PALEOSALINITY HISTORY OF A HOLOCENE LAGOON IN THE ENRIQUILLO VALLEY, DOMINICAN REPUBLIC: PORE MORPHOMETRICS AND ISOTOPE GEOCHEMISTRY OF OSTRACODA

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INTRODUCTION

The southwestern region of the Dominican Republic (Enriquillo Valley) displays well-preserved deposits of early-to middle Holocene coral crest (large *Acropora cervicornis* thicket), patch, and back reef beds. Before 4.3 ka, the valley was an extension of the Caribbean Sea where a healthy fringing coral reef thrived until flood plain and alluvial deposits choked the mouth of the valley and separated the lagoon from the sea (Mann et al., 1984). These rich fossiliferous deposits contain abundant skeletal material that are ideal for reconstructing paleoenvironmental and paleohydrology histories.

The hydrology of the modern Enriquillo Valley is complicated by basin hypsography and tectonism. Because salinity and isotope ratios can vary independently, a multi-proxy approach using ostracode normal pore morphometrics coupled with stable isotope geochemistry of their carapaces facilitates paleohydrological reconstructions within the restricted Enriquillo basin such that distinction between hyposalinity (0<34‰) and hypersalinity (>34‰) deposits is possible (Anadon et al, 2002). The primary objectives for this study are: 1) to scrutinize the relationship between salinity and pore shape and ultimately refine the pore morphometric model for ostracodes originally proposed by Rosenfeld and Vesper (1977); and 2) to provide a high-resolution paleosalinity history for the Holocene strata deposited in the Enriquillo Valley of the Dominican Republic.

METHODS

Sample Collection and Preparation

The primary locality of study for this project is a 6.5 meter stratigraphic section measured at Canada Honda (18° 31’ 57.4”N and 71° 37’ 5.8”W), an exposed gulley on the north side of Lago Enriquillo. There are three primary sedimentary units where Canada Honda was intensively sampled as follows: Unit 1 (0.0-3.25 m) sampled every 0.5 meters; Unit 2 (3.25-4.4 m) sampled every 0.5 meters, and Unit 3 (Site 1C: 4.5-6.5 m) sampled at 10cm intervals. Two subsections, Site 1A, and Site 1B, were sampled at 10 cm intervals (Fig. 1).

SEM Imaging and Pore Measurements

Rosenfeld and Vesper (1977) demonstrated that the ostracode *Cyprideis* shows a positive relationship between irregular pore shapes with increased salinity of the waters. To improve on this methodology, ostracodes were photographed using a variable pressure scanning electron microscope (Hitachi S-3400N), with emphasis on creating low magnification (~300x) images of the anterior, median and posterior regions of the external carapace. Sieve pores were observed on uncoated specimens using a backscatter detector, low gas pressures (~50-70 Pascals), and low voltages (10-15 kV). Image analysis software (Image J 1.30v: National

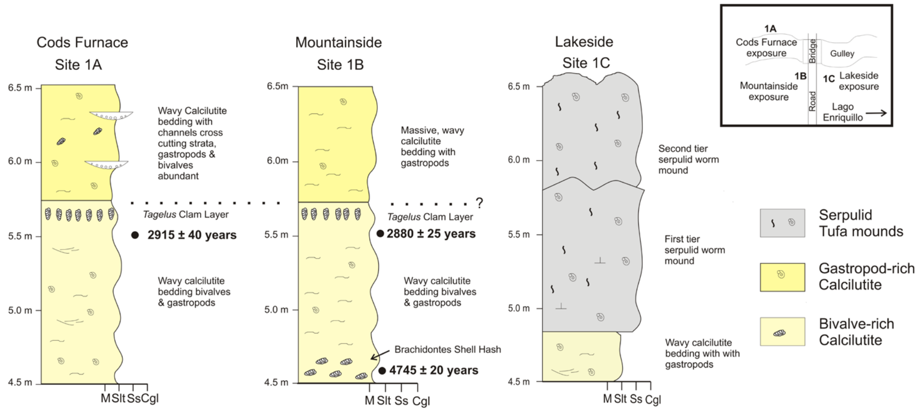

Figure 1: Three laterally equivalent subsections of Unit 3; Site 1A, 1B, and 1C. 1A and 1B were correlated based on the Tagelus razor clam layer at 5.6 m. Sites 1A and 1B were correlated with 1C based on the last occurrence of exclusively stenohaline Bairdidae and Trachyleberidae ostracodes and the appearance of the euryhaline Cyprideis salebrosa. Site 1A is the section that was subjected to rigorous ostracode pore morphometrical analyses. Carbon 14 dates also were taken: Brachiodontes sp. analyzed at 4.6 m ~4745 ± 20 years; Tagelus plebius clam analyzed at 5.6 m ~2915 ± 40 years. All dates are uncorrected.

