0.110744
	0.111831	0.00092	0.82241		0	
	0.110744	0.000627	0.565912		0.110744	
CH1-3	1.179818	0.016232	1.375812	1.364549	0	1.24174
	1.24174	0.016944	1.364549		1.24174	
	1.230997	0.018053	1.466515		0	
CH1-4	0.679049	0.001476	0.21741	0.21741	0.679049	0.679049
	0.708403	0.004213	0.59469		0	
	0.704621	0.004164	0.591011		0	
CH1-5	0.438087	0.001446	0.330098	0.232194	0	0.460085
	0.460934	0.001312	0.284662		0	
	0.460085	0.001068	0.232194		0.460085	
CH1-6	0.184885	0.002142	1.15835	0.346153	0	0.193738
	0.193738	0.000671	0.346153		0.193738	
	0.193228	0.00158	0.817505		0	
CH1-7	0.161654	0.002836	1.754362	0.254441	0	0.163027
	0.163027	0.000415	0.254441		0.163027	
	0.162401	0.000782	0.481792		0	
CH1-8	0.116961	0.005564	4.756802	0.783265	0	0.120031
	0.121149	0.001314	1.084235		0	
	0.120031	0.00094	0.783265		0.120031	
CH1-9	0.149267	0.00023	0.154046	0.154046	0.149267	0.149267
	0.156931	0.001238	0.788964		0	
	0.156107	0.001157	0.741266		0	
CH1-10	0.258943	0.001878	0.725275	0.560925	0	0.267477
	0.268469	0.001543	0.574663		0	
	0.267477	0.0015	0.560925		0.267477	
CH1-11	0.630146	0.000327	0.051897	0.036213	0	0.648714
	0.652197	0.000622	0.095329		0	
	0.648714	0.000235	0.036213		0.648714	
CH1-12	0.242211	0.004039	1.667401	0.441176	0	0.249654
	0.249654	0.001101	0.441176		0.249654	
	0.248671	0.001412	0.568007		0	

Table C.13 (Continued)

CH1-13	0.220651	0.004467	2.024633	0.717248	0	0.230323
	0.230323	0.717248	0.717248		0.230323	
	0.22943	0.001836	0.800284		0	
CH1-14	0.447849	0.001286	0.287197	0.287197	0.447849	0.447849
	0.465992	0.003979	0.853859		0	
	0.465295	0.003223	0.692777		0	
CH1-15	0.396597	0.008772	2.211841	0.928253	0	0.415285
	0.41597	0.004648	1.117485		0	
	0.415285	0.003855	0.928253		0.415285	
CH1-16	0.476533	0.003974	0.833926	0.501743	0	0.492431
	0.494156	0.003018	0.610643		0	
	0.492431	0.002471	0.501743		0.492431	
CH1-17	0.220284	0.004969	2.255804	0.379338	0	0.23216
	0.23216	0.000881	0.379338		0.23216	
	0.231436	0.001582	0.683526		0	
CH1-18	0.162167	0.000409	0.252205	0.252205	0.162167	0.162167
	0.164912	0.001049	0.636067		0	
	0.164098	0.000819	0.498904		0	
CH1-19	0.233924	0.005311	2.270587	0.418165	0	0.247348
	0.248371	0.001767	0.711277		0	
	0.247348	0.001034	0.418165		0.247348	
CH1-20	0.185728	0.007248	3.902409	0.567318	0	0.193011
	0.193011	0.001095	0.567318		0.193011	
	0.192575	0.001405	0.729716		0	
CH1-21	0.181797	0.001822	1.001964	0.221813	0	0.187833
	0.187812	0.00065	0.346122		0	
	0.187833	0.000417	0.221813		0.187833	
CH1-22	0.370557	0.007392	1.994856	1.068814	0	0.387879
	0.389229	0.004449	1.143127		0	
	0.387879	0.004146	1.068814		0.387879	
CH1-23	0.427158	0.007901	1.849691	0.390084	0	0.443439
	0.445746	0.002562	0.574709		0	
	0.443439	0.00173	0.390084		0.443439	
CH1-24	0.257452	0.006493	2.522035	1.008012	0	0.271134
	0.271134	0.002733	1.008012		0.271134	
	0.269795	0.003191	1.182922		0	

Table C.13 (Continued)

CH1-25	0.338694	0.003598	1.062444	0.108433	0	0.355484
	0.356891	0.000516	0.144491		0	
	0.355484	0.000385	0.108433		0.355484	
CH1-26	0.948198	0.010186	1.074237	1.074237	0.948198	0.948198
	1.004774	0.015953	1.587705		0	
	0.997396	0.014428	1.446589		0	
CH1-27	1.109885	0.00302	0.272088	0.248267	0	1.160273
	1.168949	0.003778	0.323166		0	
	1.160273	0.002881	0.248267		1.160273	
CH1-28	0.261331	0.007329	2.804416	0.17048	0	0.270838
	0.270838	0.000462	0.17048		0.270838	
	0.271428	0.000602	0.221821		0	
CH1-29	0.242199	0.007049	2.910452	1.266018	0	0.250907
	0.251468	0.004036	1.605173		0	
	0.250907	0.003177	1.266018		0.250907	
CH1-30	0.217559	0.005821	2.675454	1.0525	0	0.22713
	0.228755	0.002763	1.207961		0	
	0.22713	0.002391	1.0525		0.22713	
CH1-31	0.291001	0.004409	1.515268	1.031588	0	0.300497
	0.300497	0.003119	1.031588		0.300497	
	0.300497	0.00317	1.055077		0	
CH1-32	0.175438	0.007027	4.005379	0.898709	0	0.186953
	0.188003	0.00189	1.005102		0	
	0.186953	0.00168	0.898709		0.186953	
CH1-33	0.249354	0.008085	3.242302	0.98519	0	0.264286
	0.265393	0.002851	1.074306		0	
	0.264286	0.002604	0.98519		0.264286	
CH1-34	0.260581	0.010701	4.10667	1.141929	0	0.267123
	0.267123	0.00305	1.141929		0.267123	
	0.266932	0.003132	1.173452		0	
CH1-35	0.203775	0.003224	1.582237	0.415636	0	0.208168
	0.208264	0.001147	0.550977		0	
	0.208168	0.000865	0.415636		0.208168	
CH1-36	0.193722	0.003297	1.702087	0.703677	0	0.204246
	0.204329	0.001527	0.747417		0	
	0.204246	0.001437	0.703677		0.204246	

Table C.13 (Continued)

CH1-37	0.146335	0.002025	1.383557	1.02801	0	0.149656
	0.150627	0.001633	1.084049		0	
	0.149656	0.001538	1.02801		0.149656	
CH1-38	0.120569	0.007203	5.973937	1.29988	0	0.126827
	0.126827	0.001649	1.29988		0.126827	
	0.126202	0.001744	1.381874		0	
CH1-39	0.187262	0.002388	1.275342	0.806905	0	0.193296
	0.193991	0.001853	0.955304		0	
	0.193296	0.00156	0.806905		0.193296	
CH1-40	0.186904	0.008903	4.763462	0.692244	0	0.197868
	0.198475	0.001552	0.782072		0	
	0.197868	0.00137	0.692244		0.197868	
CH1-41	0.207643	0.005565	2.679837	1.444245	0	0.213748
	0.213604	0.003149	1.474453		0	
	0.213748	0.003087	1.444245		0.213748	
CH1-42	0.145336	0.00293	2.016179	0.796274	0	0.151827
	0.151827	0.001209	0.796274		0.151827	
	0.151902	0.001323	0.871212		0	
CH1-43	0.12897	0.00415	3.217685	0.415702	0	0.12995
	0.12995	0.00054	0.415702		0.12995	
	0.129406	0.000707	0.546691		0	
CH1-44	0.106714	0.001306	1.2236	0.506994	0	0.11043
	0.11043	0.00056	0.506994		0.11043	
	0.109695	0.000795	0.724883		0	
CH1-45	0.160812	0.002179	1.354958	0.981314	0	0.165633
	0.166666	0.001955	1.172892		0	
	0.165633	0.001625	0.981314		0.165633	

Table C.14 Mg ppm CH1

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CH1-1	0.644755	0.004839	0.750483	0.750483	0.644755	0.644755
	0.662609	0.005507	0.831038		0	
	0.658211	0.011181	1.698756		0	
CH1-2	1.235814	0.010863	0.878996	0.795667	0	1.271299
	1.271299	0.010115	0.795667		1.271299	
	1.273319	0.013462	1.057246		0	
CH1-3	8.910564	0.115256	1.293475	1.227869	0	9.314995
	9.362562	0.117114	1.250876		0	
	9.314995	0.114376	1.227869		9.314995	
CH1-4	7.828824	0.044073	0.562963	0.562963	7.828824	7.828824
	8.238683	0.055502	0.67368		0	
	8.144172	0.046359	0.569226		0	
CH1-5	5.916254	0.003256	0.05503	0.05503	5.916254	5.916254
	6.18202	0.004241	0.068606		0	
	6.113797	0.019396	0.317243		0	
CH1-6	2.979745	0.020419	0.68527	0.473835	0	3.073571
	3.092077	0.016791	0.543037		0	
	3.073571	0.014564	0.473835		3.073571	
CH1-7	1.968845	0.00143	0.072644	0.072644	1.968845	1.968845
	2.0265	0.005362	0.264618		0	
	2.048192	0.006698	0.32701		0	
CH1-8	1.387286	0.014581	1.051039	0.794747	0	1.427415
	1.427415	0.011344	0.794747		1.427415	
	1.443242	0.027584	1.911274		0	
CH1-9	2.02044	0.017685	0.875287	0.875287	2.02044	2.02044
	2.085791	0.021342	1.023186		0	
	2.101002	0.024826	1.181617		0	
CH1-10	4.410613	0.023684	0.536987	0.451887	0	4.612266
	4.591524	0.035212	0.766886		0	
	4.612266	0.020842	0.451887		4.612266	
CH1-11	3.779469	0.018652	0.493515	0.055105	0	3.932258
	3.932258	0.002167	0.055105		3.932258	
	3.910175	0.005092	0.130225		0	
CH1-12	4.390037	0.036105	0.822424	0.605801	0	4.595273
	4.595273	0.027838	0.605801		4.595273	
	4.572499	0.035268	0.771317		0	

Table C.14 (Continued)

CH1-13	4.042555	0.036331	0.898722		0	
	4.221326	0.021799	0.51639	0.51639	4.221326	4.221326
	4.226511	0.051907	1.228131		0	
CH1-14	8.002206	0.078681	0.983236		0	
	8.381817	0.060953	0.727208	0.727208	8.381817	8.381817
	8.418065	0.070644	0.839199		0	
CH1-15	8.325001	0.0555	0.666663		8.325001	
	8.749024	0.085601	0.978409	0.666663	0	8.325001
	8.701077	0.077159	0.886776		0	
CH1-16	7.076407	0.012072	0.170592		7.076407	
	7.416465	0.035069	0.472851	0.170592	0	7.076407
	7.38095	0.032537	0.440825		0	
CH1-17	3.965626	0.02285	0.576198		0	
	4.145548	0.017103	0.412572	0.412572	4.145548	4.145548
	4.15077	0.019658	0.473595		0	
CH1-18	2.600054	0.013185	0.50709		2.600054	
	2.69307	0.020103	0.746482	0.50709	0	2.600054
	2.708621	0.016563	0.61149		0	
CH1-19	3.638222	0.026494	0.728213		0	
	3.78809	0.024769	0.653863	0.653863	3.78809	3.78809
	3.814797	0.031665	0.830058		0	
CH1-20	2.958452	0.022945	0.77559		0	
	3.061436	0.017513	0.572055	0.269533	0	3.072613
	3.072613	0.008282	0.269533		3.072613	
CH1-21	2.980515	0.017294	0.580226		0	
	3.096087	0.011793	0.380903	0.212401	0	3.082889
	3.082889	0.006548	0.212401		3.082889	
CH1-22	6.916478	0.093309	1.349077		0	
	7.246459	0.062597	0.863833	0.863833	7.246459	7.246459
	7.231384	0.10793	1.492518		0	
CH1-23	8.570056	0.049029	0.5721		0	
	9.041705	0.05012	0.554325	0.554325	9.041705	9.041705
	9.043896	0.060863	0.672977		0	
CH1-24	5.420052	0.062993	1.162221		0	
	5.674132	0.054247	0.956049	0.956049	5.674132	5.674132
	5.693224	0.100981	1.77371		0	

Table C.14 (Continued)

CH1-25	7.084171	0.018204	0.256971		0	
	7.415002	0.010705	0.144374	0.144374	7.415002	7.415002
	7.500842	0.028984	0.386406		0	
CH1-26	10.45	0.15	1.42		0	
	11.02	0.14	1.28	1.282225	11.01648	11.01648
	11.05	0.16	1.49		0	
CH1-27	7.161522	0.029957	0.418303		0	
	7.496361	0.053656	0.715761	0.388244	0	7.464629
	7.464629	0.028981	0.388244		7.464629	
CH1-28	4.645796	0.017959	0.386559		0	
	4.836851	0.019288	0.398778	0.292772	0	4.820155
	4.820155	0.014112	0.292772		4.820155	
CH1-29	4.016173	0.043593	1.085436		4.016173	
	4.17968	0.055164	1.319806	1.085436	0	4.016173
	4.1953	0.047788	1.139074		0	
CH1-30	3.256415	0.018802	0.577378		3.256415	
	3.383258	0.04165	1.231063	0.577378	0	3.256415
	3.40302	0.02195	0.645028		0	
CH1-31	3.780043	0.025611	0.677543		3.780043	
	3.941175	0.046176	1.171631	0.677543	0	3.780043
	3.997177	0.028166	0.704653		0	
CH1-32	2.791088	0.024197	0.866937		0	
	2.880215	0.022717	0.788736	0.788736	2.880215	2.880215
	2.915078	0.037214	1.276614		0	
CH1-33	3.806704	0.040613	1.066886		3.806704	
	3.979584	0.048586	1.220889	1.066886	0	3.806704
	3.991819	0.06458	1.617816		0	
CH1-34	3.799615	0.041266	1.086062		0	
	3.949328	0.051309	1.299176	1.016684	0	3.978805
	3.978805	0.040452	1.016684		3.978805	
CH1-35	3.113518	0.009674	0.310704		3.113518	
	3.205663	0.012786	0.398842	0.310704	0	3.113518
	3.223832	0.010274	0.318704		0	
CH1-36	3.075093	0.022371	0.727484		0	
	3.191476	0.019633	0.615156	0.615156	3.191476	3.191476
	3.233492	0.039258	1.214113		0	

Table C.14 (Continued)

CH1-37	2.050302	0.019917	0.971436	0.948179	0	2.10864
	2.10864	0.019994	0.948179		2.10864	
	2.145268	0.025336	1.181005		0	
CH1-38	1.964105	0.025454	1.295984	1.295984	1.964105	1.964105
	2.031242	0.02752	1.354815		0	
	2.060355	0.033481	1.625019		0	
CH1-39	3.039518	0.039959	1.31464	0.852963	0	3.167383
	3.167383	0.027017	0.852963		3.167383	
	3.214117	0.045896	1.427935		0	
CH1-40	3.047459	0.028359	0.930589	0.881235	0	3.149406
	3.149406	0.027754	0.881235		3.149406	
	3.189243	0.043109	1.351687		0	
CH1-41	2.60092	0.034324	1.319679	1.303466	0	2.680671
	2.680671	0.034942	1.303466		2.680671	
	2.698643	0.039514	1.464209		0	
CH1-42	0.826766	0.004949	0.598569	0.226139	0	0.85466
	0.843333	0.008257	0.979121		0	
	0.85466	0.001933	0.226139		0.85466	
CH1-43	0.798462	0.003342	0.418545	0.418545	0.798462	0.798462
	0.813272	0.004602	0.565898		0	
	0.829844	0.003954	0.476517		0	
CH1-44	0.524041	0.003345	0.638264	0.137005	0	0.536037
	0.536037	0.000734	0.137005		0.536037	
	0.545837	0.004306	0.788895		0	
CH1-45	1.066078	0.011603	1.088426	1.088426	1.066078	1.066078
	1.093117	0.011924	1.090857		0	
	1.118056	0.013667	1.222379		0	

Table C.15 Ca ppm CH1

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CH1-1	1.421114	0.03773	2.654963	0.856578	0	1.467139379	146.713938
	1.467139	0.0125672	0.856578		1.467139		
CH1-2	1.766794	0.0316334	1.790442	1.790442	1.766794	1.766793761	176.679376
	1.783533	0.0365333	2.048365		0		
CH1-3	2.201423	0.0377451	1.714579	0.911244	0	2.225346824	222.534682
	2.225347	0.0202783	0.911244		2.225347		
CH1-4	1.912043	0.0282295	1.476404	0.725411	0	1.908184173	190.818417
	1.908184	0.0138422	0.725411		1.908184		
CH1-5	2.229779	0.0542304	2.432097	0.571917	0	2.26745017	226.745017
	2.26745	0.0129679	0.571917		2.26745		
CH1-6	1.346297	0.0062162	0.461723	0.461723	1.346297	1.346297341	134.629734
	1.356544	0.0120515	0.888398		0		
CH1-7	1.537491	0.0281959	1.833887	0.254658	0	1.554707245	155.470724
	1.554707	0.0039592	0.254658		1.554707		
CH1-8	1.167493	0.0218723	1.873445	0.538518	0	1.171794728	117.179473
	1.171795	0.0063103	0.538518		1.171795		
CH1-9	1.464243	0.0205258	1.401801	0.987403	0	1.488088534	148.808853
	1.488089	0.0146934	0.987403		1.488089		
CH1-10	1.754441	0.0313745	1.788291	1.016623	0	1.762499731	176.249973
	1.7625	0.017918	1.016623		1.7625		
CH1-11	1.553818	0.0261794	1.684843	0.384955	0	1.571358292	157.135829
	1.571358	0.006049	0.384955		1.571358		
CH1-12	1.672675	0.0293721	1.755997	0.413717	0	1.716141763	171.614176
	1.716142	0.0071	0.413717		1.716142		

Table C.15 (Continued)

CH1-13	1.499269	0.0116575	0.777547	0.777547	1.499269	1.499269089	149.926909
	1.520452	0.015353	1.009765		0		
CH1-14	2.525383	0.0544109	2.154561	0.230909	0	2.530817457	253.081746
	2.530817	0.0058439	0.230909		2.530817		
CH1-15	2.206666	0.0242865	1.100595	1.100595	2.206666	2.206666407	220.666641
	2.238437	0.0361002	1.612743		0		
CH1-16	1.693298	0.0205154	1.211562	0.658255	0	1.729291939	172.929194
	1.729292	0.0113832	0.658255		1.729292		
CH1-17	1.541285	0.015988	1.037315	0.431441	0	1.59107332	159.107332
	1.591073	0.0068645	0.431441		1.591073		
CH1-18	1.291175	0.0279454	2.164339	0.740386	0	1.310307645	131.030764
	1.310308	0.0097013	0.740386		1.310308		
CH1-19	2.04276	0.0308385	1.50965	0.049924	0	2.048039152	204.803915
	2.048039	0.0010225	0.049924		2.048039		
CH1-20	1.728616	0.0298466	1.726617	0.719512	0	1.727484763	172.748476
	1.727485	0.0124295	0.719512		1.727485		
CH1-21	1.470435	0.0343524	2.336204	0.365938	0	1.495043152	149.504315
	1.495043	0.0054709	0.365938		1.495043		
CH1-22	2.39064	0.0602307	2.519441	2.176939	0	2.389342748	238.934275
	2.389343	0.0520145	2.176939		2.389343		
CH1-23	2.518191	0.0520216	2.065833	0.447356	0	2.516974537	251.697454
	2.516975	0.0112598	0.447356		2.516975		
CH1-24	1.675323	0.03746	2.235986	0.919149	0	1.699028727	169.902873
	1.699029	0.0156166	0.919149		1.699029		

Table C.15 (Continued)

CH1-25	2.257573	0.0292966	1.297705	0.320916	0	2.286184513	228.618451
	2.286185	0.0073367	0.320916		2.286185		
CH1-26	2.155028	0.0197921	0.918417	0.918417	2.155028	2.155027638	215.502764
	2.15324	0.0290179	1.347641		0		
CH1-27	1.996667	0.036731	1.839615	1.839615	1.996667	1.99666666	199.666666
	2.015719	0.0397768	1.973332		0		
CH1-28	2.015383	0.0515599	2.55832	2.217991	0	2.038062334	203.806233
	2.038062	0.045204	2.217991		2.038062		
CH1-29	2.334558	2.3345578	2.654167	1.807905	0	2.344641544	234.464154
	2.344642	0.0423889	1.807905		2.344642		
CH1-30	1.972418	0.0282482	1.432162	1.432162	1.972418	1.972418172	197.241817
	1.966954	0.0368893	1.875452		0		
CH1-31	2.429909	0.0036291	0.14935	0.14935	2.429909	2.429909022	242.990902
	2.463814	0.0104006	0.422135		0		
CH1-32	1.755913	0.0204709	1.165829	0.22402	0	1.770650002	177.065
	1.77065	0.0039666	0.22402		1.77065		
CH1-33	2.538855	0.0325751	1.283063	0.674497	0	2.534724046	253.472405
	2.534724	0.0170966	0.674497		2.534724		
CH1-34	2.488449	0.0383126	1.539617	0.34285	0	2.507535458	250.753546
	2.507535	0.0085971	0.34285		2.507535		
CH1-35	1.90992	0.0145892	0.763864	0.763864	1.90992	1.909920195	190.992019
	1.931556	0.0539849	2.794892		0		
CH1-36	2.250259	0.0159415	0.70843	0.70843	2.250259	2.250259427	225.025943
	2.243437	0.0326855	1.45694		0		

Table C.15 (Continued)

