PROCEEDINGS OF THE EIGHTH SYMPOSIUM ON THE GEOLOGY OF THE BAHAMAS AND OTHER CARBONATE REGIONS

Edited by
James L. Carew

Production Editors
Daniel R. Suchy
Nicole G. Suchy

Bahamian Field Station, Ltd.
San Salvador, Bahamas
1997

Front Cover: View to the SSE on White Cay in Grahams Harbour off the north coast of San Salvador, Bahamas. At this spectacularly scenic site one can see that marine erosion has removed the entire windward portion of these early Holocene eolianites (North Point Member, with an alochem age of ~5000 radiocarbon years B.P.) that were deposited when sea level was at least 2 meters below its present position.

Back Cover: Stephen Jay Gould, keynote speaker for this symposium, holds a *Cerion rodregoi* at the Chicago Herald Tribune's 1891 monument to the landfall of Christopher Colombus, which is located on the windward coast of Crab Cay on the eastern side of San Salvador Island, Bahamas. The monument consists of an obelisk constructed from local limestone which houses a carved rock sphere depicting the globe with the continents. The inscription carved in a marble slab, reads: "On this spot, Christopher Columbus first set foot upon the soil of the New World."

Printed in USA by Don Heuer

ISBN 0-935909-63-X

STRATIGRAPHIC TESTS OF THE UTILITY OF PALEOMAGNETIC SECULAR VARIATION FOR CORRELATION OF PALEOSOLS, SAN SALVADOR ISLAND, BAHAMAS

Bruce C. Panuska and John E. Mylroie
Department of Geosciences
Mississippi State University
Mississippi State, MS 39762

James L. Carew
Department of Geology
University of Charleston
Charleston, SC 29424

ABSTRACT

We have tested the ability of mean paleomagnetic directions to distinguish the stratigraphic position of paleosols on San Salvador Island. Post-Grotto Beach Formation reference directions have been established from terra rossa paleosol outcrops of known stratigraphic setting. Geologic relationships near Singer Bar Point suggested that a contact between the Grotto Beach and Owl's Hole Formations must exist in this vicinity. Lithologic observations, supported by petrologic data, were used to constrain the position of this contact. Paleomagnetic directions from additional samples agree with the post-Grotto Beach reference directions predicted by the lithologic relationships at Singer Bar Point. Thus, post-Grotto Beach reference directions preserved in paleosols appear to be well-established. If pre-Grotto Beach reference directions can be confirmed, paleomagnetic secular variation correlation will be shown to be a valid stratigraphic tool.

INTRODUCTION

We have been attempting to develop paleomagnetic secular variation as a correlation tool for paleosols on San Salvador Island. Initial surveys of the paleomagnetic signatures of paleosols suggested that directional distinctions might be possible (Hudson and Panuska, 1990; Panuska et al., 1991). Follow up studies (Panuska and Mylroie, 1993; Kirkova, 1994; Panuska et al., 1995a) have provided considerable evidence for paleomagnetic stability of the remanence directions, a prerequisite for utilization in correlation. With these promising results, Panuska and others (1995b) made the first tentative stratigraphic correlations employing paleomagnetic direction comparison, and made some stratigraphic predictions based on field relationships and paleomagnetic signatures. Here, we report paleomagnetic results from paleosols at Singer Bar Point, which support the relationships predicted by Panuska et al. (1995b). Additionally, petrologic data support the stratigraphic and paleomagnetic context inferred from field and laboratory observations.

GEOLOGICAL SETTING

The exposed rocks of Bahamian islands (Figure 1) are all late Quaternary carbonates, with Pleistocene subtidal facies below 6 m elevation, and Pleistocene and Holocene eolianites at all elevations. Paleosols can overly any of these units. The glacio-eustatic sea-level changes of the Quaternary have alternately flooded and exposed the Bahamian platforms, subjecting them to cycles of carbonate deposition and dissolution, respectively. Significant carbonate deposition occurs only when the platform tops are partially or totally flooded.