Institutes of Health) was used to measure area and circularity of the sieve pores.

Isotope Geochemistry

Stable isotope analyses were performed on the valves of the ostracode *Cyprideis salebrosa*. The specimens were roasted *in vacuo* at 200°C and analyzed using a Keil-III carbonate preparation device directly coupled to a Finnigan MAT 253 gas source ratio mass spectrometer in the Saskatchewan Isotope Laboratory.

RESULTS

Lithofacies

Canada Honda comprises 6.5 meters of strata with the following three primary biofacies units: 1) *Monastraea annularis* rubble with stenohaline Trachyleberidae and Bairdidae ostracodes; 2) *Acropora cervicornis* rubble with the mesohaline ostracode *Loxoconcha levis*; 3) *Tagelus plebius* calcilutite with the euryhaline ostracodes *Cyprideis salebrosa*, *C. mexicana*, *C. similis*, and *C. edentata*. Unit three is of interest for pore morphometric and geochemical analysis

Pore Morphometrics

We plotted the circularity values (0 = irregular; 1 = circular) against the area of the pore and generated a best fit linear trend line to establish the general slope for each specimen analyzed. There are three typical pore shapes found on *Cyprideis salebrosa*: 1) multiradiate pores demonstrate low circularity values (1.0 = perfect circularity) with relatively large pore areas (negative slope = -0.0039); 2) elongated pores that are characterized by low circularity values and variable sized pores (negligible slope = 0.00005); round pores that demonstrate circularity values that cluster slightly under 1.0 circularity and areas are relatively small (positive slope = 0.0013). *Cyprideis salebrosa* exhibits alterations between highly irregular pores and slightly irregular pores in the 0.0-0.5 m Interval I that overlies the *Acropora cervicornis* rubble. Within the 5.1-5.6 m Interval II, *Cyprideis salebrosa* exhibits regular pores with little variability. The uppermost Interval III (5.7-5.6m) contains *Cyprideis salebrosa* that exhibit consistently positive slopes. The slope values for all measured specimens are illustrated in Figure 2 where specimens that comprise numerous large and irregular and elongated pores exhibit linear trend lines with negative slopes, and specimens that comprise numerous large and round pores tend to exhibit linear trends with positive slopes.