CH1-37	1.528653	0.0163547	1.069879	0.618604	0	1.565078679	156.507868
	1.565079	0.0096816	0.618604		1.565079		
CH1-38	1.512874	0.0180921	1.195875	0.807222	0	1.528145775	152.814578
	1.528146	0.0123355	0.807222		1.528146		
CH1-39	2.24868	0.040299	1.792119	1.442982	0	2.255562035	225.556203
	2.255562	0.0325474	1.442982		2.255562		
CH1-40	-0.00572	0.0001956	3.417794	3.376638	0	0	0
	-0.00568	0.0001917	3.376638		-0.00568		
CH1-41	1.897708	0.0279568	1.473186	1.473186	1.897708	1.897707989	189.770799
	1.912336	0.0456702	2.388187		0		
CH1-42	2.417431	0.0401145	1.659385	0.804562	0	2.41803792	241.803792
	2.418038	0.0194546	0.804562		2.418038		
CH1-43	2.096663	0.0303927	1.449574	1.449574	2.096663	2.096663141	209.666314
	2.077451	0.0305556	1.470821		0		
CH1-44	1.773529	0.0361445	2.037996	2.037996	1.773529	1.773529224	177.352922
	1.783399	0.0428386	2.402077		0		
CH1-45	1.909255	0.041661	2.182057	2.062889	0	1.927524479	192.752448
	1.927524	0.0397627	2.062889		1.927524		

Curaçao Rock Data

Lardem Rock Data

Table C.16 Sr ppm Lardem Cave rocks

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CLD3A (wall)	0.614811	0.004951	0.805236	0.546602	0	0.604692767
	0.604693	0.003305	0.546602		0.604693	
	0.632106	0.004031	0.637771		0	
CLD3B (wall)	0.789307	0.00497	0.629607	0.403012	0	0.801099034
	0.767157	0.004	0.52142		0	
	0.801099	0.003229	0.403012		0.801099	
CLD3C (wall)	0.982108	0.006336	0.645141	0.645141	0.982108	0.98210774
	0.961984	0.008351	0.868127		0	
	1.005212	0.008909	0.886244		0	
CLD4A (ceiling)	0.836861	0.005593	0.668289	0.469715	0	0.857026268
	0.819944	0.003889	0.474298		0	
	0.857026	0.004026	0.469715		0.857026	
CLD4B (ceiling)	0.573436	0.002085	0.363677	0.173269	0	0.582833878
	0.557275	0.001129	0.202633		0	
	0.582834	0.00101	0.173269		0.582834	
CLD4C (ceiling)	0.875529	0.010332	1.180089	0.549348	0	0.894178642
	0.855727	0.005641	0.659247		0	
	0.894179	0.004912	0.549348		0.894179	
CLD5A (surface)	7.289806	0.06293	0.863264	0.674892	0	7.429276472
	7.461945	0.079316	1.062941		0	
	7.429276	0.05014	0.674892		7.429276	
CLD5B (surface)	6.065207	0.056485	1.090303	1.090303	6.065207	6.065207034
	6.200564	0.078783	1.301628		0	
	6.213515	0.064369	1.326768		0	
CLD5C (surface)	7.183994	0.010691	0.148824	0.148824	7.183994	7.183994346
	7.437502	0.049335	0.663326		0	
	7.304983	0.110812	1.516936		0	

Table C.17 Mg ppm Lardem Cave rocks

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CLD3A (wall)	11.61	0.10954409	0.943851	0.627765	0	12.3041
	11.77	0.07458691	0.633472		0	
	12.30	0.07724082	0.627765		12.3041	
CLD3B (wall)	12.40	0.03517228	0.283667	0.283667	12.39914	12.39914
	12.68	0.04812016	0.379551		0	
	13.22	0.0670046	0.506929		0	
CLD3C (wall)	14.12	0.1884257	1.334241	0.84012	0	14.60693
	14.61	0.12271576	0.84012		14.60693	
	15.30	0.14114922	0.922292		0	
CLD4A (ceiling)	10.79	0.05359732	0.496509	0.373915	0	10.91259
	10.91	0.04080382	0.373915		10.91259	
	11.40	0.07640869	0.670057		0	
CLD4B (ceiling)	8.375972	0.00740071	0.088356	0.088356	8.375972	8.375972
	8.42304	0.01094107	0.129895		0	
	8.765708	0.01499092	0.171018		0	
CLD4C (ceiling)	11.40	0.08141557	0.714078	0.227553	0	12.13341
	11.54	0.04865523	0.421677		0	
	12.13	0.02760994	0.227553		12.13341	
CLD5A (surface)	0.812868	0.00358339	0.440833	0.263329	0	0.799633
	0.799633	0.00210566	0.263329		0.799633	
	0.822274	0.00420411	0.511278		0	
CLD5B (surface)	0.718246	0.00783105	1.090303	1.090303	0.718246	0.718246
	0.708711	0.00922478	1.301628		0	
	0.723221	0.00959547	1.326768		0	
CLD5C (surface)	0.66445	0.00093847	0.14124	0.14124	0.66445	0.66445
	0.655931	0.00156133	0.238033		0	
	0.675132	0.00141603	0.209742		0	

Table C.18 Ca ppm Lardem Cave rocks

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CLD3A (wall)	2.796285	0.03885998	1.3897	1.349339	0	2.779901417	277.9901417
	2.779901	0.03751029	1.349339		2.7799		
CLD3B (wall)	3.530459	0.05257205	1.4891	1.4891	3.53046	3.530458827	353.0458827
	3.518295	0.05383509	1.530147		0		
CLD3C (wall)	4.195172	0.18527065	4.416283	1.671806	0	4.344448307	434.4448307
	4.344448	0.07263077	1.671806		4.34445		
CLD4A (ceiling)	4.303773	0.13276695	3.084897	0.590632	0	4.460115871	446.0115871
	4.460116	0.02634288	0.590632		4.46012		
CLD4B (ceiling)	3.340627	0.05979342	1.789886	1.789886	3.34063	3.340627455	334.0627455
	3.318143	0.06159999	1.85646		0		
CLD4C (ceiling)	4.560497	0.11291632	2.475965	1.734018	0	4.799057398	479.9057398
	4.799057	1.73401844	1.734018		4.79906		
CLD5A (surface)	3.285331	0.04570301	1.391123	1.391123	3.28533	3.285331458	328.5331458
	3.25835	0.04610478	1.414973		0		
CLD5B (surface)	3.224556	0.09083742	2.817052	2.817052	3.22456	3.224555875	322.4555875
	3.205358	0.09852526	3.073767		0		
CLD5C (surface)	2.415703	0.05512054	2.28176	1.9558	0	2.407625028	240.7625028
	2.407625	0.04708834	1.9558		2.40763		

Raton Rock Data

Table C.19 Sr ppm Raton Cave rocks

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CR2A (wall)	1.116178	0.00230893	0.20686	0.083946	0	1.152531085
	1.167595	0.00261498	0.223963		0	
	1.152531	0.08394587	0.083946		1.152531	
CR2B (wall)	0.883425	0.0056519	0.639771	0.506813	0	0.904598286
	0.917881	0.00535756	0.583688		0	
	0.904598	0.00458462	0.506813		0.904598	
CR2C (wall)	1.220723	0.00888245	0.727638	0.389982	0	1.273290778
	1.294606	0.00669063	0.516808		0	
	1.273291	0.00496561	0.389982		1.273291	
CR3A (ceiling)	1.139963	0.00822723	0.72171	0.72171	1.139963	1.139963257
	1.192807	0.013292	1.114346		0	
	1.173483	0.01337356	1.139646		0	
CR3B (ceiling)	1.402253	0.00787857	0.561851	0.561851	1.402253	1.402253084
	1.478984	0.01207952	0.816745		0	
	1.45456	0.0115925	0.796977		0	
CR3C (ceiling)	1.187209	0.00975319	0.821522	0.821522	1.187209	1.187209424
	1.242378	0.01185198	0.953976		0	
	1.223403	0.01200623	0.981379		0	
CR5A (wall)	0.837512	0.00284226	0.33937	0.33937	0.837512	0.837512463
	0.878387	0.00366615	0.417373		0	
	0.86471	0.00343838	0.397634		0	
CR5B (wall)	1.251669	0.00540646	0.43194	0.43194	1.251669	1.25166933
	1.330818	0.00732204	0.550191		0	
	1.308543	0.00777873	0.594457		0	
CR5C (wall)	1.044267	0.00688949	0.659744	0.568465	0	1.080768873
	1.094289	0.00662782	0.605674		0	
	1.080769	0.0061438	0.568465		1.080769	
CR6A (ceiling)	1.595428	0.01560465	0.978085	0.978085	1.595428	1.595427768
	1.682464	0.01880406	1.11765		0	
	1.665483	0.01879902	1.128743		0	
CR6B (ceiling)	0.92813	0.00927422	0.999237	0.439076	0	0.954602546
	0.964985	0.00434643	0.450414		0	
	0.954603	0.00419143	0.439076		0.954603	
CR6C (ceiling)	1.055425	0.00522915	0.495454	0.1319	0	1.087017448
	1.100284	0.0024029	0.218389		0	
	1.087017	0.00143377	0.1319		1.087017	

Table C.19 (Continued)

CR7A (surface)	1.788453	0.02719997	1.520866	1.092578	0	1.88544106
	1.885441	0.02059992	1.092578		1.885441	
	1.860535	0.02040631	1.096798		0	
CR7B (surface)	1.667214	0.00388723	0.233157	0.233157	1.667214	1.667213566
	1.762354	0.01585916	0.899885		0	
	1.738895	0.01505054	0.865523		0	
CR7C (surface)	0.981916	0.00683754	0.696347	0.280909	0	1.012289264
	1.023962	0.00434639	0.424467		0	
	1.012289	0.00284361	0.280909		1.012289	
CR8A (surface)	0.993005	0.00756137	0.761464	0.761464	0.993005	0.993004952
	1.029241	0.01023343	0.99427		0	
	1.019819	0.00984504	0.965371		0	
CR8B (surface)	1.341559	0.0076706	0.571768	0.571768	1.341559	1.341558586
	1.402344	0.0102525	0.731097		0	
	1.388346	0.00889706	0.640839		0	
CR8C (surface)	1.697236	0.00360623	0.212477	0.212477	1.697236	1.697235724
	1.774312	0.01281651	0.722337		0	
	1.755557	0.01121123	0.638614		0	

Table C.20 Mg ppm Raton Cave

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CR2A (wall)	3.904217	0.006789	0.173897	0.173897	3.904217	3.904217
	4.059209	0.013220	0.325681		0	
	4.031484	0.012040	0.298657		0	
CR2B (wall)	3.386737	0.014625	0.431822	0.431822	3.386737	3.386737
	3.526508	0.023757	0.673672		0	
	3.483080	0.018193	0.522324		0	
CR2C (wall)	4.975497	0.012249	0.246188	0.0342	0	5.191868
	5.214520	0.039724	0.761790		0	
	5.191868	0.001776	0.034200		5.191868	
CR3A (ceiling)	5.984198	0.050955	0.851494	0.851494	5.984198	5.984198
	6.270740	0.060037	0.957409		0	
	6.205099	0.070623	1.138148		0	
CR3B (ceiling)	7.56497	0.053206613	0.703329	0.703329	7.56497	7.56497
	7.975313	0.065567387	0.822129		0	
	7.858964	0.067661472	0.860946		0	
CR3C (ceiling)	6.38	0.08	1.24	0.888077	0	6.63193
	6.70	0.06	0.97		0	
	6.63	0.06	0.89		6.63193	
CR5A (wall)	3.727809	0.017603768	0.472228	0.472228	3.727809	3.727809
	3.902004	0.018587351	0.476354		0	
	3.865073	0.021760902	0.563014		0	
CR5B (wall)	6.041626	0.015005104	0.248362	0.248362	6.041626	6.041626
	6.37847	0.032150622	0.504049		0	
	6.290655	0.021690101	0.344799		0	
CR5C (wall)	4.487403	0.020606146	0.4592	0.4592	4.487403	4.487403
	4.69556	0.02963411	0.631109		0	
	4.65672	0.037757342	0.810814		0	
CR6A (ceiling)	8.065866	0.082931626	1.02818	1.02818	8.065866	8.065866
	8.475159	0.110612866	1.305142		0	
	8.356611	0.097773329	1.170012		0	
CR6B (ceiling)	4.962102	0.033525078	0.675622	0.421663	0	5.196202
	5.196202	0.021910455	0.421663		5.196202	
	5.074676	0.046417958	0.914698		0	
CR6C (ceiling)	5.842252	0.014001809	0.239665	0.19599	0	6.141683
	6.141683	0.012037107	0.19599		6.141683	
	6.004737	0.013943449	0.232207		0	

Table C.20 (Continued)

CR7A (surface)	8.266074	0.103150374	1.247876		0	
	8.726653	0.084046944	0.963106	0.963106	8.726653	8.726653
	8.577673	0.116460798	1.35772		0	
CR7B (surface)	7.8231	0.047115384	0.60226		7.8231	
	8.244556	0.072708309	0.881895	0.60226	0	7.8231
	8.116837	0.056489803	0.695958		0	
CR7C (surface)	5.876178	0.012319459	0.209651		5.876178	
	6.188201	0.032272135	0.521511	0.209651	0	5.876178
	6.040429	0.020760256	0.343688		0	
CR8A (surface)	3.924786	0.040058937	0.761464		3.924786	
	4.087146	0.03722375	0.99427	0.761464	0	3.924786
	3.998005	0.043118191	0.965371		0	
CR8B (surface)	4.620844	0.030388854	0.657647		4.620844	
	4.836336	0.032235325	0.666524	0.657647	0	4.620844
	4.710195	0.060020086	1.274259		0	
CR8C (surface)	5.359385	0.035675232	0.665659		0	
	5.632653	0.019386165	0.344175	0.344175	5.632653	5.632653
	5.498168	0.044519575	0.809716		0	

Table C.21 Ca ppm Raton Cave rocks

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CR2A (wall)	2.398507	0.0161026	0.671358	0.649912	0	2.368541913	236.8541913
	2.368542	0.0153934	0.649912		2.368542		
CR2B (wall)	1.686155	0.007446	0.441593	0.441593	1.686155	1.686155364	168.6155364
	1.679391	0.0092821	0.552705		0		
CR2C (wall)	2.350798	0.0112607	0.479017	0.479017	2.350798	2.350797854	235.0797854
	2.338324	0.0189175	0.809021		0		
CR3A (ceiling)	1.905962	0.0084692	0.444353	0.242635	0	1.856790789	185.6790789
	1.856791	0.0045052	0.242635		1.856791		
CR3B (ceiling)	2.251813	0.0480709	2.134762	0.136194	0	2.242011876	224.2011876
	2.242012	0.0030535	0.136194		2.242012		
CR3C (ceiling)	2.08639	0.0333407	1.598009	1.201357	0	2.060395005	206.0395005
	2.060395	0.0247527	1.201357		2.060395		
CR5A (wall)	1.709012	0.0206731	1.209652	0.692535	0	1.694709964	169.4709964
	1.69471	0.0117365	0.692535		1.69471		
CR5B (wall)	2.549168	0.0111383	0.436938	0.436938	2.549168	2.549167534	254.9167534
	2.544219	0.0216414	0.850611		0		
CR5C (wall)	2.202707	0.0240922	1.093755	0.591238	0	2.172746132	217.2746132
	2.172746	0.0128461	0.591238		2.172746		
CR6A (ceiling)	2.32578	0.0370883	1.594659	1.293102	0	2.313722321	231.3722321
	2.313722	0.0299188	1.293102		2.313722		
CR6B (ceiling)	0.512586	0.003591	0.700558	0.700558	0.512586	0.512586287	51.2586287
	0.501439	0.5014388	0.910871		0		
CR6C (ceiling)	1.733932	0.0365445	2.10761	0.334651	0	1.763661584	176.3661584
	1.763662	0.0059021	0.334651		1.763662		

Table C.21 (Continued)

CR7A (surface)	2.629277	0.0426539	1.622266	1.254309	0	2.582349347	258.2349347
	2.582349	0.0323906	1.254309		2.582349		
CR7B (surface)	2.314432	0.0082458	0.356277	0.356277	2.314432	2.314432029	231.4432029
	2.2846	0.0220974	0.967232		0		
CR7C (surface)	1.55518	0.0039907	0.256608	0.256608	1.55518	1.555180202	155.5180202
	1.571233	0.0104939	0.667876		0		
CR8A (surface)	1.585721	0.0093393	0.58896	0.58896	1.585721	1.58572141	158.572141
	1.588434	0.010309	0.649006		0		
CR8B (surface)	1.779111	0.0290818	1.634626	0.311958	0	1.788964927	178.8964927
	1.788965	0.0055808	0.311958		1.788965		
CR8C (surface)	2.445301	0.033682	1.377417	0.744347	0	2.425376859	242.5376859
	2.425377	0.0180532	0.744347		2.425377		

Hato Rock Data

Table C.22 Sr ppm Hato Cave rocks

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
CH2A (wall)	0.621794884	0.002231561	0.358890253	0.267555158	0	0.65870873
	0.65870873	0.001762409	0.267555158		0.65870873	
	0.650521366	0.00206878	0.318018768		0	
CH2B (wall)	0.571415173	0.011847158	2.07330127	1.553383324	0	0.606607903
	0.606607903	1.553383324	1.553383324		0.606607903	
	0.600947441	1.702156087	1.702156087		0	
CH2C (wall)	0.000872905	0.001963741	224.9662276	28.11308789	0	0
	-8.16413E-05	4.98135E-05	61.02		0	
	-0.000657518	0.000184849	28.11		-0.000657518	
CH3A (ceiling)	0.365491731	0.001174272	0.321285411	0.321285411	0.365491731	0.365491731
	0.374536181	0.004683915	1.250590823		0	
	0.372733506	0.00456292	1.224177475		0	
CH3B (ceiling)	0.344268323	0.004557271	1.323755606	0.670438517	0	0.362153706
	0.362153706	0.002428018	0.670438517		0.362153706	
	0.361144876	0.0031911	0.883606741		0	
CH3C (ceiling)	0.501634351	0.011238731	2.240422876	1.021807461	0	0.524843974
	0.527964332	0.006526586	1.236179269		0	
	0.524843974	0.005362895	1.021807461		0.524843974	
CH5A (wall)	0.452017507	0.001240201	0.274370194	0.274370194	0.452017507	0.452017507
	0.470222063	0.004234297	0.900488759		0	
	0.467892994	0.003483852	0.744583137		0	
CH5B (wall)	-0.001519088	0.005236827	344.735015	27.72660979	0	0
	-0.000146391	0.000102534	70.04		0	
	-0.000710688	0.00019705	27.73		-0.000710688	
CH5C (wall)	1.233562711	0.00635798	0.515416	0.475498592	0	1.289505368
	1.289505368	0.00613158	0.475498592		1.289505368	
	1.276291343	0.009313066	0.729697511		0	

Table C.22 (Continued)

CH6A (ceiling)	0.573545712	0.00143884	0.250867586	0.1364172 7	0	0.59905137 6
	0.602256242	0.001753674	0.291183997		0	
	0.599051376	0.00081721	0.13641727		0.599051376	
CH6B (ceiling)	0.512938776	0.003706528	0.722606274	0.7226062 74	0.512938776	0.51293877 6
	0.538097322	0.004780122	0.888337738		0	
	0.536027352	0.004438866	0.828104306		0	
CH6C (ceiling)	0.409950166	0.003415501	0.833150259	0.6301903 78	0	0.42109574 4
	0.422909829	0.002731276	0.645829443		0	
	0.421095744	0.002653705	0.630190378		0.421095744	
CH7A (surface)	0.620064274	0.00327414	0.528032381	0.5280323 81	0.620064274	0.62006427 4
	0.652586072	0.007862879	1.204880002		0	
	0.646850847	0.006974426	1.078212399		0	
CH7B (surface)	-0.002035422	0.001060484	52.10	25.110252 97	0	0
	-0.000171965	7.15177E-05	41.59		0	
	-0.00068517	0.000172048	25.11		-0.00068517	
CH7C (surface)	0.557517234	0.007997669	1.434515095	1.3894199 27	0	0.57772051 9
	0.577720519	0.008026964	1.389419927		0.577720519	
	0.57436488	0.008885942	1.547090106		0	
CH8A (surface)	0.340802015	0.00515398	1.512309105	0.5304080 93	0	0.35710620 5
	0.357602733	0.00248887	0.695987516		0	
	0.357106205	0.00189412	0.530408093		0.357106205	
CH8B (surface)	0.485122874	0.006897802	1.421866952	1.1216952 3	0	0.50556551 5
	0.505565515	0.005670904	1.12169523		0.505565515	
	0.50396215	0.006425071	1.274911517		0	
CH8C (surface)	0.563583615	0.006946683	1.232591306	0.8377721 42	0	0.59025948 9
	0.594042038	0.005757709	0.969242685		0	
	0.590259489	0.00494503	0.837772142		0.590259489	

Table C.23 Mg ppm Hato Cave rocks

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
CH2A (wall)	2.318424	0.005776	0.249146	0.249145621	2.318423825	2.318423825
	2.432785	0.008261	0.339556		0	
	2.416489	0.013659	0.565222		0	
CH2B (wall)	2.093036	0.034295	1.638537	1.323143523	0	2.185828396
	2.185828	0.028922	1.323144		2.185828396	
	2.165829	0.036552	1.702156		0	
CH2C (wall)	0.000068	0.000417	616.289662	77.40723159	0	0
	0.000180	0.000494	274.772644		0	
	-0.002581	0.001998	77.407232		-0.00258081	
CH3A (ceiling)	1.393229	0.016514	1.185302	1.185302021	1.393228868	1.393228868
	1.440666	0.017477	1.213099		0	
	1.430439	0.018430	1.288446		0	
CH3B (ceiling)	1.499459869	0.007227496	0.482006604	0.482006604	1.499459869	1.499459869
	1.536847302	0.009673499	0.629437844		0	
	1.549199161	0.014491158	0.935396721		0	
CH3C (ceiling)	1.84	0.02	1.10	1.004999595	0	1.895568743
	1.90	0.02	1.00		1.895568743	
	1.90	0.02	1.23		0	
CH5A (wall)	3.107267404	0.025010524	0.804904134	0.804904134	3.107267404	3.107267404
	3.246297948	0.030459487	0.938283781		0	
	3.231536088	0.04022095	1.244638735		0	
CH5B (wall)	5.43776E-05	0.000408767	751.7192163	36.45826677	0	0
	0.000371743	0.000303667	81.69		0	
	-0.00318192	0.001160072	36.46		-0.00318192	
CH5C (wall)	2.442270631	0.017480874	0.715763179	0.388873401	0	2.543911373
	2.521608622	0.021385305	0.848081866		0	
	2.543911373	0.009892595	0.388873401		2.543911373	