The carbonate rocks of Bahamian islands consist of individual sedimentary packages deposited during sea-level highstands, separated by erosional unconformities (usually marked by terra rossa paleosols) produced largely during sea-level

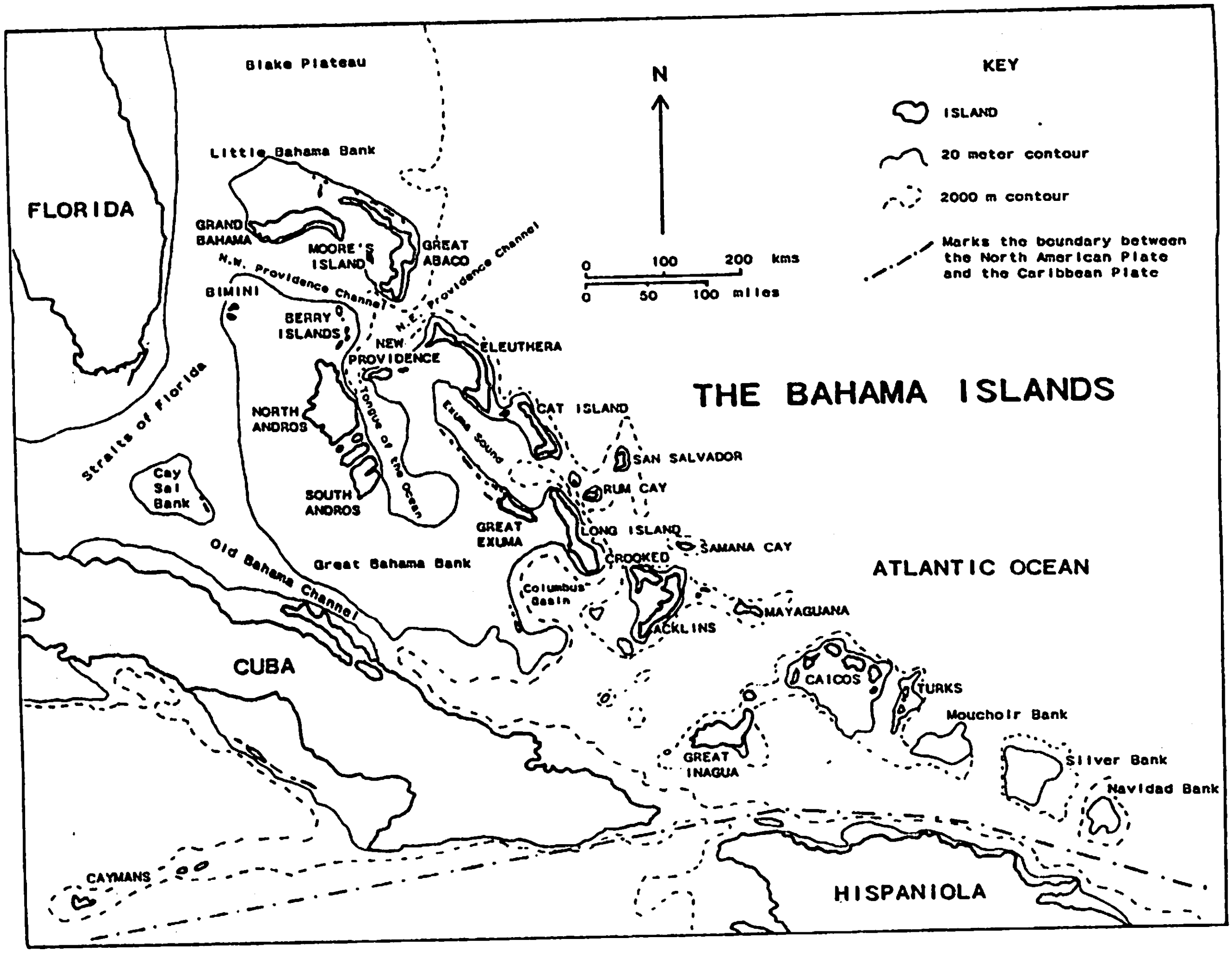

Figure 1. Map of the Bahama Islands and surrounding area, detailing islands, banks, and deep-water.

lowstands (Carew and Mylroie, 1985; 1995b). When sea level descends below the platform tops, erosional processes are dominant on the platforms, and soils that are eventually preserved as paleosols are largely produced. The use of paleosols as stratigraphic markers is very helpful in sorting out suites of Quaternary carbonates. Because of the spatially-patchy deposition of carbonates during each depositional cycle, and the complexities and similarities of paleosols, there are many potential difficulties in the use of paleosols as stratigraphic markers (Carew and Mylroie, 1991).

The Owl's Hole Formation comprises all Pleistocene eolianites older than oxygen isotope substage 5e, because these eolianite packages cannot be separated based on field criteria (Carew and Mylroie, 1994; 1995b). The eolianites of this unit are predominantly peloidal or bioclastic, and on San Salvador Island ooids are absent or rare. There are no subtidal units of this formation exposed above current sea level. The Owl's Hole Formation is usually recognized in the field by its relationship to overlying deposits (Figure 2).

