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Front Cover: The reef crest indicator species, *Acropora palmata*, on Gaulin's Reef, San Salvador Island. Gaulin's Reef is a classic bank-barrier reef that has shown remarkable resilience following two significant disturbances: El Niño-induced warming of the sea surface in 1998 and Hurricane Floyd in September, 1999 (see Peckol et al., this volume). Photo by Janet Lauroesch.

Back Cover: The oolite shoals of Joulter's Cay, north of Andros Island, Bahamas, site of the pre-meeting field trip. Photo by Ben Greenstein.

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RECONNAISSANCE PALEOSOL PALEOMAGNETISM FROM THE HARD BARGAIN AREA, SAN SALVADOR ISLAND, BAHAMAS

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ABSTRACT

Recent work has shown that the Hard Bargain area of San Salvador Island predominantly consists of oolitic eolianite dunes, nucleated on peloidal-bioclastic rocks observed in down-wind dune flanks. The initial interpretation is that most of the oolitic rocks belong to the Grotto Beach Formation, with rare exposure of Owls Hole Formation rocks expressed as peloidal-bioclastic outcrops. Interdune swale areas could also be Grotto Beach rock; however, diagenesis has masked the original composition at many localities.

New paleomagnetic data from paleosol samples collected in shallow karst depressions between the eolianite ridges yield Gaulin Cay magnetotype directions. This implies that the rock underlying the paleosols there is Owls Hole Formation. These preliminary results suggest that an Owls Hole paleo-topography in the island's interior may be more extensive than originally inferred.

INTRODUCTION

Paleomagnetic studies over the last several years on San Salvador Island have enjoyed success in addressing stratigraphic problems associated with paleosols. Stability tests have shown that the magnetic remanence is stable and dates to the origin of the paleosols (Kirkova, 1994; Panuska et al., 1995a). Data obtained over several hundred meters of continuous paleosol shoreline exposure show consistent directions within statistical error limits (Kirkova, 1994). Moreover, paleomagnetic data from samples collected from the Singer Bar Point area have been able to delineate a transition between two separate paleosol-bounded stratigraphic packages in what, at face value, appeared to be a continuous coastal exposure of a single unit (Panuska et al., 1997). This multiple unit interpretation is corroborated by petrographic data showing that the transition zone is a contact between two Pleistocene formations with distinct lithology.

To date, most paleomagnetic studies of San Salvador paleosols have been from coastal localities and relatively little is known about the paleomagnetic signatures of paleosols from the island interior. A few data sets have been produced from non-coastal outcrops: Stouts Lake (Panuska, et al., 1997), Watling's Quarry (Panuska et al., 1991; Kirkova, 1994; Panuska et al., 1995b) and Moon Rock Pond (Panuska et al., 1999). However, most of these sample localities are relatively close to the coast.

This study has been prompted by the completion of the Hard Bargain Trail, across the widest portion of San Salvador. Several geological studies have been undertaken in this interior site, owing to the access afforded by the trail (Sparkman Johnson, 1999; Lehnert, 1997; Harris et al., 1995). Recognition of established magnetotypes in the Hard Bargain area could provide important geologic context for such studies by helping to elucidate the complexities of interior dune stratigraphy.

PALEOMAGNETIC DATA

Three sample clusters were collected from two general localities along the Hard Bargain Trail (Figure 1). The first two clusters occupy the swale region between 18 m

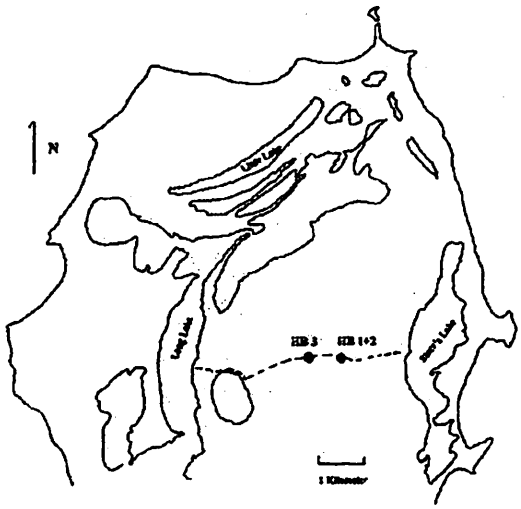

Figure 1. Location map showing Hard Bargain sampling localities. Dashed line shows the location of the Hard Bargain Trail. HB 1+2 represents Hard Bargain localities 1+2. HB 3 is Hard Bargain locality 3.

and 12 m dune ridges (Sparkman Johnson, 1999), approximately 1.2 km from the trail head. These clusters were separated by about 50 meters and were combined into a single mean direction (Localities 1 + 2). The second basic location is about 40 meters south of the trail along the eastern flank of 12 m ridge (Locality 3), about 2 km from the trail head.