Table C.23 (Continued)

CH6A (ceiling)	2.484738804	0.003204926	0.128984441	0.128984441	2.484738804	2.484738804
	2.561568553	0.012622188	0.492752302		0	
	2.583009347	0.006513484	0.252166503		0	
CH6B (ceiling)	2.28977245	0.014216336	0.620862396	0.620862396	2.28977245	2.28977245
	2.365253067	0.020646759	0.872919642		0	
	2.362030043	0.017654938	0.747447637		0	
CH6C (ceiling)	1.626865577	0.009960074	0.612224757	0.507430711	0	1.67620471
	1.668022466	0.008612968	0.516358041		0	
	1.67620471	0.008505577	0.507430711		1.67620471	
CH7A (surface)	2.716237527	0.019075844	0.702289243	0.702289243	2.716237527	2.716237527
	2.833176945	0.035797563	1.263513125		0	
	2.840072887	0.020447248	0.71995506		0	
CH7B (surface)	-7.1984E-05	0.000249983	347.2741527	65.67758856	0	0
	-3.5742E-05	0.000159949	447.5136456		0	
	-0.00168248	0.001105011	65.68		-0.00168248	
CH7C (surface)	2.290659468	0.03852056	1.681636232	1.273330421	0	2.365732004
	2.36584511	0.032663589	1.380630918		0	
	2.365732004	0.030123585	1.273330421		2.365732004	
CH8A (surface)	1.760651295	0.006041153	0.343120382	0.343120382	1.760651295	1.760651295
	1.803982712	0.019243299	1.066711916		0	
	1.807488747	0.015279495	0.845343874		0	
CH8B (surface)	2.594019894	0.03363724	1.296722499	1.02359249	0	2.681717043
	2.681717043	0.027449854	1.02359249		2.681717043	
	2.678502484	0.044815244	1.673145512		0	
CH8C (surface)	2.917204651	0.020446376	0.700889329	0.700889329	2.917204651	2.917204651
	3.027947593	0.028663465	0.94663015		0	
	3.035026027	0.036893383	1.215587033		0	

Table C.24 Ca ppm Hato Cave rocks

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
CH2A (wall)	2.480368	0.03808409	1.535421	0.581099	0	2.451392861	245.1392861
	2.451393	0.01424501	0.581099		2.451393		
CH2B (wall)	2.34742	0.06238182	2.657464	1.831446	0	2.357888502	235.7888502
	2.357889	0.04318345	1.831446		2.357889		
CH2C (wall)	1.844899	0.03081135	1.670084	1.19673	0	1.832309612	183.2309612
	1.83231	0.0219278	1.19673		1.83231		
CH3A (ceiling)	1.580826	0.01615952	1.02222	0.576858	0	1.605644459	160.5644459
	1.605644	0.00926228	0.576858		1.605644		
CH3B (ceiling)	1.842333	0.0246707	1.339101	0.566299	0	1.831816449	183.1816449
	1.831816	0.01037355	0.566299		1.831816		
CH3C (ceiling)	1.97094	0.0454076	2.303854	1.464269	0	1.99235787	199.235787
	1.992358	0.02917348	1.464269		1.992358		
CH5A (wall)	2.058353	0.04007598	1.946992	1.946992	2.058353	2.058353361	205.8353361
	2.048576	0.04322307	2.109908		0		
CH5B (wall)	1.448221	0.01840082	1.270581	0.954211	0	1.479353837	147.9353837
	1.479354	1.47935384	0.954211		1.479354		
CH5C (wall)	2.467293	0.02844107	1.152724	0.871282	0	2.446204804	244.6204804
	2.446205	0.02131334	0.871282		2.446205		

Table C.24 (Continued)

CH6A (ceiling)	2.326953	0.05109299	2.195704	1.72725	0	2.354939642	235.4939642
	2.35494	0.0406757	1.72725		2.35494		
CH6B (ceiling)	2.00745	0.05673607	2.826275	0.272243	0	2.039890686	203.9890686
	2.039891	0.00555346	0.272243		2.039891		
CH6C (ceiling)	1.564674	0.01182353	0.755654	0.755654	1.564674	1.564674022	156.4674022
	1.594167	0.01250964	0.784713		0		
CH7A (surface)	2.640211	0.02964843	1.122957	1.122957	2.640211	2.640210797	264.0210797
	2.653812	0.04278523	1.612218		0		
CH7B (surface)	1.556106	0.0220996	1.420186	0.392742	0	1.575918956	157.5918956
	1.575919	0.00618929	0.392742		1.575919		
CH7C (surface)	1.974099	0.02210121	1.11956	0.273249	0	1.984401187	198.4401187
	1.984401	0.00542236	0.273249		1.984401		
CH8A (surface)	1.677667	0.03097521	1.846326	1.283522	0	1.701245833	170.1245833
	1.701246	0.02183586	1.283522		1.701246		
CH8B (surface)	2.33024	0.04627565	1.985875	0.413736	0	2.317409395	231.7409395
	2.317409	0.00958796	0.413736		2.317409		
CH8C (surface)	1.957248	0.04449815	2.273505	1.913361	0	1.98440262	198.440262
	1.984403	0.03796878	1.913361		1.984403		

Bahamian Stalagmite Data

Abaco Stalagmite AH1

Table C.25 Sr ppm AH1

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
AH1-1	0.382025	0.01303117	3.41108	1.899072	0	0.367348848
	0.372267	0.00752271	2.020784		0	
	0.367349	0.00697622	1.899072		0.3673488	
AH1-2	0.471501	0.0025526	0.541378	0.541378	0.4715009	0.471500887
	0.464517	0.00272792	0.587261		0	
	0.458025	0.00254417	0.555464		0	
AH1-3	0.488419	0.00787226	1.611785	1.024452	0	0.470746042
	0.477762	0.00649846	1.360189		0	
	0.470746	0.00482257	1.024452		0.470746	
AH1-4	0.618431	0.01453017	2.349522	1.406667	0	0.612960871
	0.62053	0.00919495	1.481788		0	
	0.612961	0.00862232	1.406667		0.6129609	
AH1-5	0.70163	0.01373252	1.957231	1.957231	0.70163	0.701630046
	0.70665	0.01676216	2.37206		0	
	0.698002	0.01633752	2.340613		0	
AH1-6	0.683796	0.00930717	1.361104	0.832496	0	0.688465841
	0.688466	0.00573145	0.832496		0.6884658	
	0.678244	0.00577094	0.850865		0	
AH1-7	0.376078	0.00300448	0.798899	0.614189	0	0.356611011
	0.359421	0.00236767	0.658746		0	
	0.356611	0.00219027	0.614189		0.356611	
AH1-8	0.287468	0.00516711	1.797459	0.898945	0	0.273718026
	0.273718	0.00246057	0.898945		0.273718	
	0.27401	0.00250724	0.915019		0	
AH1-9	0.310703	0.00998509	3.213709	0.335479	0	0.300433893
	0.300434	0.00100789	0.335479		0.3004339	
	0.299149	0.00203684	0.680879		0	
AH1-10	0.187012	0.00578271	3.092154	1.32566	0	0.17943098
	0.177899	0.00257462	1.447234		0	
	0.179431	0.00237865	1.32566		0.179431	

Table C.26 Mg ppm AH1

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
AH1-1	6.638571475	0.122734844	1.848814074	1.609920259	0	6.479480255
	6.644883797	0.142043037	2.137630116		0	
	6.479480255	0.104314465	1.609920259		6.479480255	
AH1-2	6.209543174	0.072892442	1.173877689	0.637385361	0	6.101312847
	6.206918688	0.049488333	0.797309192		0	
	6.101312847	0.038888875	0.637385361		6.101312847	
AH1-3	5.109486786	0.072121592	1.411523207	0.939747723	0	4.976265054
	5.096590389	0.062647669	1.229207449		0	
	4.976265054	0.046764338	0.939747723		4.976265054	
AH1-4	5.05710172	0.082249915	1.626423987	1.406666537	0	4.962594385
	5.060606046	0.084443202	1.481787997		0	
	4.962594385	0.059090486	1.406666537		4.962594385	
AH1-5	5.287904402	0.111800581	2.114270093	2.030329204	0	5.268573904
	5.268573904	0.106969395	2.030329204		5.268573904	
	5.177965204	0.108427201	2.094011768		0	
AH1-6	4.365446314	0.032437321	0.743047074	0.649817301	0	4.353428637
	4.353428637	0.028289332	0.649817301		4.353428637	
	4.343636865	0.029614862	0.681798764		0	
AH1-7	3.776249784	0.010873186	0.287936093	0.287936093	3.776249784	3.776249784
	3.760320711	0.012321788	0.327679181		0	
	3.761445296	0.028375915	0.754388606		0	
AH1-8	3.715509499	0.025261235	0.679886155	0.533191213	0	3.68087619
	3.68087619	0.019626108	0.533191213		3.68087619	
	3.679889905	0.030608418	0.831775376		0	
AH1-9	3.626608593	0.012204281	0.336520482	0.336520482	3.626608593	3.626608593
	3.612521302	0.027389791	0.758190449		0	
	3.62386263	0.035756187	0.986687149		0	
AH1-10	2.304650413	0.052113299	2.261223589	1.705123202	0	2.356942396
	2.303043468	0.045791425	1.988300504		0	
	2.356942396	0.040188772	1.705123202		2.356942396	

Table C.27 Ca ppm AH1

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
AH1-1	3.949731	0.02417684	0.612113	0.612113	3.949731	3.949731411	394.9731411
	3.806946	0.04630113	1.216228		0		
AH1-2	3.779612	0.07270428	1.923591	0.483783	0	3.60399039	360.399039
	3.60399	0.01743551	0.483783		3.60399		
AH1-3	3.204889	0.02490829	0.777197	0.416325	0	3.028074563	302.8074563
	3.028075	0.01260664	0.416325		3.028075		
AH1-4	2.84784	0.04077673	1.431848	0.322031	0	2.750522828	275.0522828
	2.750523	0.00885753	0.322031		2.750523		
AH1-5	2.97311	0.03304886	1.111592	0.862983	0	2.81963502	281.963502
	2.819635	0.02433298	0.862983		2.819635		
AH1-6	3.145776	0.02389474	0.759582	0.297864	0	2.997769892	299.7769892
	2.99777	0.00892929	0.297864		2.99777		
AH1-7	3.571985	0.02626491	0.735303	0.707241	0	3.432303987	343.2303987
	3.432304	0.02427467	0.707241		3.432304		
AH1-8	3.374114	0.00719166	0.213142	0.213142	3.374114	3.374113789	337.4113789
	3.253548	0.0145137	0.446088		0		
AH1-9	4.366915	0.02438792	0.55847	0.55847	4.366915	4.366915394	436.6915394
	4.155826	0.02586885	0.622472		0		
AH1-10	2.876653	0.02256886	0.784553	0.365945	0	2.732088349	273.2088349
	2.732088	0.00999794	0.365945		2.732088		

Abaco Stalagmite AR1

Table C.28 Sr ppm AR1

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
AR1-1	0.593383	0.0135849	2.289397	2.186043	0	0.59203194
	0.601322	0.0146502	2.436333		0	
	0.592032	0.0139842	2.186043		0.592032	
AR1-2	0.713601	0.0087197	1.221933	0.967961	0	0.71186777
	0.721086	0.007895	1.094881		0	
	0.711868	0.0068906	0.967961		0.711868	
AR1-3	0.66404	0.0126199	1.900477	1.900477	0.66404	0.66403972
	0.67756	0.0163555	2.413878		0	
	0.668311	0.0174684	2.61382		0	
AR1-4	1.006781	0.0080184	0.796435	0.796435	1.006781	1.00678101
	1.047972	0.0164144	1.566299		0	
	1.034011	0.0154473	1.493919		0	
AR1-5	0.382127	0.006463	1.69132	0.747333	0	0.36139226
	0.365217	0.0034931	0.956444		0	
	0.361392	0.0027008	0.747333		0.361392	
AR1-6	0.678012	0.0059124	0.872021	0.317225	0	0.67014746
	0.680207	0.0030305	0.445523		0	
	0.670147	0.0021259	0.317225		0.670147	
AR1-7	0.53823	0.0063288	1.175853	0.859979	0	0.53029201
	0.530292	0.0045604	0.859979		0.530292	
	0.524846	0.0046512	0.886201		0	
AR1-8	0.62224	0.01179	1.89477	1.747986	0	0.61387985
	0.622466	0.0119294	1.916476		0	
	0.61388	0.0107305	1.747986		0.61388	
AR1-9	0.676422	0.0125517	1.855598	1.836677	0	0.67760217
	0.686615	0.0131988	1.922308		0	
	0.677602	0.0124454	1.836677		0.677602	

Table C.28 (Continued)

AR1-10	0.495503	0.0038255	0.772051	0.772051	0.495503	0.49550256
	0.48464	0.0059348	1.224569		0	
	0.47696	0.0065518	1.373661		0	
AR1-11	0.950885	0.0178276	1.874839	1.397562	0	0.98048481
	0.995051	0.0151758	1.525132		0	
	0.980485	0.0137029	1.397562		0.980485	
AR1-12	0.813322	0.0088641	1.08987	1.08987	0.813322	0.81332179
	0.829996	0.0121227	1.460569		0	
	0.819067	0.0098257	1.199623		0	
AR1-13	0.653092	0.0059345	0.908674	0.908674	0.653092	0.65309217
	0.653865	0.0097911	1.497423		0	
	0.64389	0.0090902	1.411763		0	
AR1-14	0.801593	0.0054803	0.683674	0.683674	0.801593	0.80159314
	0.812155	0.0072701	0.895167		0	
	0.800539	0.006502	0.812206		0	
AR1-15	0.773638	0.0060801	0.785916	0.785916	0.773638	0.7736379
	0.790429	0.0136764	1.730246		0	
	0.78014	0.012363	1.584718		0	
AR1-16	0.921027	0.0164654	1.787719	1.719237	0	0.94413703
	0.944137	0.016232	1.719237		0.944137	
	0.932426	0.0172714	1.852302		0	
AR1-17	0.770872	0.0135715	1.760542	1.271717	0	0.77002065
	0.779515	0.0112055	1.437495		0	
	0.770021	0.0097925	1.271717		0.770021	
AR1-18	0.623942	0.0074165	1.188653	0.493636	0	0.62201918
	0.622019	0.0030705	0.493636		0.622019	
	0.615254	0.0057552	0.935425		0	

Table C.29 Mg ppm AR1

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
AR1-1	7.95775	0.193989	2.437738	2.186043	0	7.702341
	7.935878	0.185287	2.334798		0	
	7.702341	0.168376	2.186043		7.702341	
AR1-2	7.457126	0.073457	0.985059	0.865555	0	7.469492
	7.469492	0.064653	0.865555		7.469492	
	7.334809	0.070632	0.962967		0	
AR1-3	1.819837	0.045501	2.500298	2.500298	1.819837	1.819837
	1.818111	0.045978	2.52888		0	
	1.901404	0.049077	2.581115		0	
AR1-4	2.886391	0.046136	1.598381	1.143765	0	2.928544
	2.878726	0.048227	1.675276		0	
	2.928544	0.033496	1.143765		2.928544	
AR1-5	1.060111	0.007256	0.684488	0.598979	0	1.072623
	1.072623	0.006425	0.598979		1.072623	
	1.15059	0.010984	0.954631		0	
AR1-6	1.787414	0.014401	0.872021	0.317225	0	1.851129
	1.779043	0.006821	0.445523		0	
	1.851129	0.006423	0.317225		1.851129	
AR1-7	1.507504	0.004732	0.313899	0.313899	1.507504	1.507504
	1.508492	0.008767	0.581161		0	
	1.581021	0.008169	0.886201		0	
AR1-8	1.846069	0.02779	1.505373	1.314382	0	1.843446
	1.843446	0.02423	1.314382		1.843446	
	1.91787	0.030884	1.610311		0	
AR1-9	1.467786	0.026287	1.790941	1.790941	1.467786	1.467786
	1.469355	0.0274	1.864793		0	
	1.550725	0.031968	2.061476		0	

Table C.29 (Continued)

AR1-10	1.300811	0.020954	1.610873	1.23045	0	1.38935
	1.302822	0.018455	1.416506		0	
	1.38935	0.017095	1.23045		1.38935	
AR1-11	2.213315	0.03482	1.573219	1.221083	0	2.291518
	2.214241	0.03545	1.600995		0	
	2.291518	0.027981	1.221083		2.291518	
AR1-12	1.713759	0.02283	1.332181	1.092575	0	1.713768
	1.713768	0.018724	1.092575		1.713768	
	1.793674	0.024043	1.340412		0	
AR1-13	1.354136	0.030236	2.382934	1.52523	0	1.434804
	1.352807	0.030236	2.235046		0	
	1.434804	0.021884	1.52523		1.434804	
AR1-14	1.647084	0.021256	1.290545	0.986509	0	1.726556
	1.644269	0.017498	1.064152		0	
	1.726556	0.017033	0.986509		1.726556	
AR1-15	1.493569	0.03092	2.070197	1.411034	0	1.582698
	1.493434	0.029469	1.973233		0	
	1.582698	0.022332	1.411034		1.582698	
AR1-16	2.232274	0.033182	1.486459	1.390809	0	2.307327
	2.233093	0.038215	1.711322		0	
	2.307327	0.032091	1.390809		2.307327	
AR1-17	1.771878	0.028487	1.607738	1.58488	0	1.848047
	1.770959	0.032442	1.831877		0	
	1.848047	0.029289	1.58488		1.848047	
AR1-18	1.15189	0.009107	0.790616	0.505968	0	1.24742
	1.16509	0.016036	1.376384		0	
	1.24742	0.006312	0.505968		1.24742	

Table C.30 Ca ppm AR1

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
AR1-1	3.010218	0.02987075	0.992312	0.982264	0	2.838743956	283.874396
	2.838744	0.02788396	0.982264		2.838744		
AR1-2	4.427381	0.01910026	0.431412	0.431412	4.427381	4.427380755	442.738076
	4.228354	0.03836002	0.907209		0		
AR1-3	4.303371	0.06471114	1.503731	0.453665	0	4.082763399	408.27634
	4.082763	0.01852207	0.453665		4.082763		
AR1-4	4.407274	0.03542241	0.803726	0.706617	0	4.174403418	417.440342
	4.174403	0.02949705	0.706617		4.174403		
AR1-5	2.665079	0.00717569	0.269249	0.269249	2.665079	2.66507909	266.507909
	2.508419	0.03651895	1.455855		0		
AR1-6	4.753178	0.0620926	1.306339	1.306339	4.753178	4.753178021	475.317802
	4.500844	0.0626591	1.392163		0		
AR1-7	3.508566	0.01086926	0.309792	0.309792	3.508566	3.508565745	350.856574
	3.301071	0.02356828	0.713959		0		
AR1-8	3.893172	0.00797841	0.204933	0.204933	3.893172	3.893172114	389.317211
	3.694571	0.01754438	0.474869		0		
AR1-9	3.873715	0.03511377	0.906463	0.906463	3.873715	3.873715029	387.371503
	3.647165	0.05446397	1.493324		0		

Table C.30 (Continued)

AR1-10	2.853609	0.01187505	0.416142	0.27787	0	2.66832181	266.832181
	2.668322	0.00741448	0.27787		2.668322		
AR1-11	6.358	0.02023986	0.318337	0.318337	6.358	6.358000285	635.800029
	6.162644	0.04614261	0.748747		0		
AR1-12	5.104459	0.03910277	0.766051	0.766051	5.104459	5.104459442	510.445944
	4.907823	0.07244788	1.476172		0		
AR1-13	4.570806	0.01839146	0.402368	0.21518	0	4.341088611	434.108861
	4.341089	0.00934117	0.21518		4.341089		
AR1-14	5.222137	0.04005446	0.767013	0.454781	0	4.918251517	491.825152
	4.918252	0.02236727	0.454781		4.918252		
AR1-15	4.409213	0.09256002	2.099241	0.439423	0	4.183614789	418.361479
	4.183615	0.01838375	0.439423		4.183615		
AR1-16	5.024572	0.03013155	0.599684	0.599684	5.024572	5.02457205	502.457205
	4.76073	0.0310639	0.652503		0		
AR1-17	4.167653	0.02566397	0.615789	0.615789	4.167653	4.167652517	416.765252
	3.966851	0.03820498	0.963106		0		
AR1-18	3.761475	0.00767569	0.204061	0.204061	3.761475	3.761474971	376.147497
	3.529307	0.01767927	0.500928		0		