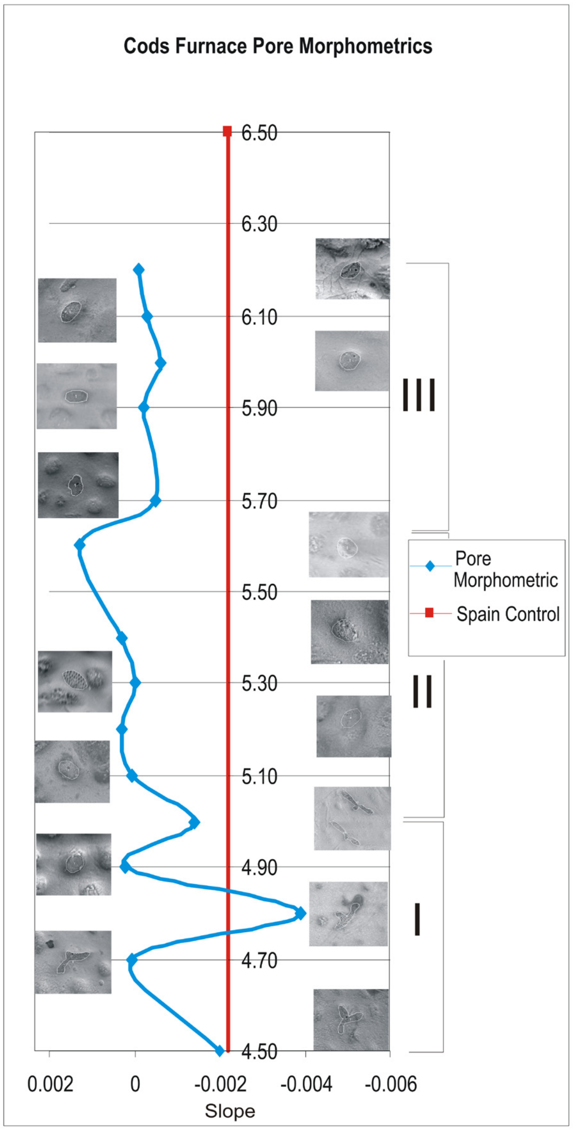

Figure 2: Salinity proxy using pore morphometrics. Slope is generated from area plotted against circularity. Negative slope is an irregular pore, positive slope is a round pore. Data generated from several modern specimens of Cyprideis torosa, collected from 60‰ waters in Alicante Spain, are shown as a red vertical line for comparative purposes.

Geochemical Analysis

Twenty one *Cyprideis salebrosa* samples were analyzed from Site 1A (Fig. 3). In the lower interval, $\delta^{18}O$ values are highly variable ranging between 0.8 and -1.2‰ VPDB with maxima at 4.6 m and minima at 4.9 m. Carbon isotope values are also highly variable in interval I with ranges between -1.5 and -5.0‰ VPDB and with maxima at 4.6 m and minima at 4.8 m. Within Interval II, $\delta^{18}O$ values are less variable ranging between -0.9 and -2.1‰ VPDB and with maxima at 5.3m and minima at 5.1 m. Carbon isotope values range between -3.6 and -6.3‰ VPDB with maxima at 5.2 m and minima at 5.6 m. Within Interval III, $\delta^{18}O$ values show a pronounced negative excursion, ranging between 0.3 and -1.5‰ VPDB with maxima occurring at 5.7 m and minima at 6.5 m. Carbon isotope values display a negative trend, ranging between -3.2 and -5.1‰ VPDB with maxima at 5.9 m and the minima at 6.5 m.

Six *Cyprideis salebrosa* samples were analyzed from Site 1B. Oxygen isotope values range between 0.8 and -1.4‰ VPDB with maxima at 5.3 m and minima at 5.8 m. Carbon isotope values range between -2.4 and -5.6‰, with maxima at 5.5 m and minima at 5.3 m.

Thirteen *Cyprideis salebrosa* samples were analyzed from the 4.5-5.7 m interval at Site 1C. $\delta^{18}O$ values ranges between 0.9 and -1.7‰ VPDB, with maxima at 5.4 m and minima at 5.3 m. Carbon isotope values range between -2.6 and -5.2‰ VPDB, with the maxima at 5.4 m and the minima at 4.9 m.

Normal marine ostracodes from Unit 1 were analyzed for comparison where $\delta^{18}O$ values range from 0.4 and -0.6‰ VPDB and $\delta^{13}C$ values range from -4.1 and -1.8‰ VPDB. Freshwater ostracodes were also analyzed for comparison and $\delta^{18}O$ values range from 0.0 and -0.9‰ VPDB and $\delta^{13}C$ values range from 0.3 and -2.5‰ VPDB.