Samples were subjected to the standard alternating field (AF) demagnetization, in order to remove secondary magnetic components. Remanence directions were measured on a Schonstedt SSM-1A spinner magnetometer. At locality 1, 7 out of 8 samples measured yielded stable end point directions, at AF intensities of 75 to 150 Oe. Only 3 data points were obtained at locality 2 and 5 cores gave no stable demagnetization endpoint. It is not known why so many samples failed selection criteria. However, these samples were analyzed as part of a student project and it is likely that the samples were not given sufficient time for viscous remanent magnetizations (VRM - temporary noise acquired in the laboratory) to decay after the samples were moved from the AF unit to the magnetometer.

Given the proximity of these localities and the similarity of directions, localities 1 and 2 are treated as a composite mean. The mean remanence direction is: 353° declination, 46° inclination (k=157.3, A_{95}=3.9°, N=10) (Figure 2, Table 1).

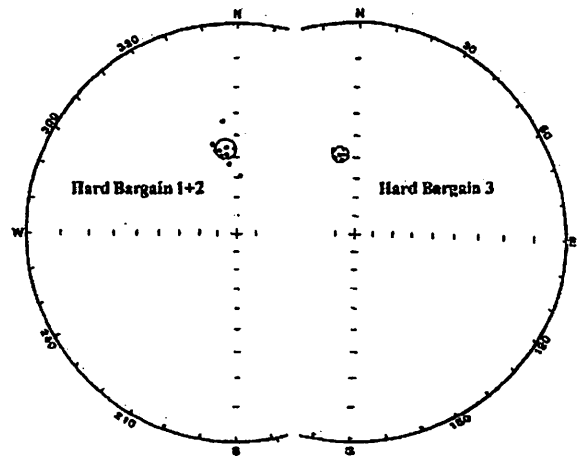

Figure 2. Stereographic plots of Hard Bargain Trail mean directions. Dots indicate characteristic directions from individual samples. Large circles are 95% confidence limits about the mean direction. Mean directions are not plotted for clarity, but would plot approximately in the center of the circle of confidence.

Samples from locality 3 displayed stable end points between 100 and 150 Oe. One sample out of the 7 analyzed failed to clean to a stable end point. The mean direction of locality 3 is: 349° declination, 48° inclination (k=697.3, A_{95}=2.6°, N=6) (Figure 2, Table 2). These data show remarkably tight clustering as indicated by the large k value. Again discarded samples are probably the result of

small, laboratory environment, VRM overprints that prevented isolation of well-defined directions.

NRM Sample	Geographic Demag	%NRM	Intensity	Dec	Inc
3A	150	10	6.1E-5	353	49
5A	75	28	5.8E-6	347	46
6A	125	14	1.3E-5	355	53
7A	175	20	6.3E-5	354	34
8A	125	19	1.2E-4	4	49
9A	150	10	1.4E-4	345	42
11A	125	15	4.6E-4	359	46
19A	110	18	2.4E-4	348	46
22A	175	6	8.3E-5	354	45
31A	150	24	1.3E-4	351	49
				353	46

$k = 157.3$ $A_{95} = 3.9°$
$R = 9.943$ $N = 10$

Table 1. Paleomagnetic data from Hard Bargain localities 1+2. k is the Fisher precision parameter, A_{95} is the 95% statistical confidence limit and N is the number of samples.

NRM Sample	Geographic Demag	%NRM	Intensity	Dec	Inc
32A	150	7	2.5E-5	352	46
34A	100	16	3.4E-5	352	49
35A	125	10	3.4E-5	350	49
36A	150	7	3.4E-5	345	45
37A	125	8	2.7E-5	350	51
38A	150	7	3.4E-5	345	49
				349	48

$k = 679.3$ $A_{95} = 2.6°$
$R = 5.993$ $N = 6$

Table 2. Paleomagnetic data from Hard Bargain locality 3. k is the Fisher precision parameter, A_{95} is the 95% statistical confidence limit and N is the number of samples.