San Salvador Stalagmite SL4

Table C.31 Sr ppm SL4

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
SL4-1	2.470944	0.047932	1.939829	1.706263	0	2.55615317
	2.591025	0.048606	1.875926		0	
	2.556153	0.043615	1.706263		2.556153	
SL4-2	2.272921	0.040626	1.787402	1.70095	0	2.34888846
	2.348888	0.039953	1.70095		2.348888	
	2.320615	0.042558	1.8339		0	
SL4-3	3.855662	0.024919	0.646289	0.519763	0	4.02104273
	4.069746	0.025043	0.615345		0	
	4.021043	0.0209	0.519763		4.021043	
SL4-4	2.486885	0.023795	0.956839	0.956839	2.486885	2.48688542
	2.600641	0.035089	1.349256		0	
	2.572036	0.035424	1.37727		0	
SL4-5	1.341253	0.005888	0.43901	0.430809	0	1.3725613
	1.392209	0.007441	0.53447		0	
	1.372561	0.005913	0.430809		1.372561	
SL4-6	1.104276	0.010651	0.964515	0.964515	1.104276	1.10427608
	1.132117	0.017175	1.517032		0	
	1.115941	0.014675	1.315005		0	
SL4-7	1.180471	0.015088	1.27811	1.141207	0	1.19620202
	1.212299	0.014756	1.217209		0	
	1.196202	0.013651	1.141207		1.196202	
SL4-8	1.018344	0.02545	2.499128	2.206089	0	1.02650344
	1.04107	0.023091	2.217968		0	
	1.026503	0.022646	2.206089		1.026503	
SL4-9	1.249694	0.022471	1.798155	1.798155	1.249694	1.24969369
	1.283369	0.032639	2.543214		0	
	1.26667	0.030948	2.443277		0	
SL4-10	0.924561	0.00806	0.87178	0.87178	0.924561	0.92456086
	0.946428	0.012759	1.348107		0	
	0.933815	0.012733	1.363576		0	
SL4-11	0.980511	0.01576	1.607369	1.467667	0	0.98225893
	0.996714	0.015045	1.509416		0	
	0.982259	0.014416	1.467667		0.982259	
SL4-12	1.203189	0.026785	2.226146	2.009552	0	1.23790732
	1.255394	0.025741	2.050418		0	
	1.237907	0.024876	2.009552		1.237907	

Table C.31 (Continued)

SL4-13	0.946066	0.003849	0.406797	0.406797	0.946066	0.94606602
	0.973495	0.009701	0.996544		0	
	0.959003	0.007947	0.828628		0	
SL4-14	1.628742	0.0267	1.639282	1.639282	1.628742	1.62874208
	1.702257	0.036983	2.172561		0	
	1.677091	0.034082	2.032204		0	
SL4-15	0.721082	0.008892	1.233172	1.233172	0.721082	0.72108207
	0.724555	0.010846	1.496949		0	
	0.714578	0.011316	1.583592		0	
SL4-16	0.627137	0.006571	1.04771	0.66883	0	0.62162281
	0.621623	0.004158	0.66883		0.621623	
	0.613165	0.004438	0.723721		0	
SL4-17	0.900609	0.013603	1.510413	1.466809	0	0.91178916
	0.924943	0.01427	1.542783		0	
	0.911789	0.013374	1.466809		0.911789	
SL4-18	0.972021	0.014553	1.497157	0.838364	0	0.98139153
	0.996317	0.010249	1.028666		0	
	0.981392	0.008228	0.838364		0.981392	
SL4-19	0.593136	0.006392	1.07763	0.956142	0	0.58699629
	0.595153	0.006662	1.119449		0	
	0.586996	0.005613	0.956142		0.586996	
SL4-20	0.701621	0.003284	0.4681	0.4681	0.701621	0.70162073
	0.705762	0.005189	0.735215		0	
	0.696202	0.0048	0.689503		0	
SL4-21	0.534308	0.005636	1.054821	1.054821	0.534308	0.53430808
	0.533057	0.007076	1.327417		0	
	0.525805	0.007102	1.350728		0	
SL4-22	0.899828	0.008829	0.981215	0.981215	0.899828	0.89982755
	0.919586	0.01354	1.472377		0	
	0.906787	0.014072	1.551872		0	
SL4-23	0.599327	0.016318	2.722795	1.347628	0	0.57911091
	0.586233	0.010007	1.706964		0	
	0.579111	0.007804	1.347628		0.579111	
SL4-24	0.88879	0.008343	0.938737	0.938737	0.88879	0.88878955
	0.896651	0.009646	1.075778		0	
	0.884281	0.00997	1.127504		0	
SL4-25	0.896934	0.018438	2.055615	2.055615	0.896934	0.89693365
	0.911809	0.032009	3.51048		0	
	0.899764	0.031888	3.543999		0	

Table C.31 (Continued)

SL4-26	0.710059	0.010037	1.413598	1.301473	0	0.70785841
	0.717788	0.011193	1.55941		0	
	0.707858	0.009213	1.301473		0.707858	
SL4-27	0.664307	0.003009	0.452956	0.452956	0.664307	0.66430671
	0.657935	0.006771	1.029184		0	
	0.65005	0.007158	1.1012		0	
SL4-28	0.675277	0.008098	1.199256	1.199256	0.675277	0.67527685
	0.673759	0.009798	1.454278		0	
	0.665121	0.00976	1.46733		0	
SL4-29	0.764418	0.010319	1.349929	1.209859	0	0.76458921
	0.774352	0.009456	1.2212		0	
	0.764589	0.00925	1.209859		0.764589	
SL4-30	0.793172	0.009261	1.167536	1.167536	0.793172	0.79317239
	0.808138	0.011056	1.368085		0	
	0.797165	0.012863	1.613561		0	
SL4-31	1.047551	0.018002	1.718474	1.718474	1.047551	1.04755148
	1.071582	0.023489	2.192038		0	
	1.057227	0.023032	2.178511		0	
SL4-32	0.628416	0.004509	0.717463	0.629063	0	0.61499132
	0.614991	0.003869	0.629063		0.614991	
	0.608502	0.004042	0.664298		0	
SL4-33	1.042589	0.013106	1.257023	1.233224	0	1.05413954
	1.068422	0.014939	1.398202		0	
	1.05414	0.013	1.233224		1.05414	
SL4-34	0.70189	0.00244	0.347615	0.259109	0	0.69271263
	0.70348	0.002098	0.298249		0	
	0.692713	0.001795	0.259109		0.692713	
SL4-35	0.98377	0.005376	0.546518	0.476306	0	1.00517948
	1.005179	0.010485	0.476306		1.005179	
	0.993226	0.016169	0.553438		0	
SL4-36	1.241499	0.011746	0.946145	0.946145	1.241499	1.24149899
	1.277556	0.017021	1.332282		0	
	1.262132	0.016547	1.311013		0	
SL4-37	1.386155	0.006081	0.438696	0.438696	1.386155	1.38615451
	1.432132	0.011327	0.790902		0	
	1.412993	0.010461	0.740354		0	
SL4-38	1.446232	0.019979	1.381479	1.381479	1.446232	1.44623188
	1.496322	0.022476	1.502104		0	
	1.47461	0.021642	1.467661		0	

Table C.32 Mg ppm SL4

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
SL4-1	6.299724	0.1171751	1.860003	1.705836	0	6.08338
	6.305815	0.1100113	1.744601		0	
	6.08338	0.1037725	1.705836		6.08338	
SL4-2	7.620444	0.1031929	1.354159	1.354159	7.620444	7.620444
	7.67204	0.1329322	1.732683		0	
	7.396412	0.1322211	1.787638		0	
SL4-3	28.69	0.4997065	1.74194	0.547038	0	31.28185
	30.66	0.240138	0.783342		0	
	31.28	0.1711237	0.547038		31.28185	
SL4-4	22.47	0.2538023	1.129612	1.129612	22.46809	22.46809
	23.25	0.2677797	1.151894		0	
	22.85	0.3091571	1.35291		0	
SL4-5	11.08	0.0900831	0.813113	0.157025	0	10.84236
	11.15	0.0766982	0.687879		0	
	10.84	0.0170252	0.157025		10.84236	
SL4-6	8.470101	0.1166705	1.37744	1.37744	8.470101	8.470101
	8.488795	0.1203998	1.418338		0	
	8.187921	0.1247165	1.523176		0	
SL4-7	8.192672	0.0921632	1.124946	1.070153	0	8.222341
	8.222341	0.0879916	1.070153		8.222341	
	7.971491	0.1249487	1.567445		0	
SL4-8	2.130362	0.0332996	1.563096	1.563096	2.130362	2.130362
	2.137503	0.0381715	1.785798		0	
	2.182153	0.0405363	1.857628		0	
SL4-9	3.237722	0.0890669	2.750912	2.459649	0	3.233217
	3.222761	0.0844747	2.621191		0	
	3.233217	0.0795258	2.459649		3.233217	
SL4-10	2.349472	0.029573	1.25871	1.218571	0	2.391922
	2.353485	0.031296	1.329771		0	
	2.391922	0.0291473	1.218571		2.391922	
SL4-11	4.289006	0.0922537	2.150934	1.404023	0	4.243201
	4.286187	0.0751687	1.753743		0	
	4.243201	0.0595755	1.404023		4.243201	
SL4-12	2.493479	0.0484243	1.942037	1.820297	0	2.555226
	2.497889	0.0508683	2.03645		0	
	2.555226	0.0465127	1.820297		2.555226	

Table C.32 (Continued)

SL4-13	2.014226	0.0260989	1.295729	0.413971	0	2.062184
	2.013411	0.0205169	1.01901		0	
	2.062184	0.0085368	0.413971		2.062184	
SL4-14	5.536495	0.1319289	2.382896	1.97582	0	5.45647
	5.543526	0.125815	2.269584		0	
	5.45647	0.1078101	1.97582		5.45647	
SL4-15	2.015437	0.0310745	1.541823	1.209705	0	2.05841
	2.010856	0.0317097	1.576924		0	
	2.05841	0.0249007	1.209705		2.05841	
SL4-16	1.961469	0.0189671	0.966983	0.575208	0	1.995859
	1.958868	0.016881	0.861772		0	
	1.995859	0.0114803	0.575208		1.995859	
SL4-17	2.174311	0.0317947	1.462288	1.090532	0	2.177825
	2.177825	0.0237499	1.090532		2.177825	
	2.232408	0.0323853	1.450689		0	
SL4-18	2.578563	0.0313737	1.216714	0.755451	0	2.611581
	2.571069	0.0280675	1.091665		0	
	2.611581	0.0197292	0.755451		2.611581	
SL4-19	1.378641	0.0166515	1.207822	1.202603	0	1.376681
	1.376681	0.016556	1.202603		1.376681	
	1.456261	0.0207874	1.427452		0	
SL4-20	1.389355	0.0149516	1.076154	1.019347	0	1.476415
	1.392999	0.0147773	1.060825		0	
	1.476415	0.0150498	1.019347		1.476415	
SL4-21	1.510998	0.0179462	1.187704	1.187704	1.510998	1.510998
	1.505937	0.0200503	1.331418		0	
	1.580914	0.0237794	1.504155		0	
SL4-22	2.298858	0.0239167	1.040373	1.040373	2.298858	2.298858
	2.296858	0.0282671	1.230685		0	
	2.352475	0.0382984	1.628005		0	
SL4-23	1.440307	0.0238315	1.654615	1.124536	0	1.445398
	1.445398	0.016254	1.124536		1.445398	
	1.521721	0.0186502	1.225597		0	
SL4-24	1.946171	0.0118024	0.606444	0.606444	1.946171	1.946171
	1.946722	0.0134206	0.689392		0	
	2.02158	0.0189328	0.936533		0	
SL4-25	2.044699	0.0674742	3.299957	2.978711	0	2.102855
	2.0433	0.0753659	3.688439		0	
	2.102855	0.062638	2.978711		2.102855	

Table C.32 (Continued)

SL4-26	1.799629	0.0334219	1.857153	0.917439	0	1.85283
	1.793622	0.0290152	1.617689		0	
	1.85283	0.0169986	0.917439		1.85283	
SL4-27	1.477924	0.013654	0.923865	0.923865	1.477924	1.477924
	1.483003	0.0178636	1.204554		0	
	1.567056	0.0149638	0.954898		0	
SL4-28	1.686921	0.0271935	1.612019	0.933481	0	1.752143
	1.686114	0.0284691	1.688445		0	
	1.752143	0.0163559	0.933481		1.752143	
SL4-29	1.77035	0.0218086	1.231882	1.231882	1.77035	1.77035
	1.773422	0.0218851	1.234063		0	
	1.856138	0.0258496	1.392655		0	
SL4-30	1.950721	0.0312746	1.603235	1.359381	0	2.020268
	1.956079	0.0337913	1.727504		0	
	2.020268	0.0274631	1.359381		2.020268	
SL4-31	3.490185	0.08411	2.4099	2.11245	0	3.530624
	3.49478	0.0862184	2.467062		0	
	3.530624	0.0745827	2.11245		3.530624	
SL4-32	1.44807	0.0116621	0.805358	0.583588	0	1.453254
	1.453254	0.008481	0.583588		1.453254	
	1.538225	0.0133925	0.870647		0	
SL4-33	2.367712	0.0281931	1.19073	0.876177	0	2.376176
	2.376176	0.0208195	0.876177		2.376176	
	2.44701	0.0318863	1.303073		0	
SL4-34	2.124069	0.0032503	0.153024	0.153024	2.124069	2.124069
	2.121924	0.0090403	0.426043		0	
	2.195586	0.0093881	0.427592		0	
SL4-35	2.558192	0.0151539	0.592369	0.409055	0	2.563187
	2.563187	0.0104849	0.409055		2.563187	
	2.648008	0.0161689	0.610606		0	
SL4-36	2.327581	0.0332453	1.428322	1.315709	0	2.416165
	2.341176	0.0350149	1.495613		0	
	2.416165	0.0317897	1.315709		2.416165	
SL4-37	3.017413	0.0304065	1.0077	0.793285	0	3.021697
	3.021697	0.0239707	0.793285		3.021697	
	3.079758	0.0319103	1.03613		0	
SL4-38	4.766376	0.0799172	1.676687	1.000878	0	4.787171
	4.778965	0.0762157	1.594815		0	
	4.787171	0.0479137	1.000878		4.787171	

Table C.33 Ca ppm SL4

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
SL4-1	3.132493	0.0174813	0.558064	0.558064	3.132493	3.132493114	313.249311
	2.946134	0.0206825	0.702022		0		
SL4-2	2.716921	0.0171296	0.63048	0.57069	0	2.560492517	256.049252
	2.560493	0.0146125	0.57069		2.560493		
SL4-3	3.83312	0.0339169	0.884838	0.454596	0	3.641379556	364.137956
	3.64138	0.0165536	0.454596		3.64138		
SL4-4	3.963611	0.0279196	0.704399	0.704399	3.963611	3.963610842	396.361084
	3.778149	0.0375771	0.99459		0		
SL4-5	4.719988	0.0358089	0.758664	0.426688	0	4.516751882	451.675188
	4.516752	0.0192724	0.426688		4.516752		
SL4-6	3.747827	0.036001	0.960584	0.920378	0	3.514819062	351.481906
	3.514819	0.0323496	0.920378		3.514819		
SL4-7	3.992192	0.0470974	1.179738	1.026231	0	3.838434991	383.843499
	3.838435	0.0393912	1.026231		3.838435		
SL4-8	2.963595	0.0222774	0.7517	0.7517	2.963595	2.963595469	296.359547
	2.786954	0.0216124	0.775484		0		
SL4-9	3.801029	0.034722	0.91349	0.866116	0	3.582204982	358.220498
	3.582205	0.0310261	0.866116		3.582205		
SL4-10	2.481969	0.0005556	0.886119	0.234813	0	2.324822162	232.482216
	2.324822	0.005459	0.234813		2.324822		
SL4-11	3.320605	0.0212958	0.641324	0.641324	3.320605	3.32060532	332.060532
	3.137314	0.0570037	1.816959		0		
SL4-12	4.469761	0.0124169	0.277798	0.209866	0	4.303222798	430.32228
	4.303223	0.009031	0.209866		4.303223		

Table C.33 (Continued)

	3.617971	0.0252692	0.698436		3.617971		
SL4-13	3.440985	0.0415307	1.206944	0.698436	0	3.617970712	361.797071
	4.003802	0.0547292	1.36693		0		
SL4-14	3.799469	0.0168323	0.443018	0.443018	3.799469	3.799469327	379.946933
	3.122556	0.0298798	0.956901		0		
SL4-15	2.936419	0.0274393	0.934447	0.934447	2.936419	2.936418545	293.641854
	2.587757	0.0388511	1.501341		0		
SL4-16	2.435821	0.0358669	1.472478	1.472478	2.435821	2.435820945	243.582094
	1.276005	0.0021789	0.170758		1.276005		
SL4-17	1.208684	0.0076475	0.632714	0.170758	0	1.276005002	127.6005
	4.085886	0.0433003	1.059754		0		
SL4-18	3.874773	0.0119147	0.307493	0.307493	3.874773	3.874772808	387.477281
	3.116738	0.0426066	1.367026		0		
SL4-19	2.971819	0.0302293	1.017198	1.017198	2.971819	2.971819426	297.181943
	3.303825	0.0423153	1.280797		0		
SL4-20	3.095322	0.0180831	0.584208	0.584208	3.095322	3.095321752	309.532175
	2.480204	0.0194883	0.785754		0		
SL4-21	2.320369	0.0036922	0.159119	0.159119	2.320369	2.320369373	232.036937
	4.588504	0.0409018	0.891396		0		
SL4-22	4.361244	0.0132444	0.303684	0.303684	4.361244	4.36124351	436.124351
	2.53332	0.0100226	0.395631		2.53332		
SL4-23	2.399205	0.0179206	0.746941	0.395631	0	2.533319811	253.331981
	4.042068	0.0148181	0.366597		4.042068		
SL4-24	3.838142	0.0251265	0.654653	0.366597	0	4.042068297	404.20683
	2.894902	0.0088982	0.307376		2.894902		
SL4-25	2.715489	0.0258809	0.953086	0.307376	0	2.894902272	289.490227

Table C.33 (Continued)

SL4-26	2.908193	0.0407664	1.401776	0.917585	0	2.744589617	274.458962
	2.74459	0.0251839	0.917585		2.74459		
SL4-27	2.645146	0.019071	0.720983	0.720983	2.645146	2.64514626	264.514626
	2.466152	0.0246002	0.997512		0		
SL4-28	2.588167	0.0168593	0.6514	0.626984	0	2.444079345	244.407934
	2.444079	0.015324	0.626984		2.444079		
SL4-29	3.451146	0.049454	1.432973	0.74854	0	3.212324446	321.232445
	3.212324	0.0240455	0.74854		3.212324		
SL4-30	3.595173	0.0534014	1.485364	0.732336	0	3.384564401	338.45644
	3.384564	0.0247864	0.732336		3.384564		
SL4-31	4.754089	0.0260102	0.547113	0.234484	0	4.507283426	450.728343
	4.507283	0.0105689	0.234484		4.507283		
SL4-32	2.668423	0.0153866	0.576619	0.576619	2.668423	2.668423479	266.842348
	2.506718	0.0238116	0.949912		0		
SL4-33	4.489767	0.0622447	1.386369	1.357816	0	4.261555101	426.15551
	4.261555	0.0578641	1.357816		4.261555		
SL4-34	3.172714	0.0421212	1.327608	0.875834	0	2.997749031	299.774903
	2.997749	0.0262553	0.875834		2.997749		
SL4-35	4.880762	0.0383526	0.785791	0.785791	4.880762	4.88076184	488.076184
	4.667542	0.0764873	1.638706		0		
SL4-36	3.849	0.0564178	1.465778	0.430952	0	3.651462693	365.146269
	3.651463	0.015736	0.430952		3.651463		
SL4-37	4.460381	0.0314317	0.704686	0.704686	4.460381	4.460380912	446.038091
	4.294838	0.0416821	0.970517		0		
SL4-38	4.713195	0.0454165	0.963604	0.753396	0	4.510176234	451.017623
	4.510176	0.0339795	0.753396		4.510176		

Long Island Stalagmite LH4

Table C.34 Sr ppm LH4

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
LH4-1	0.150947	0.00536368	3.553344	1.138588	0	0.1470945
	0.144981	0.00188029	1.29692		0	
	0.147094	0.0016748	1.138588		0.147094	
LH4-2	0.128737	0.00441726	3.43124	0.772513	0	0.11806389
	0.116607	0.00148631	1.274638		0	
	0.118064	0.00091206	0.772513		0.118064	
LH4-3	0.258867	0.00595927	2.30206	0.390922	0	0.24077857
	0.239978	0.00107979	0.449957		0	
	0.240779	0.00094126	0.390922		0.240779	
LH4-4	0.252896	0.00479365	1.895503	0.93186	0	0.24168825
	0.241688	0.0022522	0.93186		0.241688	
	0.243612	0.00254516	1.044761		0	
LH4-5	0.280321	0.01003491	3.579794	1.209456	0	0.27395141
	0.273951	0.00331332	1.209456		0.273951	
	0.273646	0.00429688	1.570231		0	
LH4-6	0.225193	0.00530234	2.354574	1.174692	0	0.21812552
	0.218126	0.0025623	1.174692		0.218126	
	0.219582	0.00300948	1.370553		0	
LH4-7	0.175263	0.00642172	3.66405	0.942286	0	0.16753961
	0.165434	0.00225711	1.364352		0	
	0.16754	0.0015787	0.942286		0.16754	
LH4-8	0.132451	0.00138393	1.044855	1.044855	0.132451	0.1324514
	0.123649	0.00251137	2.031046		0	
	0.125253	0.00168412	1.34457		0	
LH4-9	0.219058	0.00565124	2.579796	0.203472	0	0.21223634
	0.210682	0.00061937	0.293982		0	
	0.212236	0.00043184	0.203472		0.212236	
LH4-10	0.201011	0.00817854	4.068698	1.029977	0	0.1917685
	0.190156	0.00255173	1.341917		0	
	0.191769	0.00197517	1.029977		0.191769	
LH4-11	0.199807	0.00424788	2.125992	1.249636	0	0.19122523
	0.189455	0.00253969	1.340527		0	
	0.191225	0.00238962	1.249636		0.191225	
LH4-12	0.149622	0.00428958	2.866941	1.419529	0	0.14526588
	0.145266	0.00206209	1.419529		0.145266	
	0.146466	0.00254399	1.73692		0	