Overlying the Owl's Hole, and separated from it by a terra rossa paleosol or other erosion surface, is the late Pleistocene Grotto Beach Formation. This formation was deposited during the substage-5e highstand (~125 ka). During Grotto Beach time, ooids were produced in great numbers and the vast majority of eolianites in the Grotto Beach Formation are either oolitic (up to 80-90% ooids) or contain appreciable ooids. Overlying the Grotto Beach Formation, and separated from it by a paleosol or other erosion surface, is the Holocene Rice Bay Formation.

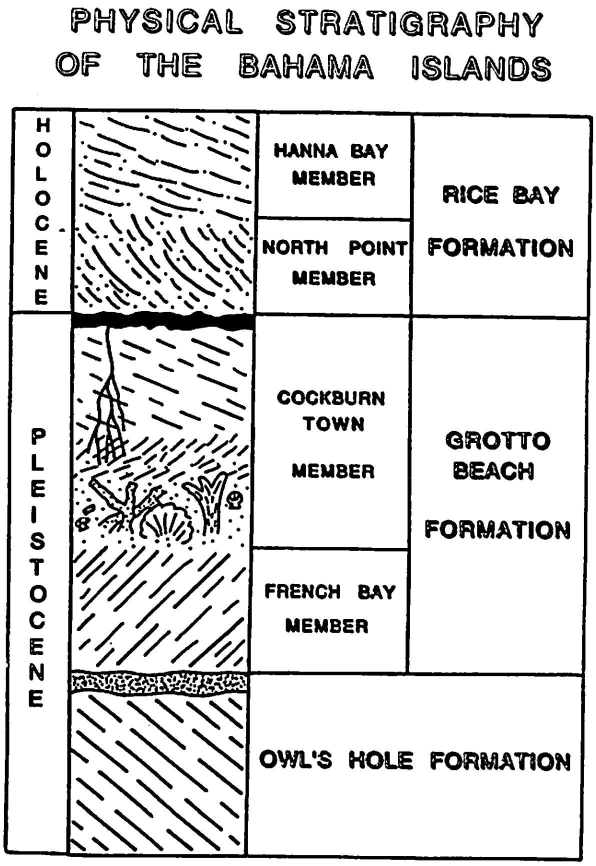

Figure 2. Physical stratigraphic column illustrating the temporal relationship between stratigraphic units (from Carew and Mylroie, 1995b). In the field, individual units are not necessarily seen stacked atop one another, but are often lateral to one another. The thin stippled and black layers are the terra rossa paleosols which are the subject of this study.

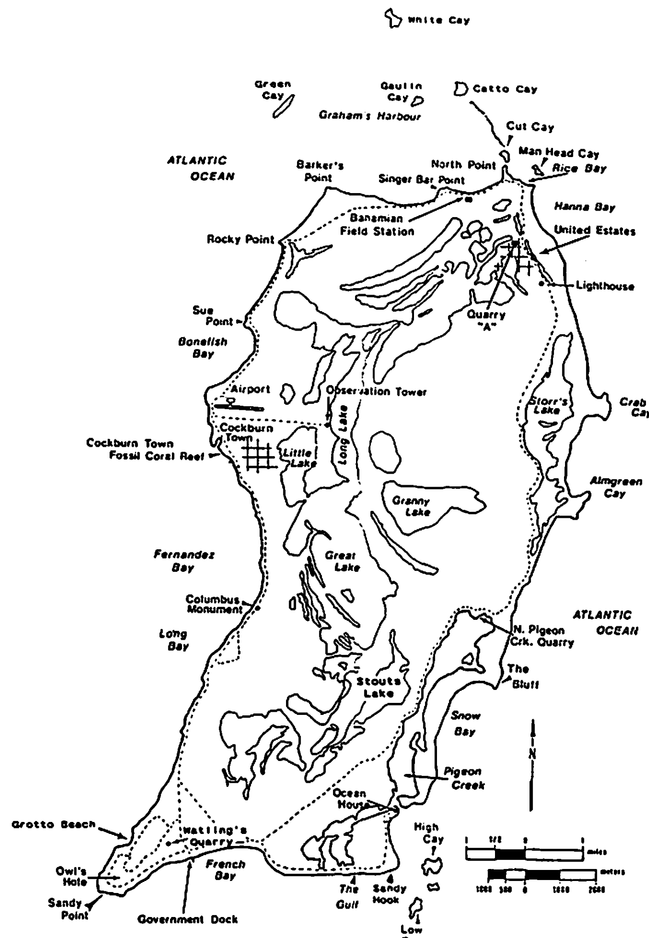

Figure 3. Map of San Salvador showing referenced localities.