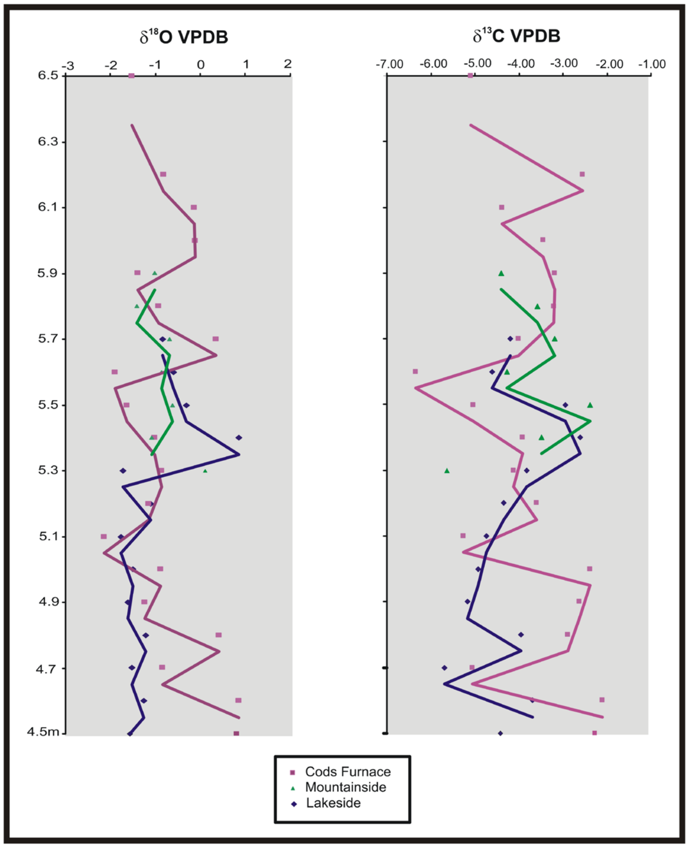

Figure 3: Stable oxygen and carbon isotope values for the three intervals from Unit 3 (Sites 1A, 1B, 1C).

DISCUSSION

The pore morphometric results support Rosenfeld and Vesper's (1977) model that predicted increased irregularity of normal pores coincident with increased salinity of the water. A small population of *Cyprideis torosa* characterized by irregular pore shapes that lived in 60‰ water at the time of collection, yielded a negative slope with respect to the area versus circularity relationship. This supports the original model proposed by Rosenfeld and Vesper (1977) and justifies the following depositional model for the early late Holocene for the relict marine, coastal lake deposits in the Enriquillo Valley (Fig 4).

Interval I (4.5-5.0 m) is characterized by variable amplitudes in all proxy indicators that includes negative pore slopes and positive $\delta^{18}O$ and $\delta^{13}C$ values that suggests highly variable salinities soon after the lake was isolated from open marine communication.

Interval II (5.1-5.6 m) demonstrates significantly lower amplitude variation in both the pore slopes and isotope trends suggestive of freshening of the lake waters which is culminated at the *Tagelus plebius* clam horizon (Fig. 4).

Interval III (5.7-6.5 m) is characterized by a significant change in lithology at 5.7 m coincident with a negative pore slope and higher $\delta^{18}O$ and $\delta^{13}C$ values suggestive of increased salinity of the lake waters. The uppermost trend towards decreased isotope values and relative abundance of the fresh-to brackish ostracode *Cytheridella* sp. signifies a return to low salinity in the lake waters.

Several processes influence oxygen and carbon isotope fractionation, including precipitation trajectory paths, atmospheric and water temperature effects, vital effects, and precipitation and evaporation budgets. The high variability in the ostracode isotope proxies are attributed to changes in evaporation and precipitation within the region. Oxygen isotope values reported from ostracodes shells collected from Holocene lake deposits in Haiti show a strong trend from positive to negative values that are attributed to changes in precipitation in Haiti during the late Holocene (Hodell et al., 1991).

Positive $\delta^{13}C$ values likely record the influence of dissolved inorganic carbon (DIC) derived from weathering of Miocene carbonates that characterize the watershed of the Enriquillo Valley (Bold, 1990). Similar bedrock DIC influenced trends in $\delta^{13}C$ have been reported from western Ireland (Diefendorf et al., in review).