Table C.34 (Continued)

LH4-13	0.229821	0.00489405	2.129506	0.875246	0	0.21800194
	0.218002	0.00190805	0.875246		0.218002	
	0.219542	0.00249444	1.136206		0	
LH4-14	0.274584	0.00495089	1.803054	1.051897	0	0.2611174
	0.260251	0.00316576	1.216429		0	
	0.261117	0.00274669	1.051897		0.261117	
LH4-15	0.149653	0.00395762	2.644531	1.456246	0	0.14503262
	0.144724	0.00225539	1.558404		0	
	0.145033	0.00211203	1.456246		0.145033	
LH4-16	0.169199	0.00296717	1.753654	0.863233	0	0.16437396
	0.16336	0.00157548	0.964423		0	
	0.164374	0.00141893	0.863233		0.164374	
LH4-17	0.219053	0.00318486	1.453921	0.242542	0	0.21023632
	0.209202	0.00091019	0.435074		0	
	0.210236	0.00050991	0.242542		0.210236	
LH4-18	0.232725	0.00711616	3.057761	1.352554	0	0.21746739
	0.217467	0.00294136	1.352554		0.217467	
	0.219361	0.00368112	1.678112		0	
LH4-19	0.228961	0.00614915	2.685676	0.228837	0	0.21551641
	0.215516	0.00049318	0.228837		0.215516	
	0.217514	0.00130693	0.600851		0	
LH4-20	0.1933	0.00208083	1.076477	0.80556	0	0.17894008
	0.177342	0.00148517	0.837462		0	
	0.17894	0.00144147	0.80556		0.17894	
LH4-21	0.196918	0.00136708	0.694238	0.694238	0.196918	0.19691815
	0.185232	0.00271953	1.46818		0	
	0.187052	0.00238664	1.27592		0	
LH4-22	0.179326	0.00601421	3.353778	0.442904	0	0.16674941
	0.165182	0.00161807	0.979566		0	
	0.166749	0.00073854	0.442904		0.166749	
LH4-23	0.179777	0.00474293	2.638233	0.667516	0	0.1744876
	0.172855	0.00130799	0.7567		0	
	0.174488	0.00116473	0.667516		0.174488	
LH4-24	0.289741	0.0017534	0.605164	0.605164	0.289741	0.28974064
	0.273752	0.00471032	1.720655		0	
	0.273725	0.00420889	1.537634		0	

Table C.34 (Continued)

LH4-25	0.18031	0.00594386	3.296474	0.071288	0	0.17384007
	0.173325	0.00055397	0.319611		0	
	0.17384	0.00012393	0.071288		0.17384	
LH4-26	0.22334	0.0018237	0.816561	0.816561	0.22334	0.22333978
	0.212909	0.0028219	1.325399		0	
	0.214097	0.00189369	0.884501		0	
LH4-27	0.18164	0.00520834	2.867394	0.309719	0	0.17185345
	0.170868	0.00089482	0.523691		0	
	0.171853	0.00777684	0.309719		0.171853	
LH4-28	0.189863	0.00477646	2.515737	0.258752	0	0.17747031
	0.17747	0.00045921	0.258752		0.17747	
	0.179398	0.00055735	0.31068		0	
LH4-29	0.202533	0.00118813	0.586637	0.317071	0	0.19194879
	0.190252	0.0007557	0.397209		0	
	0.191949	0.00060861	0.317071		0.191949	
LH4-30	0.219502	0.00597439	2.721791	0.750535	0	0.20604746
	0.206047	0.00154646	0.750535		0.206047	
	0.207563	0.00166213	0.800784		0	
LH4-31	0.272217	0.00169564	0.6229	0.6229	0.272217	0.27221652
	0.255615	0.00294544	1.152295		0	
	0.256634	0.00216162	0.842295		0	
LH4-32	0.257778	0.00716978	2.781375	1.288621	0	0.24701792
	0.245171	0.00365002	1.488762		0	
	0.247018	0.00318312	1.288621		0.247018	
LH4-33	0.200591	0.00127581	0.636026	0.636026	0.200591	0.20059089
	0.19004	0.00224434	1.18098		0	
	0.191928	0.00246969	1.286778		0	
LH4-34	0.184867	0.00802977	4.343548	0.562861	0	0.17444897
	0.174449	0.00098191	0.562861		0.174449	
	0.17559	0.00168835	0.961532		0	
LH4-35	0.206863	0.0090105	4.355789	1.104056	0	0.19055708
	0.190557	0.00210386	1.104056		0.190557	
	0.191752	0.002488	1.297511		0	
LH4-36	0.176426	0.00194851	1.104434	0.407627	0	0.16703924
	0.167039	0.0006809	0.407627		0.167039	
	0.169346	0.00149227	0.881192		0	

Table C.34 (Continued)

LH4-37	0.247048	0.00477999	1.93484	1.009218	0	0.22835666
	0.225806	0.00335012	1.483625		0	
	0.228357	0.00230462	1.009218		0.228357	
LH4-38	0.277189	0.0030385	1.096184	0.467682	0	0.26522535
	0.265225	0.00124041	0.467682		0.265225	
	0.266312	0.00200931	0.754495		0	
LH4-39	0.29518	0.0071618	2.426245	1.817232	0	0.27905906
	0.279076	0.00620598	2.22376		0	
	0.279059	0.00507115	1.817232		0.279059	
LH4-40	0.224728	0.00482349	2.146369	0.334767	0	0.21817115
	0.218171	0.00073036	0.334767		0.218171	
	0.219863	0.00191748	0.872123		0	
LH4-41	0.226145	0.01006967	4.452745	0.910155	0	0.20847109
	0.208471	0.00189741	0.910155		0.208471	
	0.210257	0.00197399	0.938847		0	
LH4-42	0.279371	0.00147088	0.526496	0.526496	0.279371	0.27937082
	0.262261	0.00228782	0.872343		0	
	0.263557	0.0028059	1.064626		0	
LH4-43	0.235572	0.00598147	2.53913	0.21441	0	0.22108896
	0.219207	0.00149615	0.682529		0	
	0.221089	0.00047404	0.21441		0.221089	
LH4-44	0.203028	0.00294335	1.44973	0.514396	0	0.19614158
	0.193623	0.00059399	0.804569		0	
	0.196142	0.00023266	0.514396		0.196142	
LH4-45	0.24812	0.00311999	1.257453	0.994775	0	0.23326576
	0.233266	0.00232047	0.994775		0.233266	
	0.2349	0.00265758	1.131366		0	
LH4-46	0.181451	0.0009019	0.497051	0.497051	0.181451	0.18145104
	0.172625	0.00087603	0.507476		0	
	0.174375	0.00131159	0.752169		0	
LH4-47	0.244365	0.00342008	1.399577	0.895704	0	0.23317905
	0.231027	0.00284475	1.231347		0	
	0.233179	0.00208859	0.895704		0.233179	

Table C.35 Mg ppm LH4

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
	1.818234	0.0300265	1.65141		0	
LH4-1	1.799724	0.03263795	1.813498	0.956592	0	1.92341189
	1.923412	0.01839921	0.956592		1.923412	
	0.922465	0.01059905	1.148993		0	
LH4-2	0.935319	0.01001017	1.070241	0.424816	0	1.04682751
	1.046828	0.00444709	0.424816		1.046828	
	2.402374	0.01061232	0.441743		0	
LH4-3	2.373062	0.00856424	0.360894	0.337564	0	2.52445201
	2.524452	0.00852164	0.337564		2.524452	
	3.116947	0.0341074	1.094257		0	
LH4-4	3.084202	0.03361794	1.090005	1.009959	0	3.22007304
	3.220073	0.03252142	1.009959		3.220073	
	3.908405	0.04588392	1.173981		3.908405	
LH4-5	3.863427	0.05514832	1.427446	1.173981	0	3.90840485
	4.003762	0.06529235	1.630775		0	
	3.182501	0.02941512	0.924277		3.182501	
LH4-6	3.138202	0.03383833	1.078271	0.924277	0	3.18250063
	3.26438	0.03086188	0.945413		0	
	1.716187	0.02656558	1.547942		0	
LH4-7	1.70611	0.02427679	1.422932	1.022946	0	1.84038383
	1.840384	0.01882614	1.022946		1.840384	
	0.857907	0.01922252	2.240629		0	
LH4-8	0.869358	0.01717311	1.97538	1.432553	0	0.97391406
	0.973914	0.01395183	1.432553		0.973914	
	1.387776	0.01008679	0.726831		0	
LH4-9	1.37956	0.00492323	0.35687	0.173971	0	1.52867943
	1.528679	0.00265946	0.173971		1.528679	
	1.632025	0.01812871	1.110811		0	
LH4-10	1.614558	0.01852884	1.147611	1.057008	0	1.77261133
	1.772611	0.01873665	1.057008		1.772611	
	1.601178	0.01888609	1.179512		0	
LH4-11	1.588087	0.01975854	1.244172	0.866835	0	1.7381876
	1.738188	0.01506723	0.866835		1.738188	
	1.086187	0.01664278	1.532221		0	
LH4-12	1.097397	0.0218497	1.991049	1.394288	0	1.22132033
	1.22132	0.01702873	1.394288		1.22132	

Table C.35 (Continued)

LH4-13	2.326293	0.02161526	0.929172	0.649955	0	2.31410914
	2.314109	0.01504066	0.649955		2.314109	
	2.467191	0.03174159	1.286547		0	
LH4-14	2.914101	0.0510803	1.752867	1.044299	0	3.02512342
	2.880722	0.03647936	1.266327		0	
	3.025123	0.03159133	1.044299		3.025123	
LH4-15	1.071375	0.01364828	1.273903	0.709826	0	1.20538529
	1.082265	0.00955816	0.883162		0	
	1.205385	0.00855613	0.709826		1.205385	
LH4-16	1.677215	0.01354785	0.807759	0.578764	0	1.80927483
	1.667751	0.01441117	0.864108		0	
	1.809275	0.01047143	0.578764		1.809275	
LH4-17	2.512709	0.01633393	0.650052	0.604443	0	2.4845339
	2.484534	0.01501758	0.604443		2.484534	
	2.619902	0.01972747	0.752985		0	
LH4-18	1.923283	0.03844117	1.998726	1.394092	0	2.04470288
	1.902728	0.03984865	2.094291		0	
	2.044703	0.02850503	1.394092		2.044703	
LH4-19	2.046264	0.01306872	0.638662	0.222005	0	2.17449363
	2.032227	0.01183839	0.582533		0	
	2.174494	0.00482749	0.222005		2.174494	
LH4-20	1.564949	0.01123745	0.718072	0.718072	1.564949	1.5649487
	1.55664	0.01443814	0.927519		0	
	1.69265	0.01347581	0.796137		0	
LH4-21	1.585022	0.01920937	1.211931	0.950425	0	1.70770941
	1.573556	0.01825564	1.160152		0	
	1.707709	0.0162305	0.950425		1.707709	
LH4-22	1.475506	0.01822577	1.235221	0.459626	0	1.58800289
	1.466005	0.01062461	0.724732		0	
	1.588003	0.00729887	0.459626		1.588003	
LH4-23	2.091652	0.01801223	0.861149	0.491954	0	2.21261635
	2.080245	0.0121368	0.583431		0	
	2.212616	0.01088505	0.491954		2.212616	
LH4-24	2.511702	0.04193704	1.669666	1.39893	0	2.48597548
	2.485975	0.03477705	1.39893		2.485975	
	2.623721	0.03789	1.444132		0	

Table C.35 (Continued)

LH4-25	1.810022	0.00700961	0.387266	0.3046	0	1.7927101
	1.79271	0.00546059	0.3046		1.79271	
	1.923569	0.01767655	0.918945		0	
LH4-26	2.264133	0.03636751	1.606244	1.596119	0	2.38159486
	2.249461	0.04159991	1.849328		0	
	2.381595	0.03801309	1.596119		2.381595	
LH4-27	1.787656	0.01208673	0.676122	0.409532	0	1.89895692
	1.776989	0.01393849	0.784388		0	
	1.898957	0.00777684	0.409532		1.898957	
LH4-28	2.119566	0.01837102	0.866735	0.740782	0	2.10572972
	2.10573	0.01559887	0.740782		2.10573	
	2.213119	0.0197964	0.894502		0	
LH4-29	2.348428	0.00508073	0.216346	0.216346	2.348428	2.34842758
	2.334402	0.01117972	0.478911		0	
	2.450239	0.00842022	0.343649		0	
LH4-30	2.236562	0.01834629	0.82029	0.667891	0	2.22409318
	2.224093	0.01485451	0.667891		2.224093	
	0.024037	0.02403699	1.021168		0	
LH4-31	2.063109	0.0240737	1.166865	1.08954	0	2.05112839
	2.051128	0.02234787	1.08954		2.051128	
	2.172346	0.02799433	1.288668		0	
LH4-32	3.035186	0.04652524	1.532863	1.442184	0	3.12553521
	3.012924	0.04891595	1.623537		0	
	3.125535	0.04507597	1.442184		3.125535	
LH4-33	2.403314	0.03107809	1.293135	1.132187	0	2.39073327
	2.390733	0.02706758	1.132187		2.390733	
	2.490728	0.03040825	1.220858		0	
LH4-34	2.441342	0.01047491	0.429064	0.429064	2.441342	2.44134165
	2.424504	0.0209097	0.862432		0	
	2.509037	0.01651583	0.658254		0	
LH4-35	2.163364	0.02786438	1.288011	1.288011	2.163364	2.16336431
	2.145271	0.02969733	1.384316		0	
	2.249136	0.03616888	1.608124		0	
LH4-36	2.023366	0.01353246	0.668809	0.398033	0	2.1193431
	2.011827	0.00987321	0.490759		0	
	2.119343	0.00843569	0.398033		2.119343	

Table C.35 (Continued)

LH4-37	2.093218	0.03505381	1.674637	1.01557	0	2.2126466
	2.082306	0.0322381	1.548192		0	
	2.212647	0.02247098	1.01557		2.212647	
LH4-38	2.354761	0.00936873	0.397863	0.397863	2.354761	2.3547613
	2.344186	0.0105715	0.450967		0	
	2.464036	0.01545032	0.627033		0	
LH4-39	2.286693	0.04906382	2.145624	1.598777	0	2.39725373
	2.275041	0.04116218	1.809294		0	
	2.397254	0.03832674	1.598777		2.397254	
LH4-40	2.231581	0.01918033	0.859495	0.513288	0	2.33778214
	2.225568	0.0229391	1.030708		0	
	2.337782	0.01199954	0.513288		2.337782	
LH4-41	2.845204	0.0365878	1.285947	1.028432	0	2.92480656
	2.823259	0.03173252	1.123968		0	
	2.924807	0.03007965	1.028432		2.924807	
LH4-42	3.221508	0.04747073	1.473556	0.708767	0	3.29322295
	3.197464	0.03942992	1.233162		0	
	3.293223	0.02334129	0.708767		3.293223	
LH4-43	2.451216	0.00695495	0.283735	0.283735	2.451216	2.4512159
	2.443815	0.00773282	0.316424		0	
	2.554615	0.0165997	0.649793		0	
LH4-44	1.858936	0.01568147	0.843572	0.514396	0	1.95927918
	1.85697	0.01494061	0.804569		0	
	1.959279	0.01007845	0.514396		1.959279	
LH4-45	2.090499	0.03647945	1.745012	0.876568	0	2.18631741
	2.085969	0.02818777	1.351304		0	
	2.186317	0.01916456	0.876568		2.186317	
LH4-46	1.541452	0.01666925	1.081399	0.955522	0	1.53935064
	1.539351	0.01470884	0.955522		1.539351	
	1.649781	0.01736718	1.052696		0	
LH4-47	2.359981	0.02575966	1.09152	0.797366	0	2.44785893
	2.351537	0.02140962	0.910452		0	
	2.447859	0.01951839	0.797366		2.447859	

Table C.36 Ca ppm LH4

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
LH4-1	1.40239	0.0147883	1.054506	0.638442	0	1.417177676	141.717768
	1.417178	0.00904786	0.638442		1.417178		
LH4-2	1.365135	0.0333509	2.443047	1.201476	0	1.399454389	139.945439
	1.399454	0.01681411	1.201476		1.399454		
LH4-3	2.361323	0.04803234	2.034129	0.737193	0	2.356523383	235.652338
	2.356523	0.01737213	0.737193		2.356523		
LH4-4	2.308723	0.03988584	1.727615	1.727615	2.308723	2.308722897	230.87229
	2.299003	0.04888677	2.126433		0		
LH4-5	2.774372	0.08728759	3.146211	0.611536	0	2.778819156	277.881916
	2.778819	0.01699348	0.611536		2.778819		
LH4-6	2.045157	0.0126853	0.620261	0.313947	0	2.060284301	206.02843
	2.060284	0.00646819	0.313947		2.060284		
LH4-7	1.478345	0.02489666	1.68409	0.111512	0	1.511077198	151.10772
	1.511077	0.00168504	0.111512		1.511077		
LH4-8	1.213166	0.01524133	1.256326	0.58789	0	1.228943065	122.894307
	1.228943	0.00722484	0.58789		1.228943		
LH4-9	2.232023	0.04507477	2.019458	1.905434	0	2.258651667	225.865167
	2.258652	0.04303712	1.905434		2.258652		
LH4-10	2.132231	0.046651	2.187897	2.050664	0	2.139821819	213.982182
	2.139822	0.04388056	2.050664		2.139822		
LH4-11	2.11355	0.03022875	1.430236	0.676262	0	2.112805637	211.280564
	2.112806	0.01428809	0.676262		2.112806		
LH4-12	1.429163	0.01753397	1.22687	0.193197	0	1.443315882	144.331588
	1.443316	0.00278845	0.193197		1.443316		

Table C.36 (Continued)

LH4-13	2.007511	0.02744416	1.367074	1.367074	2.007511	2.007510965	200.751096
	2.015686	0.04056737	2.012584		0		
LH4-14	2.537602	0.04280161	1.686695	1.033534	0	2.543908424	254.390842
	2.543908	0.02629216	1.033534		2.543908		
LH4-15	1.443049	0.02650862	1.836987	1.3251	0	1.45909819	145.909819
	1.459098	0.01933452	1.3251		1.459098		
LH4-16	1.21227	0.02050169	1.691181	0.7255	0	1.222497137	122.249714
	1.222497	0.00886921	0.7255		1.222497		
LH4-17	1.807322	0.0523051	2.894066	0.424951	0	1.81229678	181.229678
	1.812297	0.00770137	0.424951		1.812297		
LH4-18	1.987662	0.04301663	2.164182	0.968875	0	1.98868278	198.868278
	1.988683	0.01926786	0.968875		1.988683		
LH4-19	1.993567	0.03303105	1.656882	0.661717	0	2.000624094	200.062409
	2.000624	0.01323848	0.661717		2.000624		
LH4-20	1.599571	0.01768883	1.105849	0.29539	0	1.631304202	163.13042
	1.631304	0.0048187	0.29539		1.631304		
LH4-21	1.559022	0.02043325	1.310645	0.847772	0	1.577502175	157.750217
	1.577502	0.01337363	0.847772		1.577502		
LH4-22	1.295697	0.02829188	2.183526	0.540617	0	1.325169162	132.516916
	1.325169	0.0071641	0.540617		1.325169		
LH4-23	1.541256	0.03122061	2.02566	0.618918	0	1.574224134	157.422413
	1.574224	0.00974315	0.618918		1.574224		
LH4-24	2.233466	0.01645034	0.736539	0.736539	2.233466	2.23346573	223.346573
	2.243453	0.03118037	1.389839		0		

Table C.36 (Continued)

	1.639586	0.02935006	1.79009		0		
LH4-25	1.67878	0.01696777	1.010721	1.010721	1.67878	1.678779899	167.87799
	1.98555	0.04590487	2.311947		0		
LH4-26	1.995589	0.03638429	1.823236	1.823236	1.995589	1.995588772	199.558877
	1.649823	0.03340998	2.025065		0		
LH4-27	1.700016	0.00629138	0.370078	0.370078	1.700016	1.700016157	170.001616
	1.718276	0.02568288	1.494689		0		
LH4-28	1.751346	0.01032153	0.589348	0.589348	1.751346	1.751345701	175.13457
	1.790944	0	1.207037		0		
LH4-29	1.792235	0.01009191	0.563091	0.563091	1.792235	1.792234728	179.223473
	1.876284	0.03770527	2.009572		0		
LH4-30	1.896528	0.01951559	1.029017	1.029017	1.896528	1.896527602	189.65276
	1.521802	0.02283326	1.500409		0		
LH4-31	1.553268	0.00651943	0.419723	0.419723	1.553268	1.553267884	155.326788
	1.910034	0.04689015	2.454938		0		
LH4-32	1.921343	0.00663186	0.345168	0.345168	1.921343	1.921342775	192.134277
	1.728249	0.03344627	1.93527		0		
LH4-33	1.756693	0.01003867	0.571453	0.571453	1.756693	1.756693265	175.669327
	1.469083	0.02842891	1.935147		0		
LH4-34	1.50371	0.01147619	0.763192	0.763192	1.50371	1.503710364	150.371036
	1.655311	0.01628802	0.983986		0		
LH4-35	1.668889	0.00379865	0.227616	0.227616	1.668889	1.668888996	166.8889
	1.466779	0.01752	1.194454		0		
LH4-36	1.482467	0.00022159	0.014948	0.014948	1.482467	1.482467377	148.246738

Table C.36 (Continued)