PROVISIONAL PALEOMAGNETIC REFERENCE DIRECTIONS

Localities

Panuska et al (1995b) compiled the existing paleomagnetic studies, and based on results from stratigraphically well-controlled outcrops, established provisional reference directions for paleosols occurring both above and below the Grotto Beach Formation. The location of relevant sites is shown in Figure 3. Of particular interest to this study are outcrops at Pigeon Creek, Watling's Quarry, Fernandez Bay, Stout's Lake, Miller Pond, Singer Bar Point, "Stop 3", and Gaulin Cay. The Pigeon Creek outcrop consists of a fossil tidal delta (Thalman and Teeter, 1983) of the Grotto Beach Formation, which overlies a paleosol. At Watling's Quarry, excavation of Grotto Beach eolianites has exposed a lower paleosol and the underlying Owl's Hole rocks (Carew and Mylroie, 1985, 1995b). At Fernandez Bay, there is a broad stretch of Grotto Beach intertidal facies covered by a well-developed paleosol (Carew and Mylroie, 1995b). At Stout's Lake, there are exposed Grotto Beach lagoonal facies overlain by a well-developed paleosol, as is also found in the Miller Pond area (Hagey and Mylroie, 1995). Singer Bar Point is a geologically complex area where Grotto Beach and Owl's Hole rocks meet. At "Stop 3" (Carew and Mylroie, 1994), Grotto Beach rocks are overlain by Holocene Rice Bay Formation rocks. Gaulin Cay is a small island immediately northeast of Singer Bar Point that probably consists of Owl's Hole rocks (Panuska et al., 1995a).

Previous Paleomagnetic Data

At Fernandez Bay and Miller Pond, mean paleomagnetic directions from paleosols overlying subaqueous deposits of the Grotto Beach Formation yield a clearly post-Grotto Beach direction. In contrast, pre-Grotto Beach directions were initially identified at Pigeon Creek Quarry from the paleosol which occurs below the tidal delta sediments of the Grotto Beach Formation. Mean directions from paleosols sampled just east of Singer Bar Point and on Gaulin Cay were assigned to the pre-Grotto Beach magnetotype based on statistical similarity with the Pigeon Creek direction, using the test of McFadden and Lowes (1981). Unfortunately, although the lower paleosol at Watling's Quarry is stratigraphically well-understood, its paleomagnetic characterization is equivocal, perhaps due to its high elevation above sea level and possibly diachronous nature (Panuska et al., 1995b). That is, because the paleosol seen in the quarry exposure is well above any past Quaternary sea level position, it developed continuously from the time of deposition of the lower eolianite (stage 7 or earlier) until deposition of the overlying eolianite during substage 5e (~ 125 ka), and thus it may contain a complex paleomagnetic signature.

A pre-Grotto Beach paleomagnetic direction in the paleosol exposed at Singer Bar Point can be used to predict that the paleosol here rests on the Owl's Hole Formation; however, rocks just 1 km to the south-southwest of this locality consist of a paleosol overlying oolitic Grotto Beach Formation rocks (Stop 3, Carew and Mylroie, 1994). These data suggest that a formational contact exists somewhere between these two localities. Panuska et al. (1995b) provisionally identified the contact at a locality approximately 30 m east of Singer Bar Point based on the presence of bioclastic rocks beneath the paleosol from which the paleomagnetic samples were taken. In contrast, southwest of the Point there are ooid-rich rocks that can be traced continuously from the Point to the Stop 3 locality. This relationship implies that the paleosol overlying these oolitic (Grotto Beach) rocks should yield a post-Grotto Beach paleomagnetic signature.

PETROLOGIC EVIDENCE

A suite of samples from just beneath the paleosol was taken along the outcrops at Singer Bar Point. The easternmost sample of Pleistocene rock was obtained about 10 meters west of the westernmost Holocene Hanna Bay Member outcrop, beneath a bright red terra rossa paleosol. Samples were then taken at approximately 50 meter intervals and visually examined in the field with a hand lens. Where the outcrop reaches its westernmost exposure and then trends south-southwest, there is a pronounced change in composition that is readily seen in hand sample. Closely spaced samples were examined at that location in an attempt to determine the precise location of the change and to determine the relationships between the rocks types there. Thin sections of three samples from east of the point, and three at the point and to the south-southwest were point counted using standard procedures.

The three eastern samples are moderate to poorly-sorted coarse to very coarse calcarenites (average size of ~1 to 1.5 mm) containing abundant peloids, mollusc fragments, forams, *Halimeda*, and red algae, but few or no ooids. Among the few ooids, both well-developed and superficial ooids are present. These rocks are cemented with nearly equant low-Mg calcite. The pore spaces in some layers are nearly completely cemented, and other layers have open pores and only meniscus cements. The pores of some *Halimeda* are filled with spar. These rocks are coarse peloidal biosparites, or peloidal fossiliferous grainstones.