DISCUSSION

The Hard Bargain mean directions were compared with established magnetotype directions, using the statistical technique of McFadden and Lowes (1981). Hard Bargain localities are statistically similar to each other at 95% confidence and thus are likely to be the same paleosol. Mean directions from the Hard Bargain Trail are similar to the Gaulin Cay magnetotype but different from the

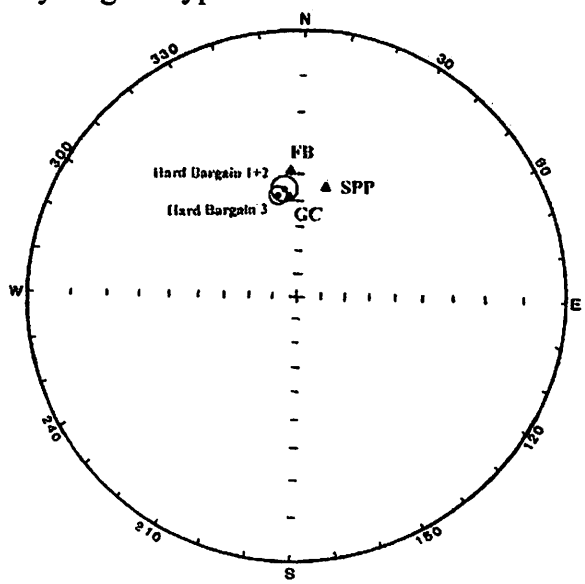

Figure 3. Stereographic plot of Hard Bargain mean direction with circles of 95% confidence. Triangles represent magnetotype reference directions: FB-Fernandez Bay, GC-Gaulin Cay, and SPP-Sandy Point Pits. Note that the Hard Bargain directions correlate with the Gaulin Cay magnetotype.

Fernandez Bay (cluster C) and Sandy Point Pits (SPP) magnetotypes (Figure 3). (The Moon Rock Pond mean was used in lieu of the Owls Hole data as the SPP reference direction, as it is a more stringent test of directional affinities.) Thus, the Hard Bargain reconnaissance directions are Gaulin Cay equivalents, indicating that the Hard Bargain paleosols overlie Owls Hole Formation rocks.

At face value, these findings are at odds with the work of Sparkman Johnson (1999) and Sparkman Johnson et al. (this volume). Petrographic analyses reported in these studies indicate that the majority of the rocks exposed in the Hard Bargain area are oolitic in

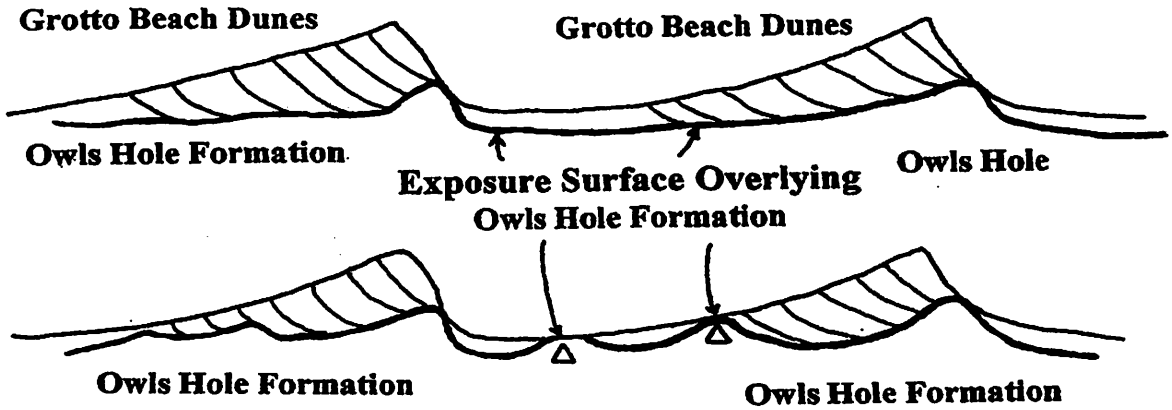

Figure 4. Cartoon showing model of dune formation in the Hard Bargain area. Upper diagram shows Sparkman Johnson model of Grotto Beach Formation dunes nucleating on topographic highs of Owls Hole rock. Lower diagram depicts a modified model where the pre-Grotto Beach exposure surface has more topographic relief than petrographic evidence would suggest. This implies that the occurrence of Owls Hole rock outcrops in the island's interior is probably very patchy. Triangles indicate Hard Bargain paleomagnetic sample localities.

nature: Grotto Beach Formation. Only the downwind portions of the eolianite dune ridges show bioclastic Owls Hole rocks. The paleomagnetic results strongly suggest Owls Hole rock in locations where Sparkman Johnson (1999) argues for Grotto Beach eolianite. The petro-graphic data are compelling; however, several outcrops in the Grotto Beach units determined by Sparkman Johnson (1999) are extensively micritized and neither bioclasts nor ooids are observed. It is suggested that the paleomagnetic data come from such localities where original lithology is masked and petrographic affinities can not be established.