	1.929042	0.04099719	2.125262		0		
LH4-37	1.929498	0.02849256	1.476682	1.476682	1.929498	1.9294982	192.94982
	2.201354	0.03155968	1.433649		2.201354		
LH4-38	2.188656	0.04988822	2.2794	1.433649	0	2.201353866	220.135387
	1.959021	0.03821401	1.950669		0		
LH4-39	1.950416	0.02224827	1.140694	1.140694	1.950416	1.950415556	195.041556
	1.980418	0.03271175	1.65176		0		
LH4-40	2.001996	0.01529174	0.763824	0.763824	2.001996	2.001996248	200.199625
	1.897151	0.03193062	1.683083		0		
LH4-41	1.91108	0.01581904	0.827754	0.827754	1.91108	1.911080246	191.108025
	2.495584	0.03714828	1.48856		0		
LH4-42	2.496919	0.03298183	1.320901	1.320901	2.496919	2.4969195	249.69195
	2.116272	0.02533873	1.197329		2.116272		
LH4-43	2.15092	0.02704681	1.257453	1.197329	0	2.116271523	211.627152
	1.889001	0.04565996	2.417149		0		
LH4-44	1.894969	0.00827965	0.436928	0.436928	1.894969	1.894969244	189.496924
	2.212529	0.02995927	1.354073		0		
LH4-45	2.209123	0.01276958	0.578039	0.578039	2.209123	2.20912327	220.912327
	1.829371	0.01893154	1.034866		0		
LH4-46	1.846324	0.01295434	0.701629	0.701629	1.846324	1.84632414	184.632414
	2.391877	0.06133794	2.564427		0		
LH4-47	2.373403	0.02359251	0.994037	0.994037	2.373403	2.373403375	237.340338

Bahamian Cave Rock Data

Abaco Hole in the Wall Cave Rock

Table C.37 Sr ppm Hole in the Wall Cave rock

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
AH2A (wall)	0.888519	0.009229	1.038713	0.792066	0	0.890872
	0.904464	0.008357	0.924006		0	
	0.890872	0.007056	0.792066		0.890872	
AH2B (wall)	1.020801	0.009536	0.934123	0.934123	1.020801	1.020801
	1.058163	0.018734	1.770383		0	
	1.041249	0.014789	1.420288		0	
AH2C (wall)	1.0824	0.00614	0.567291	0.567291	1.0824	1.0824
	1.122769	0.006752	0.601353		0	
	1.105074	0.008266	0.747982		0	
AH3A (ceiling)	0.82198	0.012356	1.5032	1.109597	0	0.840769
	0.840769	0.009329	1.109597		0.840769	
	0.826469	0.009439	1.142148		0	
AH3B (ceiling)	1.219353	0.004277	0.350779	0.350779	1.219353	1.219353
	1.262728	0.006592	0.522064		0	
	1.245987	0.005789	0.464636		0	
AH3C (ceiling)	0.783293	0.006355	0.81131	0.768443	0	0.788397
	0.788397	0.006058	0.768443		0.788397	
	0.777698	0.006176	0.794089		0	
AH5A (wall)	0.481122	0.009198	1.911772	1.340378	0	0.469989
	0.469989	0.0063	1.340378		0.469989	
	0.46405	0.006233	1.343201		0	
AH5B (wall)	0.648423	0.012777	1.970453	0.658775	0	0.651741
	0.651741	0.004294	0.658775		0.651741	
	0.642584	0.005499	0.855781		0	
AH5C (wall)	0.709818	0.009558	1.346562	1.346562	0.709818	0.709818
	0.71602	0.009793	1.367677		0	
	0.707163	0.010305	1.457297		0	

Table C.37 (Continued)

AH6A (ceiling)	1.19874	0.016445	1.37185	1.37185	1.19874	1.19874
	1.225322	0.019884	1.622739		0	
	1.210007	0.020604	1.702778		0	
AH6B (ceiling)	1.578313	0.019478	1.234073	1.120522	0	1.641184
	1.641184	0.01839	1.120522		1.641184	
	1.621151	0.01873	1.15536		0	
AH6C (ceiling)	1.564956	0.02496	1.594906	1.089534	0	1.640989
	1.640989	0.017879	1.089534		1.640989	
	1.618724	0.018613	1.149871		0	
AH7A (surface)	0.890487	0.005479	0.615277	0.615277	0.890487	0.890487
	0.910234	0.011074	1.216565		0	
	0.897156	0.011635	1.296915		0	
AH7B (surface)	0.865251	0.00849	0.981229	0.981229	0.865251	0.865251
	0.877605	0.012216	1.392006		0	
	0.866011	0.012318	1.422395		0	
AH7C (surface)	0.644966	0.00619	0.95974	0.95974	0.644966	0.644966
	0.650411	0.007679	1.180589		0	
	0.640882	0.006914	1.07887		0	
AH8A (surface)	0.547505	0.000749	0.136786	0.136786	0.547505	0.547505
	0.538705	0.004376	0.81225		0	
	0.531349	0.0029	0.545817		0	
AH8B (surface)	0.943908	0.012068	1.278476	0.683762	0	0.94308
	0.955233	0.00682	0.713971		0	
	0.94308	0.006448	0.683762		0.94308	
AH8C (surface)	0.604777	0.004503	0.744531	0.641353	0	0.609961
	0.609961	0.003912	0.641353		0.609961	
	0.602968	0.004192	0.695234		0	
AH10A (ceiling)	0.995691	0.01418	1.424161	0.894046	0	1.013663
	1.013663	0.009063	0.894046		1.013663	
	1.002544	0.009462	0.943838		0	
AH10B (ceiling)	0.802652	0.010445	1.301293	1.301293	0.802652	0.802652
	0.814436	0.017491	2.147573		0	
	0.805809	0.018264	2.266513		0	
AH10C (ceiling)	0.983811	0.014114	1.434587	1.434587	0.983811	0.983811
	1.000795	0.014396	1.438471		0	
	0.987989	0.014835	1.501488		0	

Table C.38 Mg ppm Hole in the Wall Cave rock

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
AH2A (wall)	5.865386	0.070618	1.203984	0.321669	0	5.833604
	5.861579	0.066104	1.12775		0	
	5.833604	0.018765	0.321669		5.833604	
AH2B (wall)	7.111696	0.155538	2.187069	1.432911	0	7.01291
	7.085026	0.130349	1.839781		0	
	7.01291	0.100489	1.432911		7.01291	
AH2C (wall)	7.052715	0.061325	0.869526	0.869526	7.052715	7.052715
	7.056461	0.085591	1.212942		0	
	6.966983	0.063588	0.91271		0	
AH3A (ceiling)	5.773574	0.053444	0.925665	0.676881	0	5.684615
	5.756745	0.070234	1.220032		0	
	5.684615	0.038478	0.676881		5.684615	
AH3B (ceiling)	8.405267	0.065973	0.784905	0.390886	0	8.409643
	8.463497	0.038413	0.453871		0	
	8.409643	0.032872	0.390886		8.409643	
AH3C (ceiling)	5.278958	0.059117	1.119857	0.931485	0	5.266979
	5.271386	0.068806	1.30528		0	
	5.266979	0.049061	0.931485		5.266979	
AH5A (wall)	6.535525	0.054128	0.828219	0.828219	6.535525	6.535525
	6.540928	0.073124	1.117953		0	
	6.43703	0.079072	1.228395		0	
AH5B (wall)	9.30202	0.074757	0.803668	0.803668	9.30202	9.30202
	9.327833	0.095429	1.023058		0	
	9.14248	0.094691	1.035728		0	
AH5C (wall)	7.807583	0.09868	1.263897	1.263897	7.807583	7.807583
	7.84213	0.108557	1.384281		0	
	7.636062	0.103448	1.354732		0	

Table C.38 (Continued)

AH6A (ceiling)	20.06	0.340135	1.695868	1.695868	20.0567	20.0567
	20.62	0.394049	1.911459		0	
	20.48	0.359432	1.755452		0	
AH6B (ceiling)	19.85	0.229144	1.154616	1.154616	19.84589	19.84589
	20.43	0.267818	1.3108		0	
	20.25	0.248069	1.225196		0	
AH6C (ceiling)	22.87	0.254362	1.11223	1.11223	22.86954	22.86954
	23.62	0.2799	1.184888		0	
	23.32	0.259949	1.114611		0	
AH7A (surface)	4.922517	0.058564	1.189724	0.845988	0	4.877264
	4.910377	0.053649	1.092559		0	
	4.877264	0.041261	0.845988		4.877264	
AH7B (surface)	6.069862	0.100531	1.656226	1.445261	0	5.944203
	6.057867	0.09239	1.525129		0	
	5.944203	0.085909	1.445261		5.944203	
AH7C (surface)	4.145027	0.05896	1.422433	0.861512	0	4.108734
	4.130307	0.047637	1.153355		0	
	4.108734	0.035397	0.861512		4.108734	
AH8A (surface)	4.216798	0.045158	1.070911	0.535902	0	4.189912
	4.203066	0.029722	0.707154		0	
	4.189912	0.022454	0.535902		4.189912	
AH8B (surface)	5.210005	0.011817	0.226821	0.226821	5.210005	5.210005
	5.200881	0.011879	0.22841		0	
	5.161519	0.027715	0.536946		0	
AH8C (surface)	5.560431	0.064646	1.162603	0.754784	0	5.469181
	5.555979	0.046838	0.843014		0	
	5.469181	0.04128	0.754784		5.469181	
AH10A (ceiling)	9.817577	0.125491	1.278227	0.883308	0	9.679095
	9.878049	0.119325	1.207983		0	
	9.679095	0.085496	0.883308		9.679095	
AH10B (ceiling)	9.477083	0.187585	1.979352	1.979352	9.477083	9.477083
	9.541123	0.215565	2.259324		0	
	9.289876	0.199584	2.148403		0	
AH10C (ceiling)	10.54	0.118778	1.126549	1.126549	10.54352	10.54352
	10.63	0.130032	1.223706		0	
	10.38	0.14611	1.407161		0	

Table C.39 Ca ppm Hole in the Wall Cave rock

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
AH2A (wall)	1.756432	0.036457	2.075608	0.642818	0	1.78067935	178.067935
	1.780679	0.011447	0.642818		1.780679		
AH2B (wall)	2.178458	0.064153	2.944903	2.378794	0	2.197745415	219.774541
	2.197745	0.05228	2.378794		2.197745		
AH2C (wall)	2.281097	0.015236	0.667908	0.667908	2.281097	2.28109721	228.109721
	2.284213	0.041713	1.826131		0		
AH3A (ceiling)	1.709146	0.006048	0.353884	0.34792	0	1.750663761	175.066376
	1.750664	0.006091	0.34792		1.750664		
AH3B (ceiling)	2.558076	0.058484	2.286231	0.534573	0	2.526332967	252.633297
	2.526333	0.013505	0.534573		2.526333		
AH3C (ceiling)	1.591072	0.034347	2.158762	0.475593	0	1.597699479	159.769948
	1.597699	0.007599	0.475593		1.597699		
AH5A (wall)	1.329551	0.02124	1.597544	0.453962	0	1.342619482	134.261948
	1.342619	0.006095	0.453962		1.342619		
AH5B (wall)	1.506516	0.018837	1.250398	1.021109	0	1.504992472	150.499247
	1.504992	0.015368	1.021109		1.504992		
AH5C (wall)	3.211203	0.038911	1.211737	1.076024	0	3.21606287	321.606287
	3.216063	0.034606	1.076024		3.216063		

Table C.39 (Continued)

AH6A (ceiling)	3.563352	0.069734	1.956967	1.956967	3.563352	3.563351622	356.335162
	3.624875	0.110196	3.04		0		
AH6B (ceiling)	4.609197	0.130362	2.828297	0.863039	0	4.626436635	462.643663
	4.626437	0.039928	0.863039		4.626437		
AH6C (ceiling)	4.704524	0.060219	1.280031	1.176114	0	4.727638669	472.763867
	4.727639	0.055602	1.176114		4.727639		
AH7A (surface)	3.482146	0.070709	2.030625	2.030625	3.482146	3.482146018	348.214602
	3.544464	0.075742	2.136914		0		
AH7B (surface)	4.031029	0.06023	1.494151	1.494151	4.031029	4.031029047	403.102905
	4.112757	0.074018	1.799729		0		
AH7C (surface)	3.257202	0.057844	1.775872	1.33815	0	3.266025027	326.602503
	3.266025	0.043704	1.33815		3.266025		
AH8A (surface)	3.063038	0.062332	2.034979	1.895927	0	3.058934385	305.893439
	3.058934	0.057995	1.895927		3.058934		
AH8B (surface)	3.635045	0.097405	2.679596	1.680667	0	3.652354466	365.235447
	3.652354	0.061384	1.680667		3.652354		
AH8C (surface)	4.288573	0.061801	1.441068	1.441068	4.288573	4.288572941	428.857294
	4.349766	0.064024	1.4719		0		
AH10A (ceiling)	4.138349	0.0129	0.311711	0.311711	4.138349	4.138348892	413.834889
	4.017423	0.028908	0.719557		0		
AH10B (ceiling)	3.650526	0.013329	0.365133	0.365133	3.650526	3.650526276	365.052628
	3.521241	0.028587	0.811853		0		
AH10C (ceiling)	4.467543	0.012243	0.274039	0.274039	4.467543	4.467543097	446.75431
	4.343409	0.020801	0.478913		0		

Abaco Roadside Cave Rock

Table C.40 Sr ppm Roadside Cave rock

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
AR2A (wall)	2.163274	0.018779	0.868065	0.868065	2.163274	2.163274
	2.279321	0.024055	1.055379		0	
	2.248353	0.024115	1.072568		0	
AR2B (wall)	1.695864	0.02588	1.526064	1.526064	1.695864	1.695864
	1.766347	0.03617	2.047737		0	
	1.742056	0.033245	1.908386		0	
AR2C (wall)	1.552332	0.005974	0.384861	0.384861	1.552332	1.552332
	1.603552	0.008837	0.551094		0	
	1.584818	0.009122	0.575569		0	
AR3A (ceiling)	1.455569	0.019466	1.337327	1.337327	1.455569	1.455569
	1.512313	0.023349	1.543938		0	
	1.48713	0.021945	1.475681		0	
AR3B (ceiling)	1.113333	0.003505	0.314841	0.314841	1.113333	1.113333
	1.138775	0.006881	0.604232		0	
	1.124966	0.009228	0.820332		0	
AR3C (ceiling)	1.550618	0.011703	0.754715	0.381672	0	1.608922
	1.608922	0.006141	0.381672		1.608922	
	1.587547	0.006486	0.408554		0	

Table C.41 Mg ppm Roadside Cave rock

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
AR2A (wall)	10.06	0.092058	0.914794	0.914794	10.06324	10.06324
	10.14	0.105577	1.040786		0	
	9.97	0.113025	1.134124		0	
AR2B (wall)	8.197106	0.195232	2.381714	1.907145	0	8.053888
	8.241925	0.198087	2.403412		0	
	8.053888	0.153599	1.907145		8.053888	
AR2C (wall)	7.099592	0.057655	0.812089	0.654084	0	7.028743
	7.131846	0.068215	0.956482		0	
	7.028743	0.045974	0.654084		7.028743	
AR3A (ceiling)	10.14	0.144981	1.42964	1.335947	0	10.18143
	10.18	0.136019	1.335947		10.18143	
	9.91	0.16705	1.685108		0	
AR3B (ceiling)	7.985533	0.063951	0.800834	0.800834	7.985533	7.985533
	8.036905	0.078439	0.975987		0	
	7.845408	0.081555	1.039524		0	
AR3C (ceiling)	11.80	0.046011	0.389946	0.365464	0	11.92265
	11.92	0.043573	0.365464		11.92265	
	11.68	0.043586	0.373208		0	

Table C.42   Ca ppm Roadside Cave rock

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
AR2A (wall)	5.179438	0.043607	0.841934	0.558586	0	4.934826	493.4825802
	4.934826	0.027565	0.558586		4.934826		
AR2B (wall)	3.866608	0.037366	0.966381	0.723298	0	3.719129	371.9128779
	3.719129	0.0269	0.723298		3.719129		
AR2C (wall)	1.632799	0.010789	0.660745	0.520668	0	1.563791	156.3791164
	1.563791	0.008142	0.520668		1.563791		
AR3A (ceiling)	3.984536	0.046744	1.17313	1.17313	3.984536	3.984536	398.4535571
	3.751992	0.060148	1.603105		0		
AR3B (ceiling)	3.719604	0.061927	1.664878	0.492993	0	3.51921	351.920976
	3.51921	0.017349	0.492993		3.51921		
AR3C (ceiling)	4.531691	0.079579	1.756061	0.2106	0	4.387511	438.7510622
	4.387511	0.00924	0.2106		4.387511		

San Salvador Light House Cave Rock

Table C.43 Sr ppm Light House Cave rock

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
SL2A (wall)	1.618255	0.031037	1.917923	1.315487	0	1.680151
	1.680151	0.022102	1.315487		1.680151	
	1.66027	0.022194	1.336767		0	
SL2B (wall)	1.399554	0.022335	1.595871	0.920941	0	1.431182
	1.450779	0.013394	0.92325		0	
	1.431182	0.01318	0.920941		1.431182	
SL2C (wall)	1.116257	0.008696	0.779029	0.524153	0	1.154167
	1.154167	0.00605	0.524153		1.154167	
	1.139175	0.007136	0.626426		0	
SL3A (ceiling)	1.956831	0.026552	1.356904	0.768248	0	2.050733
	2.050733	0.015755	0.768248		2.050733	
	2.022737	0.019947	0.986158		0	
SL3B (ceiling)	2.048462	0.019876	0.970266	0.970266	2.048462	2.048462
	2.136246	0.02538	1.188051		0	
	2.107358	0.023373	1.109119		0	
SL3C (ceiling)	3.224822	0.011449	0.355019	0.355019	3.224822	3.224822
	3.407697	0.012632	0.370701		0	
	3.367807	0.012458	0.369922		0	
SL5A (wall)	1.238602	0.019453	1.570542	0.853648	0	1.270262
	1.270262	0.010844	0.853648		1.270262	
	1.25425	0.011819	0.942339		0	
SL5B (wall)	0.939728	0.005132	0.546126	0.259843	0	0.945262
	0.957081	0.003264	0.341026		0	
	0.945262	0.002456	0.259843		0.945262	
SL5C (wall)	1.833082	0.011886	0.648408	0.389545	0	1.890876
	1.91373	0.008641	0.451513		0	
	1.890876	0.007366	0.389545		1.890876	

Table C.43 (Continued)

SL6A (ceiling)	2.013818	0.013303	0.660593	0.660593	2.013818	2.013818
	2.102102	0.023942	1.138934		0	
	2.071303	0.022887	1.104979		0	
SL6B (ceiling)	2.6018	0.03327	1.278715	1.278715	2.6018	2.6018
	2.737492	0.04258	1.555426		0	
	2.701996	0.038045	1.408021		0	
SL6C (ceiling)	2.505823	0.027547	1.099301	0.901866	0	2.633396
	2.633396	0.02375	0.901866		2.633396	
	2.59777	0.024999	0.962307		0	
SL7A (surface)	0.003375	0.008061	238.8143	222.6879	0	0
	0.000229	0.000874	382.476		0	
	-0.00041	0.000911	222.6879		-0.00041	
SL7B (surface)	1.531386	0.027081	1.768374	1.768374	1.531386	1.531386
	1.565833	0.03348	2.138186		0	
	1.544521	0.033618	2.1766		0	
SL7C (surface)	1.290695	0.019418	1.504486	1.043068	0	1.322036
	1.322036	0.01379	1.043068		1.322036	
	1.304015	0.014407	1.104802		0	
SL8A (surface)	1.980548	0.024647	1.244448	1.023282	0	2.054198
	2.054198	0.02102	1.023282		2.054198	
	2.028611	0.021075	1.038911		0	
SL8B (surface)	1.769689	0.029967	1.693342	1.693342	1.769689	1.769689
	1.833472	0.033022	1.80105		0	
	1.809918	0.030797	1.701572		0	
SL8C (surface)	2.04493	0.035743	1.7479	1.33016	0	2.118073
	2.118073	0.028174	1.33016		2.118073	
	2.093617	0.03205	1.530855		0	

Table C.44 Mg ppm Light House Cave rock

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
SL2A (wall)	10.01	0.119214	1.190967	1.190967	10.00987	10.00987
	10.10	0.121668	1.204858		0	
	9.86	0.120815	1.225617		0	
SL2B (wall)	10.76	0.058651	0.54524	0.54524	10.75691	10.75691
	10.83	0.110153	1.016883		0	
	10.48	0.123907	1.182143		0	
SL2C (wall)	7.751437	0.028261	0.364591	0.299848	0	7.767407
	7.767407	0.02329	0.299848		7.767407	
	7.542699	0.050701	0.672186		0	
SL3A (ceiling)	9.851849	0.057205	0.580654	0.580654	9.851849	9.851849
	9.901419	0.075604	0.76357		0	
	9.56271	0.117441	1.22811		0	
SL3B (ceiling)	8.873776	0.085394	0.962317	0.779623	0	8.936317
	8.936317	0.06967	0.779623		8.936317	
	8.652925	0.074476	0.860704		0	
SL3C (ceiling)	10.23	0.043423	0.424429	0.077147	0	10.30861
	10.31	0.007953	0.077147		10.30861	
	10.07	0.049108	0.487709		0	
SL5A (wall)	7.084764	0.039845	0.5624	0.5624	7.084764	7.084764
	7.103042	0.062484	0.879683		0	
	6.890333	0.069135	1.003365		0	
SL5B (wall)	5.827816	0.030263	0.51928	0.086134	0	5.822422
	5.822422	0.005015	0.086134		5.822422	
	5.6427	0.007715	0.136725		0	
SL5C (wall)	8.604315	0.052855	0.614281	0.277891	0	8.425905
	8.668892	0.052938	0.610662		0	
	8.425905	0.023415	0.277891		8.425905	

Table C.44 (Continued)