The three western samples are well-sorted fine to medium calcarenites (average allochem size of ~0.25 to 0.4 mm) containing abundant well-developed ooids, peloids, and relatively few mollusc fragments and forams. Porosity is generally high, and cementation is primarily by low-Mg calcite meniscus cement, with limited areas of pore-filling equant calcite. These rocks are fine oosparites, or oolitic grainstones.

Close examination of the outcrop, at

and just south-southwest of the Point, failed to identify the precise location of the overlap of the oolitic rocks onto the bioclastic ones, and there is no recognizable paleosol between them at this location. However, the petrologic data are consistent with a contact at which the paleosol, once covering the Owl's Hole rocks, has been partially removed by marine erosion during deposition of the Grotto Beach rocks. Such a sequence has been described at the Grotto Beach Formation type locality at Grotto Beach (Figure 3), where reefal rocks of the Grotto Beach Formation sit directly on a wave-cut bench carved into the underlying Owl's Hole Formation, such that the paleosol separating the two formations is eroded away (Carew and Mylroie, 1985, 1994, 1995b). At Singer Bar Point, it appears that portions of the terra rossa paleosol covering the Owl's Hole Formation, in the area of the present contact with the Grotto Beach Formation, were removed by erosion. Farther east, where the Owl's Hole rocks are slightly higher in elevation, and are not currently onlapped by Grotto Beach rocks, the paleosol survived. Thus, the petrologic data support the interpretation that the paleosol east of the Point appears to be the one between the Owl's Hole Formation and the Grotto Beach Formation, while west of the Point it is the post-Grotto Beach paleosol.

PALEOMAGNETIC DATA

As a test of the validity of correlation of paleosols based on paleomagnetic directions, we collected paleosol core samples from three localities at and to the south-southwest of Singer Bar Point where there is a presumed contact between the Owl's Hole Formation (east of the point) and the Grotto Beach Formation (west of the point). Unfortunately, about half of the samples were too weak for measurement using a spinner magnetometer (Schonstedt SSM-1A).

Six cores were measured from the locality at Singer Bar Point, locality A, with three giving reliable demagnetization end points. Seven samples from a locality 30-40 m south-southwest of Singer Bar Point, locality B, were also strong enough to measure. Most cores (14) from a third locality located about 100 m southwest of the Point (locality C) were too weak for reliable measurement and three samples, although strong enough to measure, gave no stable demagnetization end point direction.

Initial intensities of the measured samples ranged from 5.6 x 10^6 emu/cm3 to 8.2 x 10^8 emu/cm^3. The initial intensity of the weak sample is misleading because this sample had a strong secondary component antiparallel to the characteristic direction. This secondary component was removed by 25 Oersteds (Oe) of alternating field (AF) cleaning, at which point the intensity increased ten-fold.

All samples were subjected to stepwise AF cleaning (using a Molspin Shielded Alternating Field Demagnetizer) to peak fields of 150 to 250 Oe, usually in 25 Oe increments. Some samples showed modest effects of rotation remanent magnetization (RRM), a spurious remanence applied to the sample during AF cleaning. When RRM was suspected, the sample was remeasured after a second cleaning at the same intensity, but loaded into the AF unit with opposite tumbling orientation. This procedure reorients the RRM component 180° to the previous measurement. Averaging the remanence directions for normal and inverted sample loading in the AF tumbler effectively removes the RRM.

Secondary components were removed between 25 and 75 Oe of AF treatment (Figure 4). At higher AF peak fields, characteristic directions were observed as nearly straight-line signal decay to the origin. Characteristic directions for samples were averaged by locality to calculate a mean direction and estimate the scatter. The three samples from Singer Bar Point yield a Fisher precision parameter, kappa, of 242, indicating low data dispersion (Table 1). The seven samples from locality B showed a more dispersed kappa of 43, because of the effects of one sample with a direction located 27° from the mean direction (Figure 5; Table 2). This datum can be rejected, using the theta statistic of McFadden (1980).