The preferred interpretation is that, at least some of the micritized localities observed in the Hard Bargain area, represent windows exposing Gaulin Cay type paleosols and the underlying Owls Hole Formation. In this scenario, the Hard Bargain area consists of a significant paleo-topography of Owls Hole dune surface, extensively overlain by Grotto Beach rock (Figure 4). If the magnetozone correlation of Panuska et al. (1997, 1999) can be applied to interior sites of San Salvador, this interpretation predicts that numerous Fernandez Bay magnetozones should be observed in the Hard Bargain area, with only minor occurrence of Gaulin Cay or Sandy Point Pits magnetotypes.

CONCLUSIONS

Reconnaissance paleomagnetic data from the Hard Bargain region of San Salvador Island indicate Gaulin Cay magnetozone paleosols. This implies that older Owls Hole rock is more common than suggested by Sparkman Johnson (1999). It is possible that localized micritization prevented petrographic data from detecting Owls Hole units that appear to be indicated by paleomagnetic data. The preferred interpretation is that a significant paleo-topography of Owls Hole Formation is exposed beneath the Grotto Beach Formation dune ridges of Hard Bargain.

REFERENCES

Harris, J.G., Mylroie, J.E., and Carew, J.L., 1995, Banana holes: Unique karst

features of the Bahamas: Carbonates and Evaporites, v. 10, n. 2, p. 215-224.

Kirkova, J.T., 1994, Stability of paleomagnetic directions of paleosols on San Salvador Island, Bahamas [M.S. Thesis]: Mississippi State University, 91 p.

Lehnert, M.K., Mylroie, J.E., and Arnold, D.L., 1997, An analysis of the relationship between karst features and vegetation type on San Salvador Island, Bahamas, *in* Carew, J.L., ed., Proceedings of the 8th Symposium on the geology of the Bahamas and other carbonate regions: Bahamian Field Station, San Salvador, Bahamas, p. 122-134.

McFadden, P.L., and Lowes, F.J., 1981, The discrimination of mean directions drawn from Fisher distributions: Geophysical Journal of the Royal Astronomical Society, v. 67, p. 19-33.

Panuska, B.C., Carew, J.L., and Mylroie, J.E., 1991, Paleomagnetic directions of paleosols on San Salvador Island, Bahamas: prospects for a stratigraphic correlation, *in* Bain, R.J., ed., Proceedings of the Fifth Symposium on the Geology of the Bahamas: Bahamian Field Station, San Salvador, Bahamas, p. 193-202.

Panuska, B.C., Kirkova, J.T., Mylroie, J.E., and Carew J.L. 1995a, New Paleomagnetic stability tests for paleosols on San Salvador Island, Bahamas, *in* Boardman, M., ed., Proceedings of the Seventh Symposium on the Geology of the Bahamas: Bahamian Field Station, San Salvador, Bahamas, p. 89-96.

Panuska, B.C., Kirkova, J.T., Mylroie, J.E., and Carew J.L. 1995b, Correlation of paleosols on San Salvador Island using paleomagnetic directions, *in* Boardman, M., ed., Proceedings of the Seventh Symposium on the geology of the Bahamas: Bahamian Field Station, San Salvador, Bahamas, p. 82-98.

Panuska, B.C., Mylroie, J.E., and Carew, J.L., 1997, Stratigraphic Tests of Paleomagnetic Secular Variation Correlation of Paleosols, San Salvador Island, Bahamas, *in* Carew, J.L., ed., Proceedings of the 8th Symposium on the geology of the Bahamas and other carbonate regions: Bahamian Field Station, San Salvador, Bahamas, p. 148-157.

Panuska, B.C., Mylroie, J.E., and Carew, J.L., 1999, Paleomagnetic Evidence for Three Pleistocene Paleosols on San Salvador Island Bahamas *in* Curran, H.A., and Mylroie, J.E., eds., Proceedings of the 9th Symposium on the geology of the Bahamas and other carbonate regions, Bahamian Field Station, San Salvador, Bahamas, p. 93-100.

Sparkman Johnson, S.D., 1999, Investigation of the Geology of the Hard Bargain area, San Salvador Island, Bahamas [M.S. Thesis]: Mississippi State University, 121 p.

Sparkman-Johnson, S.D., Carew, J.L., and Mylroie, J.E., this volume, The surficial geology of the Hard Bargain area, San Salvador Island, Bahamas, in Greenstein, B. J. and Carney, C, eds., Proceedings of the 10th Symposium on the geology of the Bahamas and other carbonate regions: Bahamian Field Station, San Salvador, Bahamas, p. 68-80.