SL6A (ceiling)	3.24	0.03498	1.080159	1.064339	0	3.225168
	3.23	0.039696	1.227887		0	
	3.23	0.034327	1.064339		3.225168	
SL6B (ceiling)	4.60	0.084823	1.842207	1.493664	0	4.609711
	4.61	0.068854	1.493664		4.609711	
	4.55	0.070049	1.538431		0	
SL6C (ceiling)	4.66	0.04618	0.990037	0.811153	0	4.666403
	4.67	0.037852	0.811153		4.666403	
	4.60	0.043216	0.938576		0	
SL7A (surface)	0.000679	0.001611	237.1929	114.8265	0	0.001373
	0.001373	0.001577	114.8265		0.001373	
	-0.00161	0.002423	150.5545		0	
SL7B (surface)	12.72	0.252699	1.986669	1.986669	12.71973	12.71973
	12.87	0.283786	2.204535		0	
	12.43	0.273372	2.199404		0	
SL7C (surface)	10.68	0.115972	1.085891	1.077009	0	10.27781
	10.74	0.131533	1.225012		0	
	10.28	0.110693	1.077009		10.27781	
SL8A (surface)	11.00	0.137495	1.24987	0.899689	0	10.6958
	11.09	0.118539	1.068525		0	
	10.70	0.096229	0.899689		10.6958	
SL8B (surface)	11.20	1.618243	1.618243	1.618243	11.20173	11.20173
	11.31	1.808851	1.808851		0	
	10.93	1.773894	1.773894		0	
SL8C (surface)	11.45	0.126603	1.10563	1.10563	11.45078	11.45078
	11.57	0.135414	1.170049		0	
	11.22	0.15637	1.393406		0	

Table C.45 Ca ppm Light House Cave rock

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
SL2A (wall)	4.893244	0.03361123	0.68689	0.240137	0	4.71053464	471.0534643
	4.710535	0.01131174	0.240137		4.710535		
SL2B (wall)	5.209263	0.03855344	0.740094	0.213002	0	4.98709184	498.7091839
	4.987092	0.01062261	0.213002		4.987092		
SL2C (wall)	3.809493	0.06803266	1.785872	1.785872	3.809493	3.80949298	380.9492979
	3.57511	0.06449532	1.804009		0		
SL3A (ceiling)	4.20202	0.00745667	0.177454	0.177454	4.20202	4.20202019	420.2020185
	4.036695	0.02744476	0.679882		0		
SL3B (ceiling)	4.002911	0.0144305	0.3605	0.3605	4.002911	4.00291115	400.2911147
	3.790086	0.0319445	0.842844		0		
SL3C (ceiling)	4.647754	0.01079875	0.232343	0.232343	4.647754	4.64775374	464.7753744
	4.447947	0.04816023	1.082752		0		
SL5A (wall)	3.611349	0.02263468	0.626765	0.626765	3.611349	3.61134885	361.134885
	3.412201	0.05624424	1.648327		0		
SL5B (wall)	3.550084	0.04801114	1.352394	0.332599	0	3.3400607	334.0060704
	3.340061	0.01110902	0.332599		3.340061		
SL5C (wall)	5.562711	0.09341185	1.67925	0.30638	0	5.32859021	532.8590211
	5.32859	0.01632575	0.30638		5.32859		

Table C.45 (Continued)

SL6A (ceiling)	2.898967	0.02966413	1.023266	0.281496	0	2.74308163	274.308163
	2.743082	0.00772166	0.281496		2.743082		
SL6B (ceiling)	4.067432	0.04315991	1.06111	0.899471	0	3.86452432	386.4524323
	3.864524	0.03476026	0.899471		3.864524		
SL6C (ceiling)	5.647265	0.01923992	0.340694	0.340694	5.647265	5.64726518	564.7265177
	5.361488	0.03237297	0.603806		0		
SL7A (surface)	2.772027	0.01265702	0.456598	0.456598	2.772027	2.77202732	277.202732
	2.593273	0.04434067	1.709835		0		
SL7B (surface)	2.980201	0.0124282	0.417026	0.417026	2.980201	2.98020069	298.0200688
	2.782866	0.02310782	0.83036		0		
SL7C (surface)	2.599096	0.03712634	1.428433	0.508911	0	2.47480195	247.4801955
	2.474802	0.01259455	0.508911		2.474802		
SL8A (surface)	3.062205	0.01948423	0.636281	0.343266	0	2.88562458	288.5624575
	2.885625	0.00990535	0.343266		2.885625		
SL8B (surface)	3.66433	0.04066988	1.109886	0.37706	0	3.48704879	348.7048785
	3.487049	0.01314825	0.37706		3.487049		
SL8C (surface)	3.400672	0.27460354	0.274604	0.274604	3.400672	3.40067227	340.0672267
	3.247222	0.50292463	0.502925		0		

Long Island Hamilton's Cave Rock

Table C.46 Sr ppm Hamilton's Cave rock

Specimen	Sr	Sr Std Dev	%RSD	Min RSD	PPM	Avg Sr PPM
LH2A (wall)	0.959692	0.004077	0.424838	0.424838	0.959692	0.959692
	1.010601	0.007745	0.766384		0	
	1.004463	0.00788	0.78454		0	
LH2B (wall)	0.590149	0.008499	1.440077	0.491735	0	0.612546
	0.612546	0.003012	0.491735		0.612546	
	0.610677	0.003445	0.564112		0	
LH2C (wall)	0.612309	0.008157	1.332203	0.195404	0	0.633936
	0.63743	0.001456	0.228424		0	
	0.633936	0.001239	0.195404		0.633936	
LH3AA (ceiling)	0.103506	0.001984	1.91635	0.579682	0	0.104106
	0.105065	0.001458	1.387805		0	
	0.104106	0.000603	0.579682		0.104106	
LH3AB(ceiling)	0.116129	0.004847	4.173636	0.591582	0	0.11892
	0.11976	0.000731	0.610084		0	
	0.11892	0.000704	0.591582		0.11892	
LH3AC(ceiling)	0.11387	0.002053	1.803053	0.583124	0	0.116041
	0.117314	0.000859	0.731857		0	
	0.116041	0.000677	0.583124		0.116041	
LH3BA (ceiling)	0.083855	0.000509	0.606727	0.504917	0	0.088338
	0.089271	0.000613	0.687208		0	
	0.088338	0.000446	0.504917		0.088338	
LH3BB (ceiling)	0.195966	0.003832	1.955653	0.741443	0	0.207553
	0.20784	0.002407	1.157901		0	
	0.207553	0.001539	0.741443		0.207553	
LH3BC (ceiling)	0.229341	0.003192	1.391937	0.739607	0	0.235921
	0.235851	0.001982	0.840331		0	
	0.235921	0.001745	0.739607		0.235921	

Table C.46 (Continued)

LH5A (wall)	0.618757	0.006428	1.03883	0.498424	0	0.651729
	0.651729	0.003248	0.498424		0.651729	
	0.648873	0.003951	0.608835		0	
LH5B (wall)	0.723007	0.005216	0.72145	0.627703	0	0.75146
	0.756977	0.005507	0.727435		0	
	0.75146	0.004717	0.627703		0.75146	
LH5C (wall)	0.761344	0.00402	0.527957	0.445371	0	0.79867
	0.804846	0.004035	0.501305		0	
	0.79867	0.003557	0.445371		0.79867	
LH6A (surface)	7.526271	0.02209	0.293507	0.293507	7.526271	7.526271
	7.702924	0.082687	1.073452		0	
	7.75596	0.057938	0.747009		0	
LH6B (surface)	0.473018	0.006228	1.316633	0.608598	0	0.491747
	0.492861	0.004404	0.893459		0	
	0.491747	0.002993	0.608598		0.491747	
LH6C (surface)	0.429994	0.006144	1.428836	1.385576	0	0.451059
	0.451045	0.006733	1.492814		0	
	0.451059	0.00625	1.385576		0.451059	
LH7A (surface)	0.379292	0.004065	1.071832	0.747347	0	0.359432
	0.365366	0.003267	0.894104		0	
	0.359432	0.002686	0.747347		0.359432	
LH7B (surface)	0.254301	0.002524	0.992611	0.992611	0.254301	0.254301
	0.235724	0.003278	1.390478		0	
	0.237354	0.002871	1.209403		0	
LH7C (surface)	0.713105	0.003522	0.493848	0.470741	0	0.702954
	0.712944	0.003633	0.509592		0	
	0.702954	0.003309	0.470741		0.702954	

Table C.47 Mg ppm Hamilton's Cave rock

Specimen	Mg	Mg Std Dev	% RSD	Min RSD	PPM	Avg Mg
LH2A (wall)	6.309357	0.057747	0.915254	0.738199	0	6.593848
	6.593848	0.048676	0.738199		6.593848	
	6.673123	0.063691	0.954439		0	
LH2B (wall)	3.641369	0.028475	0.781972	0.340641	0	3.765117
	3.765117	0.012826	0.340641		3.765117	
	3.788957	0.026428	0.697509		0	
LH2C (wall)	4.060652	0.011315	0.278652	0.252367	0	4.250584
	4.233207	0.011751	0.277598		0	
	4.250584	0.010727	0.252367		4.250584	
LH3AA (ceiling)	1.440784	0.010608	0.7363	0.345351	0	1.517208
	1.482935	0.015525	1.046937		0	
	1.517208	0.00524	0.345351		1.517208	
LH3AB(ceiling)	1.619406	0.009343	0.576928	0.55718	0	1.701127
	1.671502	0.010596	0.633901		0	
	1.701127	0.009478	0.55718		1.701127	
LH3AC(ceiling)	1.529194	0.006028	0.394175	0.394175	1.529194	1.529194
	1.573549	0.011614	0.738085		0	
	1.611655	0.007023	0.43579		0	
LH3BA (ceiling)	1.438909	0.005943	0.413024	0.413024	1.438909	1.438909
	1.470698	0.009233	0.627828		0	
	1.496968	0.008255	0.551457		0	
LH3BB (ceiling)	2.314102	0.020059	0.8668	0.773333	0	2.380664
	2.380664	0.01841	0.773333		2.380664	
	2.425131	0.025782	1.0631		0	
LH3BC (ceiling)	3.124233	0.015974	0.511299	0.511299	3.124233	3.124233
	3.232187	0.027121	0.839086		0	
	3.279841	0.022784	0.694654		0	

Table C.47 (Continued)

LH5A (wall)	5.872089	0.034704	0.591006	0.53594	0	6.119137
	6.119137	0.032795	0.53594		6.119137	
	6.119225	0.057719	0.943245		0	
LH5B (wall)	7.269243	0.037959	0.522188	0.522188	7.269243	7.269243
	7.631046	0.062537	0.819507		0	
	7.693022	0.050033	0.650372		0	
LH5C (wall)	6.743382	0.026844	0.398075	0.398075	6.743382	6.743382
	7.062996	0.043024	0.609146		0	
	7.154377	0.045849	0.640849		0	
LH6A (surface)	3.30	0.012006	0.363985	0.363985	3.298526	3.298526
	3.42	0.016044	0.46907		0	
	3.46	0.028129	0.812792		0	
LH6B (surface)	3.78	0.039366	1.041893	1.041893	3.778344	3.778344
	3.92	0.050846	1.29618		0	
	3.98	0.04726	1.186816		0	
LH6C (surface)	3.55	0.043005	1.209788	1.209788	3.554721	3.554721
	3.66	0.051306	1.401599		0	
	3.71	0.055296	1.489942		0	
LH7A (surface)	3.884347	0.051286	1.320326	0.459358	0	3.939674
	3.833286	0.043271	1.12883		0	
	3.939674	0.018097	0.459358		3.939674	
LH7B (surface)	2.763787	0.037707	1.364323	0.836345	0	2.862527
	2.720201	0.033074	1.215854		0	
	2.862527	0.023941	0.836345		2.862527	
LH7C (surface)	6.431738	0.04378	0.680689	0.514516	0	6.447428
	6.378251	0.037483	0.587663		0	
	6.447428	0.033173	0.514516		6.447428	

Table C.48 Ca ppm Hamilton's Cave rock

Specimen	Ca (1:100)	Ca Std Dev	% RSD	Min RSD	PPM	Avg Ca 1:100	Avg Ca PPM
LH2A (wall)	2.649986	0.015719	0.593171	0.593171	2.649986	2.649986	264.9986
	2.690091	0.028923	1.075164		0		
LH2B (wall)	1.750668	0.004804	0.274435	0.274435	1.750668	1.750668	175.0668
	1.744771	0.031779	1.821381		0		
LH2C (wall)	1.692987	0.056736	3.351231	1.148374	0	1.728705	172.8705
	1.728705	0.019852	1.148374		1.728705		
LH3AA (ceiling)	2.020272	0.019732	0.976718	0.522812	0	2.033391	203.3391
	2.033391	0.010631	0.522812		2.033391		
LH3AB(ceiling)	1.650476	0.015796	0.95708	0.892242	0	1.67514	167.514
	1.67514	0.014946	0.892242		1.67514		
LH3AC(ceiling)	1.853755	0.031738	1.712067	1.712067	1.853755	1.853755	185.3755
	1.872565	0.032496	1.735378		0		
LH3BA (ceiling)	1.474907	0.01035	0.701727	0.701727	1.474907	1.474907	147.4907
	1.496703	0.016347	1.092215		0		
LH3BB (ceiling)	1.934592	0.019911	1.029207	1.029207	1.934592	1.934592	193.4592
	1.947103	0.027694	1.422298		0		
LH3BC (ceiling)	2.444146	0.002617	0.107068	0.107068	2.444146	2.444146	244.4146
	2.468028	0.009005	0.364878		0		

Table C.48 (Continued)

LH5A (wall)	2.12556	0.054333	2.55616	1.564472	0	2.138266	213.8266
	2.138266	0.033453	1.564472		2.138266		
LH5B (wall)	2.177303	0.024176	1.110384	1.110384	2.177303	2.177303	217.7303
	2.202148	0.043911	1.993995		0		
LH5C (wall)	1.48564	0.017216	1.158795	0.790311	0	1.520037	152.0037
	1.520037	0.012013	0.790311		1.520037		
LH6A (surface)	1.724641	0.009879	0.572833	0.572833	1.724641	1.724641	172.4641
	1.720877	0.026744	1.554069		0		
LH6B (surface)	2.01457	0.004994	0.247899	0.247899	2.01457	2.01457	201.457
	2.017979	0.009582	0.474824		0		
LH6C (surface)	1.858063	0.021861	1.176569	1.176569	1.858063	1.858063	185.8063
	1.849694	0.022562	1.219751		0		
LH7A (surface)	2.207092	0.023102	1.046716	0.924791	0	2.195568	219.5568
	2.195568	0.020304	0.924791		2.195568		
LH7B (surface)	1.977669	0.028239	1.427897	1.427897	1.977669	1.977669	197.7669
	1.979929	0.034167	1.725651		0		
LH7C (surface)	2.566426	0.060865	2.371577	1.614002	0	2.585017	258.5017
	2.585017	0.041722	1.614002		2.585017		