It should be noted that the demagnetization path for that specimen appeared somewhat anomalous because its remanence decay path was curved, which suggests multiple components with overlapping coercivity spectra. This sample's characteristic

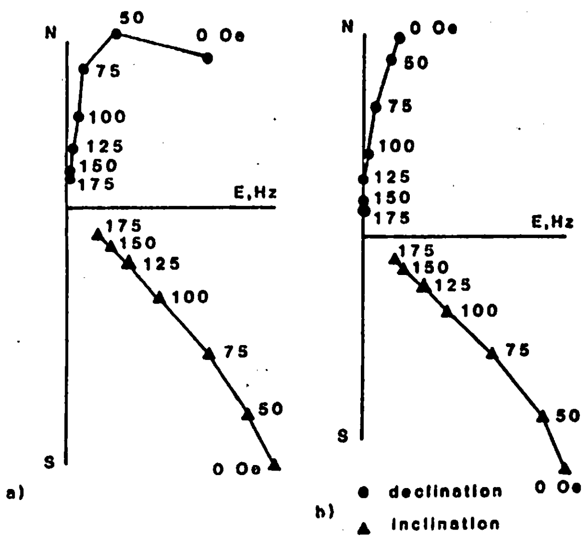

Figure 4. Representative vector diagrams showing demagnetization paths. a) Secondary component is removed after 75 Oe of AF demagnetization. b) this sample is essentially free of secondary magnetic components. Declination (dots) is shown in terms of north, east, and south directions. Inclination (triangles) are plotted in terms of up, down, and horizontal orientation.

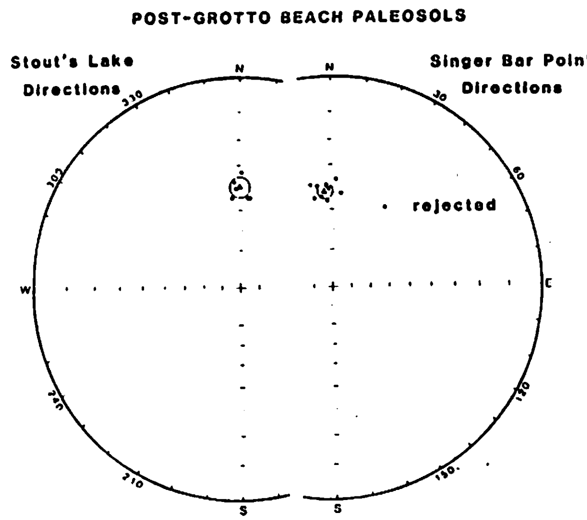

Figure 5. Stereographic projection showing characteristic sample directions and means. Mean is shown with a triangle. Circle represents 95% confidence interval. Singer Bar Point directions comprise both the A and B localities. The aberrant datum, which is probably an incompletely cleaned direction, was rejected on the basis of the theta statistic.

TABLE 1. Singer Bar Point, Locality A - Paleomagnetic Data

Sample	Demag	%NRM	NRM Intensity	Geographic Dec	Geographic Inc
84A	150	33	9.8E-7	357	39
97A	175	8	5.6E-6	6	42
98A	125	16	4.7E-6	357	46
				0	42

k = 242.3 $A_{95} = 7.9^{o}$
R = 2.992 N = 3

direction had the greatest departure from a linear trend to the origin, and it is possible that the sample could not be fully cleaned. All other samples displayed vector plots composed of linear demagnetization segments indicating no overlap of component coercivities. So, with the deletion of that sample, the dispersion improved dramatically to kappa = 219.

The mean directions for these new localities were tested for similarity with each other, and with other localities, using the statistical technique of McFadden and Lowes (1981). Localities A and B (Singer Bar Point and 30 m to the southwest) are statistically the same at 95% confidence. These two localities were then averaged together for comparison with other localities. The Singer Bar A/B direction was found to be the same as the directions from the Fernandez Bay and Miller Pond localities (known post-Grotto Beach paleosols). Additionally, the Singer Bar A/B directions are statistically different from the pre-Grotto Beach directions obtained from samples taken 30 m east of Singer Bar Point.

An additional set of paleomagnetic data was acquired from a terra rossa paleosol at

TABLE 2. Singer Bar Point, Locality B - Paleomagnetic Data

Sample	Demag	%NRM	NRM Intensity	Geographic Dec	Geographic Inc
46A	250	34	1.0E-6	34	41*
47A	125	61	7.5E-7	358	40
49A	150	37	1.1E-6	352	39
51A	100	439	8.2E-8	3	36**
53A	200	37	5.4E-7	354	44
54A	200	34	9.3E-7	349	44
55A	200	51	7.0E-7	348	38
				354	40
			k = 219.1	A95 = 4.5°	
			R = 5.977	N = 6	

* - omitted from mean by Theta statistic

** - Sample 51A contained a low coercivity antiparallel component which was removed by 25 Oe AF cleaning; removal of this component allowed the intensity to increase to 1,000% of initial intensity. Percent NRM relative to the maximum intensity is 43.9%.