With respect to climate forcing mechanism, we

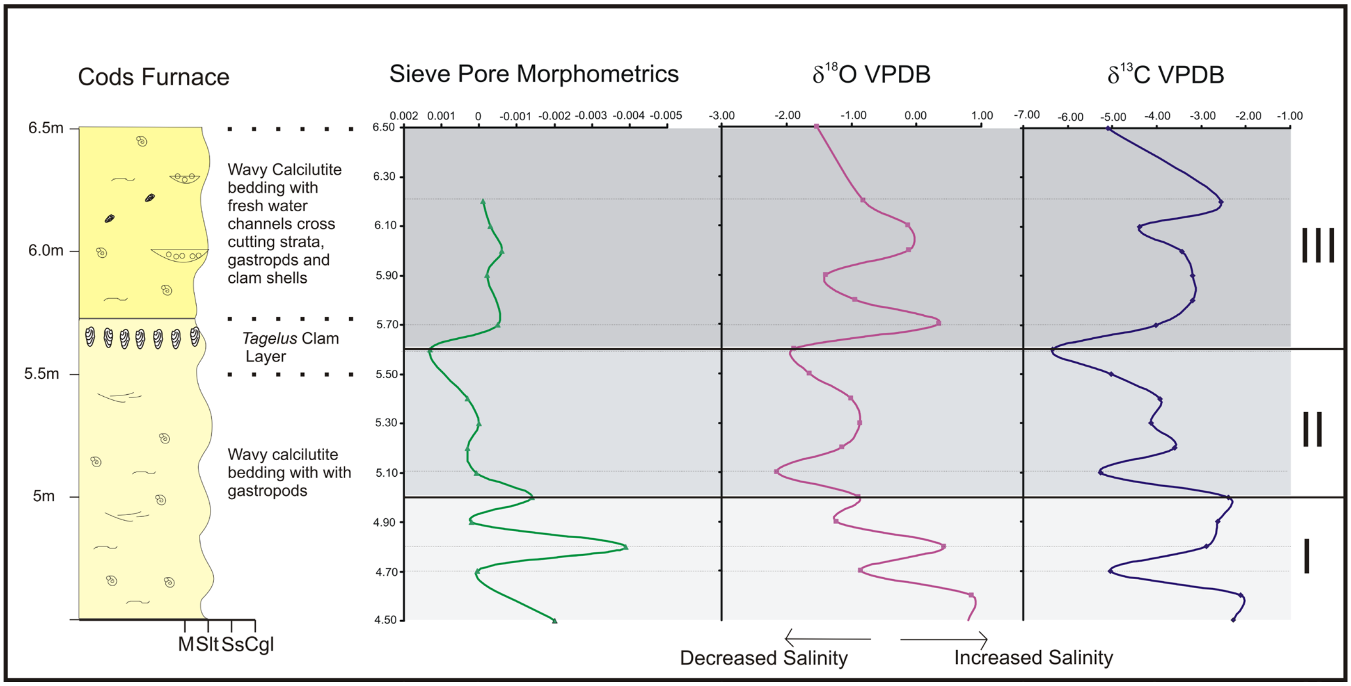

Figure 4: Synthesis of lithology, pore results, and oxygen and carbon isotope values for site 1A. Values to the left indicate increased salinity and values to the right indicate decreased salinity.

favor the model proposed by Hodell et al (1991) who invoked a southern to northern shift in the ITCZ to account for increased humidity during the mid-to-late Holocene on Hispaniola.

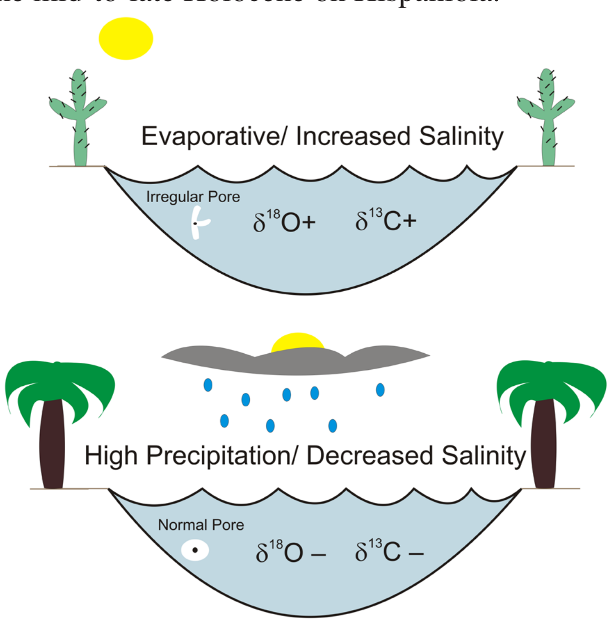

Figure 5: Model illustrating times of high evaporation and high precipitation, where round pores and low oxygen and carbon isotope values are representative of high precipitation and irregular pores and high oxygen and carbon isotope values are representative of high evaporation.

CONCLUSION

The following conclusions are based on our pore morphometrics and isotope geochemistry study: 1) the relationship between ostracode pore shape and salinity confirms the paleosalinity model proposed by Rosenfeld and Vesper (1977); and 2) the complex paleosalinity history for the Holocene strata in the Enriquillo Valley of the Dominican Republic was likely forced by climate induced changes in evaporation and precipitation such that there is a distinct trend of basal, highly variable salinity that trends upward towards lower salinity.

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