APPENDIX D

XRD RESULTS

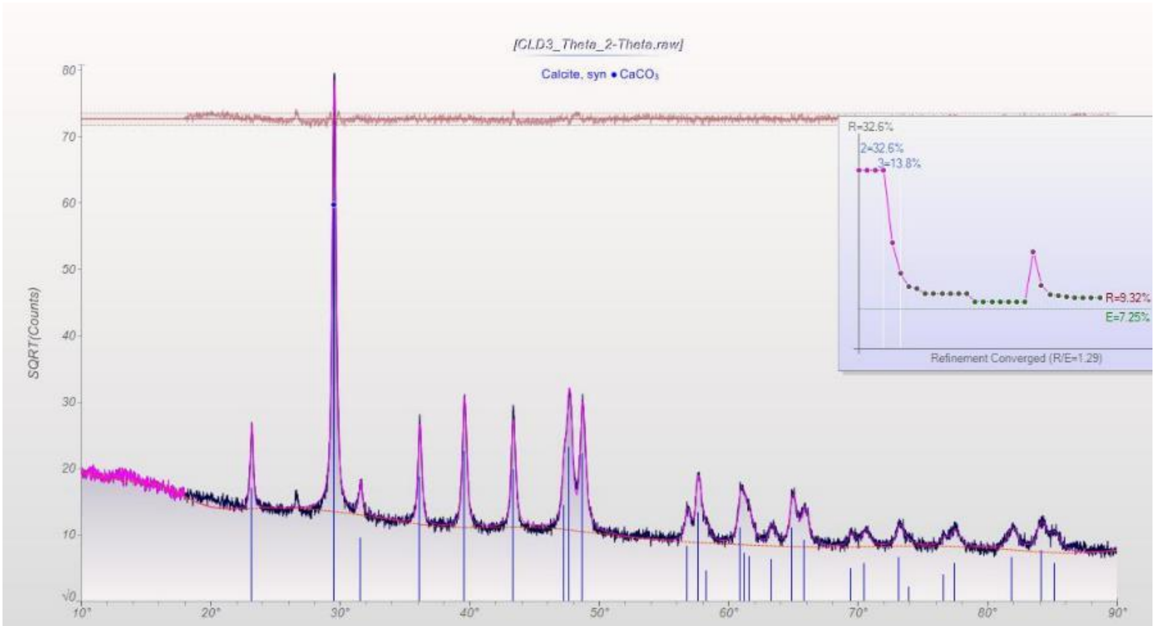

Figure D.1 Lardem Cave Rock

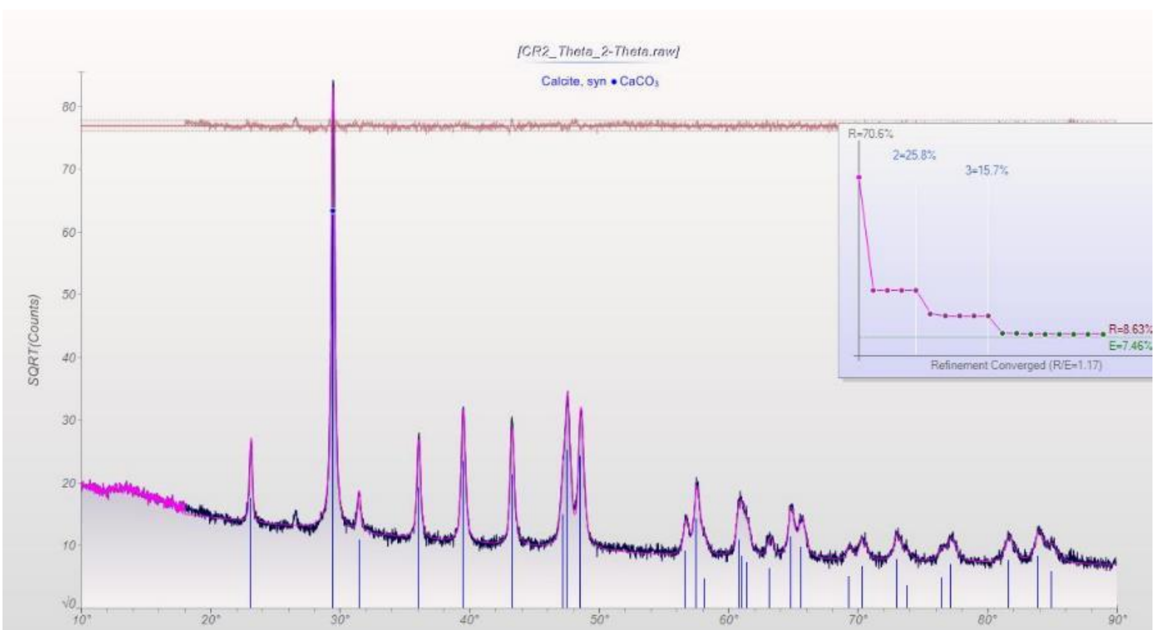

Figure D.2 Raton Cave Rock

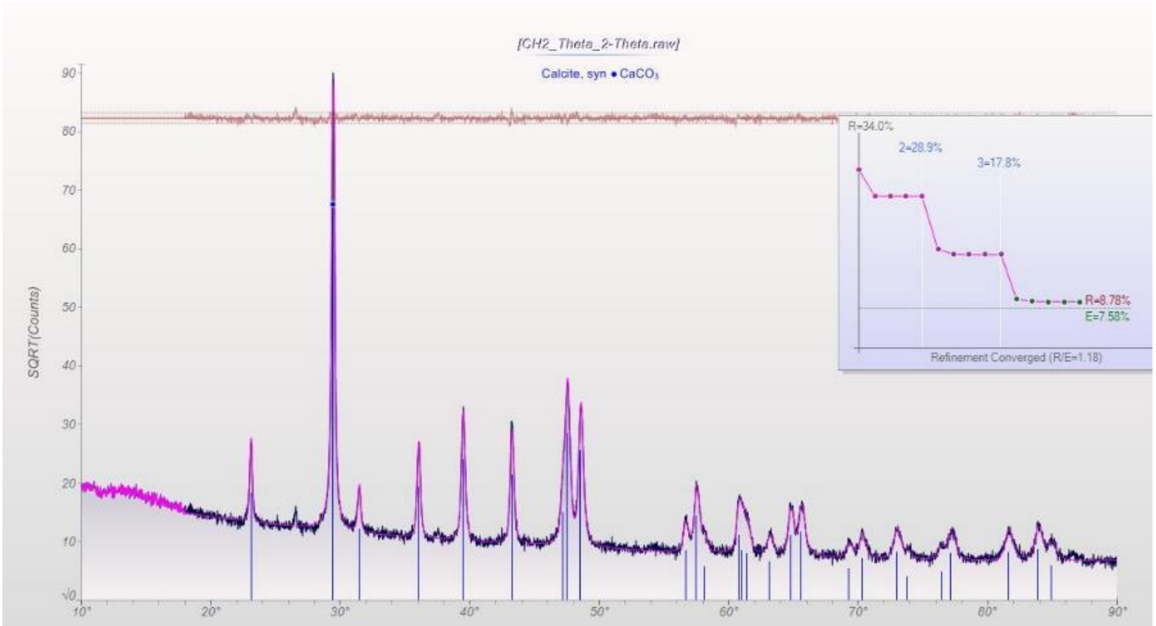

Figure D.3 Hato Cave Rock

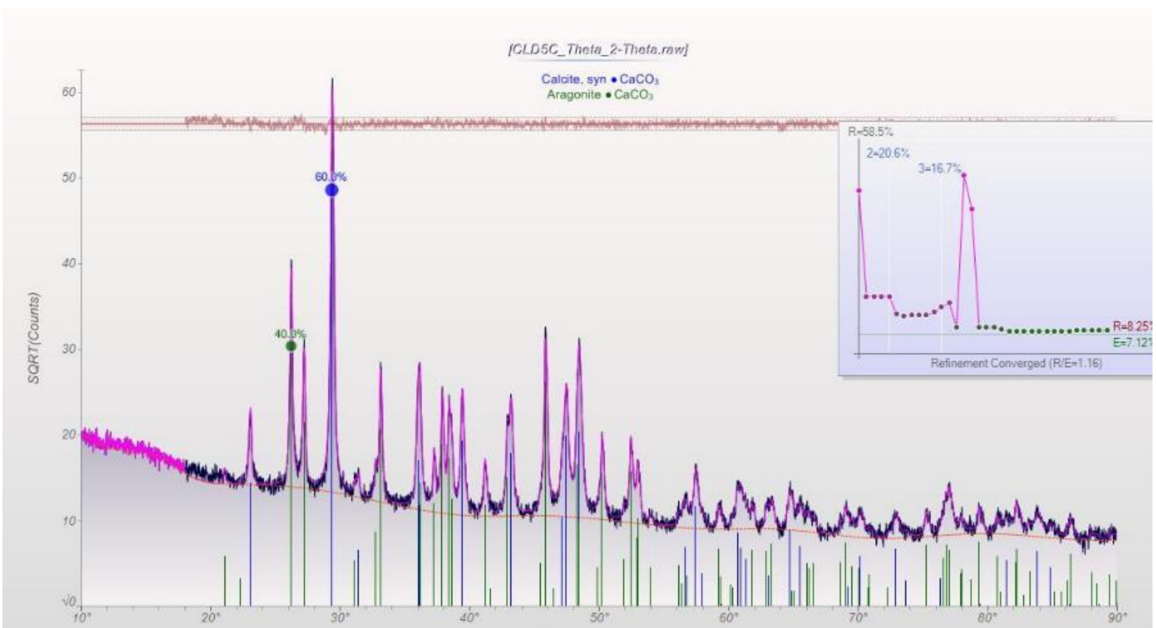

Figure D.4 Surface rock above Lardem Cave

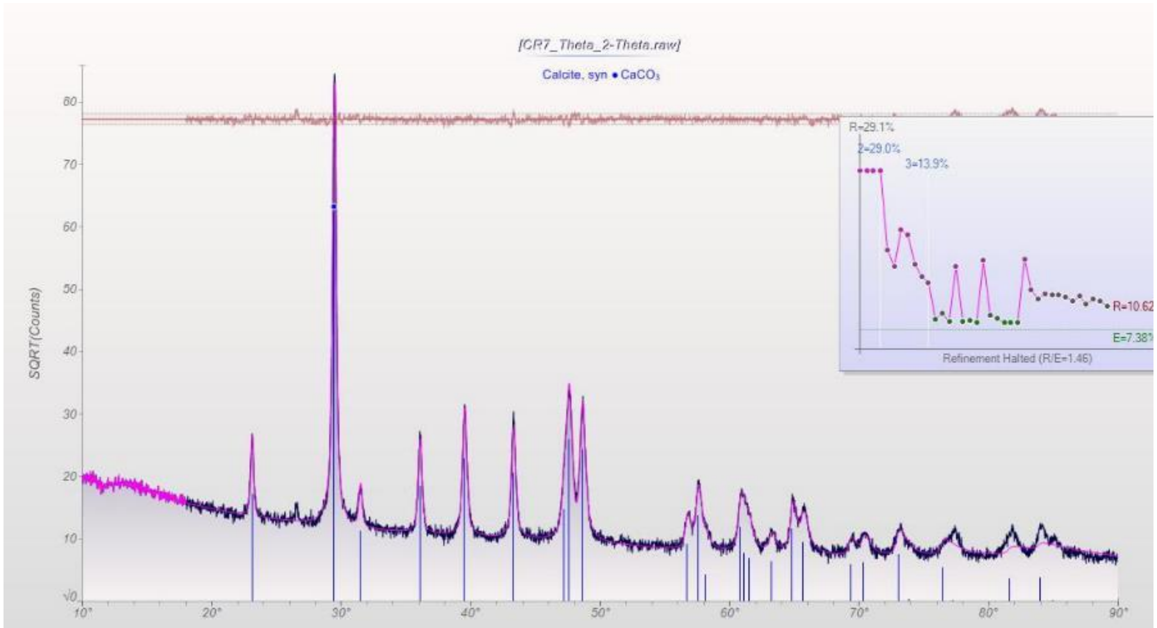

Figure D.5 Surface rock above Raton Cave

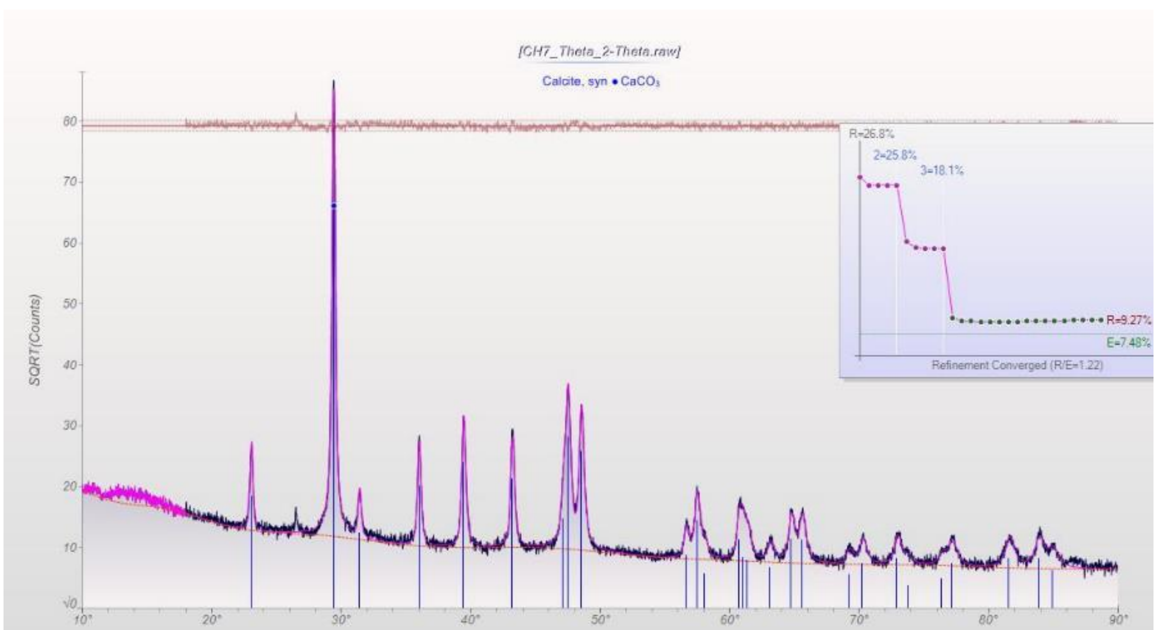

Figure D.6 Surface rock above Hato Cave

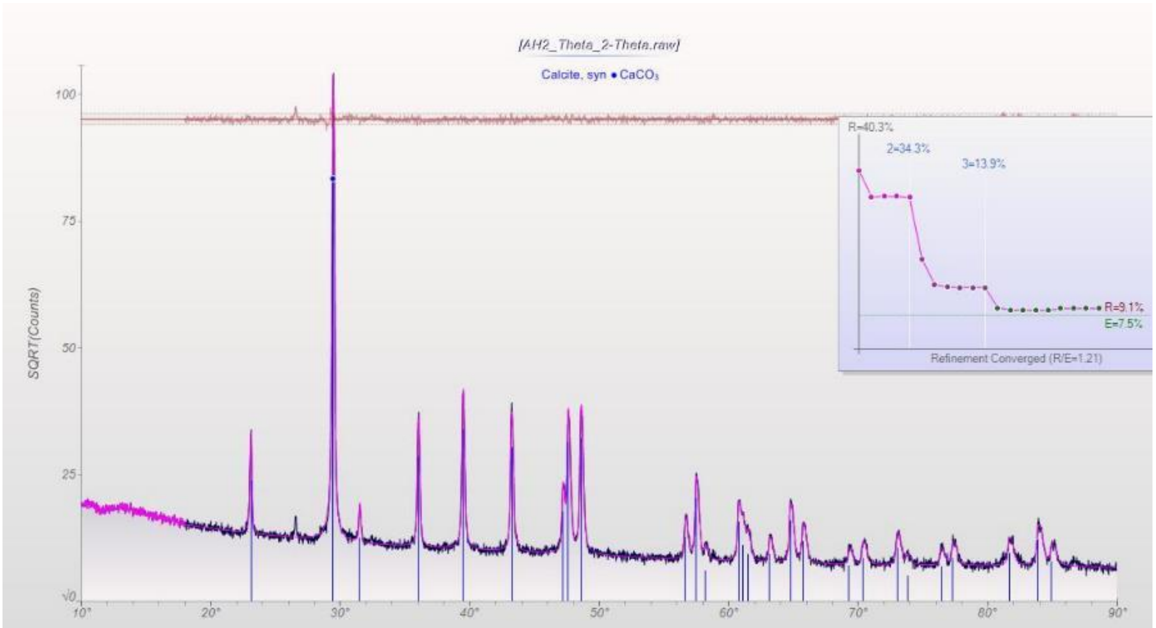

Figure D.7 Hole in the Wall Cave rock

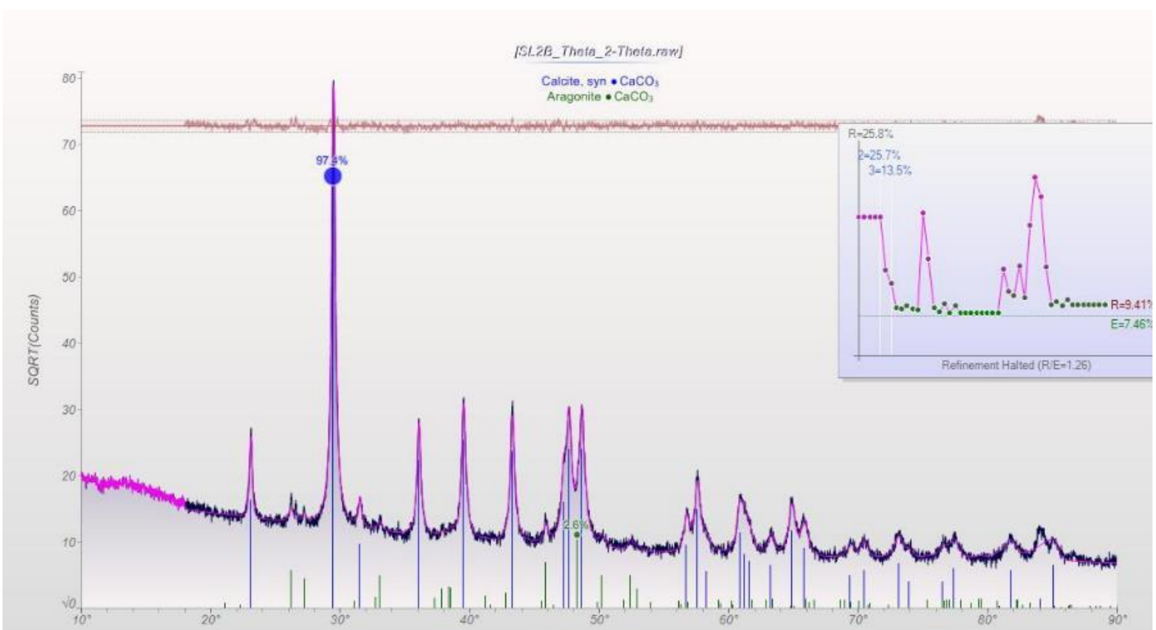

Figure D.8 Light House Cave rock

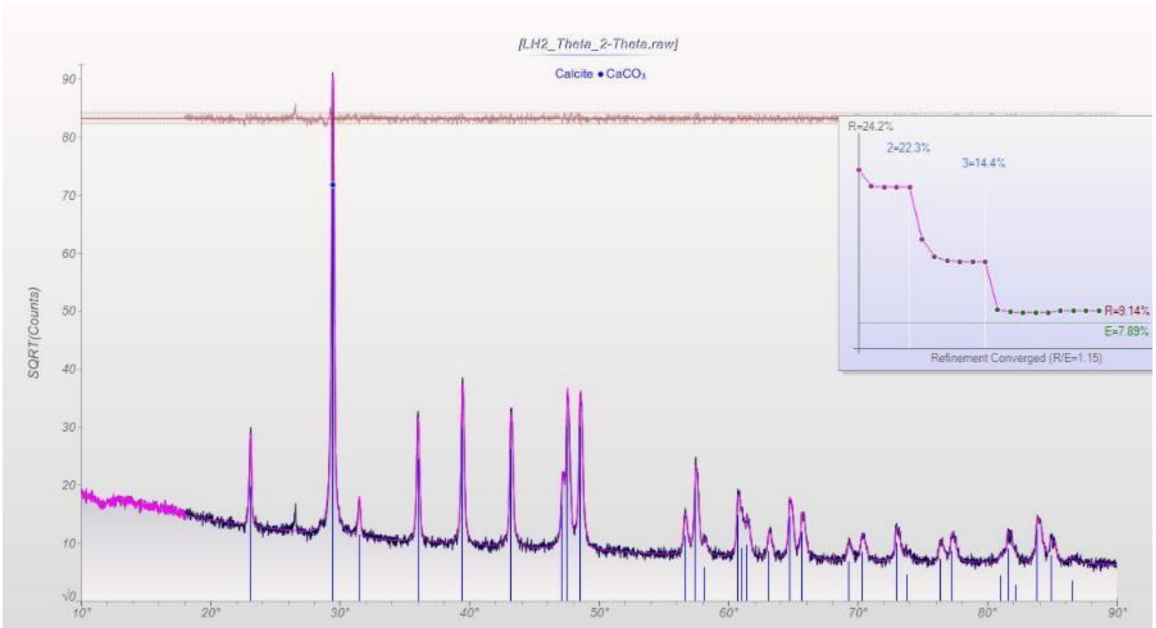

Figure D.9 Hamilton's Cave rock

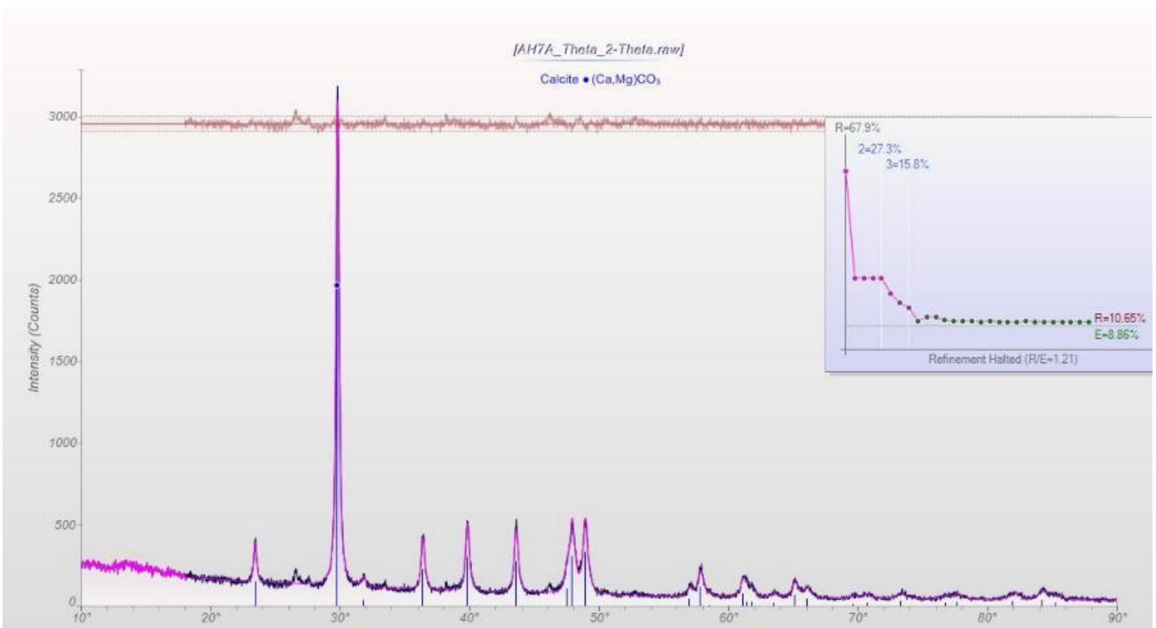

Figure D.10 Surface rock above Hole in the Wall Cave

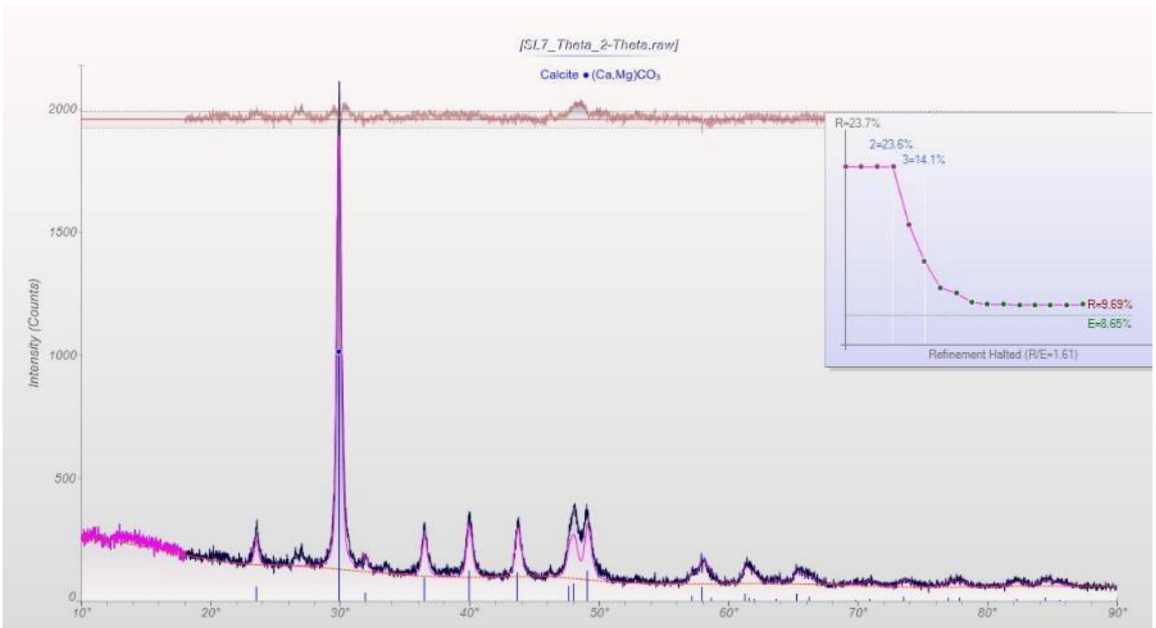

Figure D.11 Surface rocks above Light House Cave

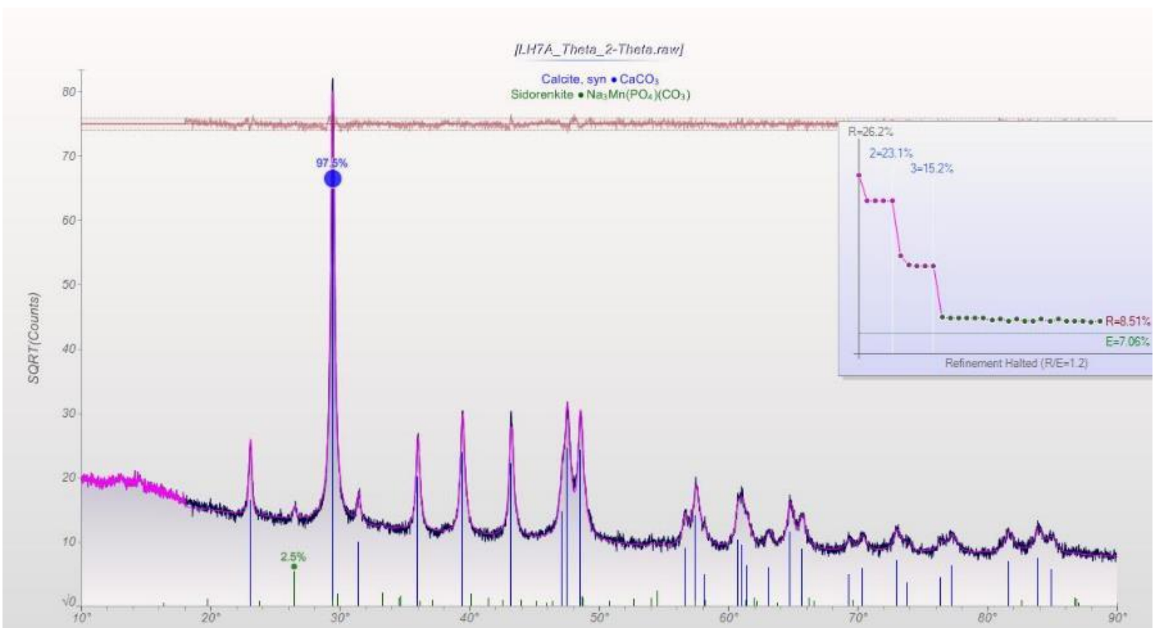

Figure D.12 Surface rocks above Hamilton's Cave