Mean of Singer Bar Point Localities A + B:

Declination = 356°, Inclination = 41°
k = 208.2 A95 = 3.6, N = 9, R = 8.962

Stout's Lake. At this locality, the paleosol overlies a lagoon/tidal creek facies of the Grotto Beach Formation (Hagey, 1991; Hagey and Mylroie, 1995). Six paleosol samples were analyzed from a paleosol overlying Grotto Beach rocks. Initial intensities were fairly strong, ranging from 1.8 x 10^5 to 9.5 x 10^5 emu/cm^3. AF demagnetization of the samples was performed as described for the Singer Bar Point samples. RRM was encountered between 125 and 200 Oe. Averaging effectively removed RRM overprints and demagnetization plots displayed linear vector paths to the origin.

The Stout's Lake mean direction is 0° declination, 40° inclination (Table 3). This mean is well defined with a low dispersion (kappa = 205, Figure 5) and is statistically similar to those of the post-Grotto Beach Singer Bar Point (A/B), Fernandez Bay, and Miller Pond samples; and they are statistically different from the pre-Grotto Beach paleosol directions.

DISCUSSION

The discrimination between pre- and post-Grotto Beach directions at Singer Bar Point, as predicted by the hand sample and petrologic data, strongly suggests that use of paleomagnetic directions for paleosol correlation is valid. Further demonstration of the utility of paleomagnetic signatures for correlation of paleosols is provided by the occurrence of the predicted post-Grotto Beach direction from the Stout's Lake paleosol. The post-Grotto Beach directions show very little dispersion of locality means (Figure 6). All directions are statistically the same as the Fernandez Bay locality, which consists of 5 sub-localities comprising 28 samples. These directions are here termed the Fernandez Bay

TABLE 3. Stout's Lake Locality - Paleomagnetic Directions

Sample	Demag	%NRM	NRM Intensity	Geographic Dec	Geographic Inc
29A	150	17	1.8E-5	5	44
31A	100	32	4.7E-5	6	44
32A	175	12	1.8E-5	357	37
34A	200	11	9.5E-5	355	44
35A	150	16	9.2E-5	358	40
40A	125	14	7.3E-5	1	33
				0	40

k = 204.5 A95 = 4.7°
R = 5.976 N = 6

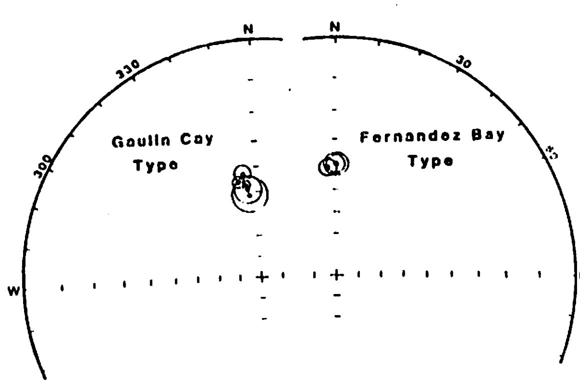

Figure 6. Stereographic projection of locality means and circles of confidence for different stratigraphic horizons. Fernandez Bay Type directions are from post-Grotto Beach Formation paleosols. Gaulin Cay Type directions are from pre-Grotto Beach Formation paleosols. The open dot mean in the Gaulin Cay directions represents the Watling's Quarry data that gives equivocal directional correlation (see text and Panuska et al., 1995b for discussion).

Type directions, and they are considered the magnetotype correlation criterion for relating paleosols occurring above the Grotto Beach Formation. The Fernandez Bay Type direction (mean of locality means) is declination = 358°, inclination = 40°, (kappa = 1956, A_{95} = 2.1°, N=4).

The pre-Grotto Beach directions are somewhat less well defined Figure 6). The mean of locality means listed in Panuska et al. (1995b) (omitting the Watling's Quarry directions) is declination = 353°, inclination = 48°, (kappa = 736, A_{95} = 3.4°, N=4). Although no single pre-Grotto Beach direction is clearly representative, the Gaulin Cay directions are provisionally designated as the magnetotype because Gaulin Cay is the site with the most convincing stability test and the mean of both the upper and lower paleosol horizons probably gives the best time-averaged direction. As the Gaulin Cay Type mean directions are based on relatively few samples, it is desirable to acquire more data to provide for a better directional characterization.

CONCLUSIONS

The mean of locality mean directions for two temporally different paleosols shows a small but measurable difference (Figure 7). With suites of 6-10 cores from a terra rossa paleosol, it should be possible to distinguish between these directions on a statistically valid basis. If the Gaulin Cay magnetotype can be confirmed with more detailed sampling, paleomagnetic directions can be considered a valid stratigraphic correlation criterion for paleosols on San Salvador and perhaps elsewhere in the Bahamas.

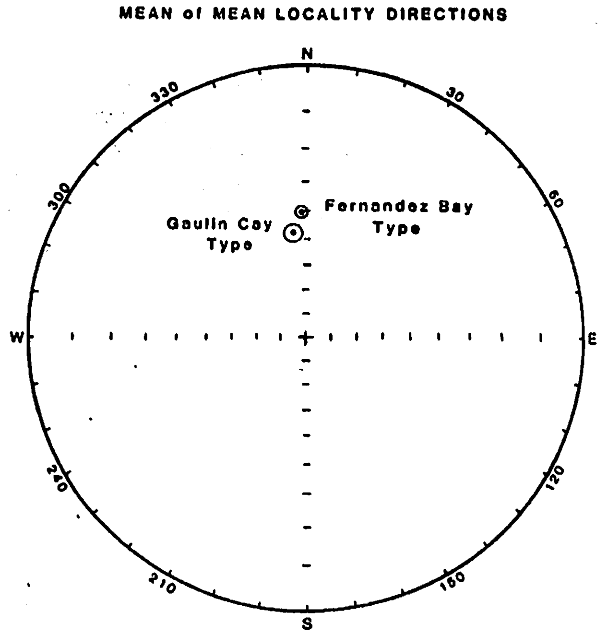

Figure 7. Mean of locality mean directions. The comparison of stratigraphically distinct paleosols shows small but statistically different paleomagnetic mean directions.

ACKNOWLEDGMENTS

We thank the Bahamian Field Station and its staff for logistical and financial support of this research; and we thank the Bahamian government for granting us research permits for this work. We also thank Mississippi State University and the University of Charleston for support.

REFERENCES

Carew, J. L. and Mylroie, J. E., 1985, Pleistocene and Holocene stratigraphy of San Salvador Island, Bahamas, with reference to marine and terrestrial lithofacies at French Bay, *in* Curran, H. A., ed., Guidebook for Geological Society of America, Orlando Annual Meeting Field Trip #2, Fort Lauderdale, Florida: San Salvador, CCFL Bahamian Field Station, p. 11-61.

Carew, J. L. and Mylroie, J. E., 1991, Some pitfalls in paleosol interpretation in carbonate sequences: Carbonates and Evaporites, v. 6, p. 69-74.

Carew, J. L. and Mylroie, J. E., 1994, Geology and Karst of San Salvador Island, Bahamas: A Field Trip Guidebook: San Salvador, Bahamian Field Station, 32p.

Carew, J. L. and Mylroie, J. E., 1995a, Quaternary tectonic stability of the Bahamian Archipelago: Evidence from fossil coral reefs and flank margin caves: Quaternary Science Reviews, v. 14, p. 145-153.

Carew, J. L. and Mylroie, J. E., 1995b, Depositional model and stratigraphy for the Quaternary geology of the Bahama Islands, *in* Curran, H. A. and White, B., eds., Terrestrial and Shallow Marine Geology of the Bahamas and Bermuda: Geological Society of America Special Paper 300, p.5-32.

Hagey, F. M., 1991, Analysis of Pleistocene inland lake and lagoon deposits, San Salvador Island, Bahamas: M.Sc. Thesis, Mississippi State University, 132 p.

Hagey, F. M. and Mylroie, J. E., 1995, Pleistocene lake and lagoon deposits, San Salvador Island, Bahamas, *in* Curran, H. A. and White, B., eds., Terrestrial and Shallow Marine Geology of the Bahamas and Bermuda: Geological Society of America Special Paper 300, p. 77-90.

Hudson, C. A. and Panuska, B. C., 1990, Paleomagnetic correlation of Pleistocene paleosols: San Salvador Island, Bahamas: The Compass, v. 67, p. 240-247.

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

McFadden, P. L., 1980, Determination of the angle in a Fisher distribution which will be exceeded with a given probability: Geophysical Journal of the

Royal Astronomical Society: v. 60, p. 391-396.

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.

Mylroie, J. E., Carew, J. L. and Barton, C. E., 1985, Paleosols and karst development, San Salvador Island, Bahamas: Program of the 1985 National Speleological Society Annual Convention, Frankfurt, KY, p. 43.

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: San Salvador, Bahamian Field Station, p. 193-202.

Panuska, B. C. and Mylroie, J. E., 1993, Evidence for paleomagnetic stability of paleosols on San Salvador Island, Bahamas, *in* White, B., ed., Proceedings of the Sixth Symposium on the Geology of the Bahamas: San Salvador, Bahamian Field Station, p. 125-129.

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

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

Thalman, K. L. and Teeter, J. W., 1983, A Pleistocene estuary and its modern analog, San Salvador, Bahamas, *in* Gerace, D. T., ed., Proceedings of the First Symposium on the Geology of the Bahamas: Miami, Florida, CCFL Bahamian Field Station, p. 13-21.