PROCEEDINGS OF THE FIRST SYMPOSIUM ON THE GEOLOGY OF THE BAHAMAS

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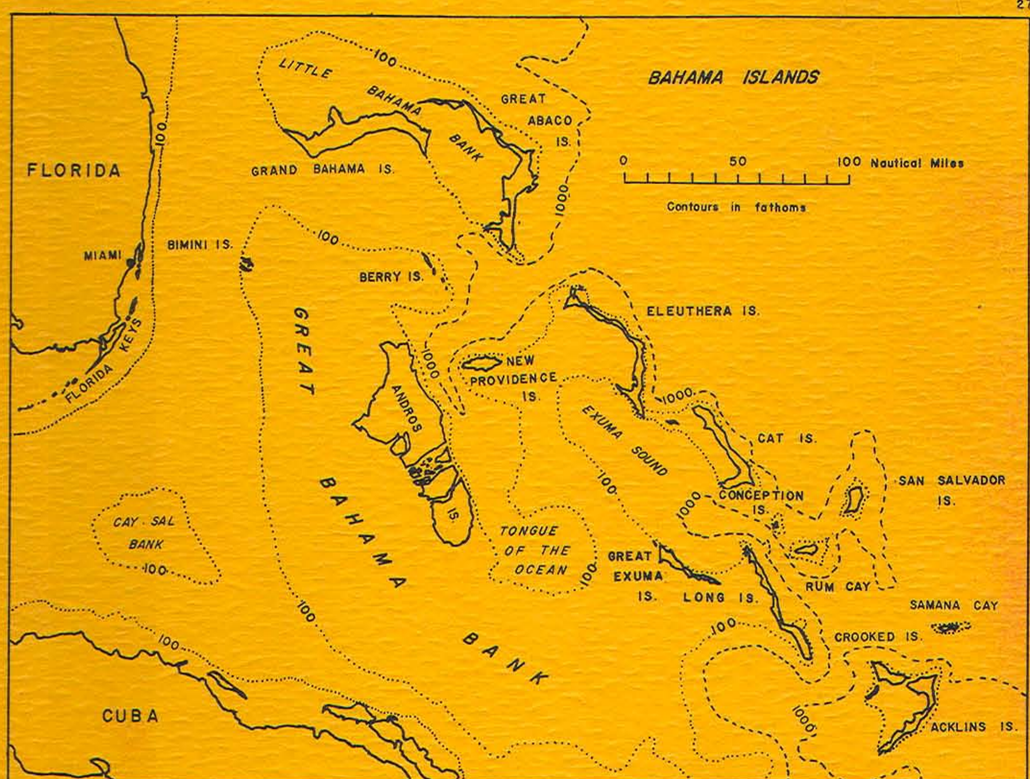

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KARST GEOLOGY AND PLEISTOCENE HISTORY OF SAN SALVADOR ISLAND, BAHAMAS

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San Salvador Island has provided an excellent field laboratory for the investigation of karst processes in the Pleistocene and Holocene limestone of the Bahamas. The denudation of limestone landscapes, with the concurrent development of surface and subsurface karst features, provide an insight into present and past climatic conditions. As climate changes through time, the nature of the karst features change as well, and relict karst features preserve a record of past events. The rise and fall of sea level during the Pleistocene changes base level conditions and therefore, cave conduit horizons. The change of position of dateable cave conduit levels allows accurate assessment of sea level changes. In the Bahamas, the changes of sea level and climate were the major driving forces in producing the Pleistocene geologic history of the area.

San Salvador Island has been the focus of this study because it has excellent field facilities, a wealth of karst features, and it is an isolated platform remaining discrete during the sea level changes of the Pleistocene. This is critical, for on the main Bahama platform, sea level fluctuation can greatly change the exposed catchment area of the platforms. The karst studies have two main aspects: the study of surface features, primarily paleosols; and the study of solution conduits (caves) in the subsurface. The investigations described herein are still in the preliminary stage, with data collection and reduction far from complete.

The surface karst study shows that denudation by solution has been the major sculptor of the island's landscape. The evidence of this denudation is the persistent paleosols, and the current rock surface itself, which cuts across subsurface features formed at earlier times. The paleosols are being analyzed for their paleomagnetic record, in hopes of providing a means of correlating the many scattered paleosol sites of the island. Amino acid racemization dating of fossil shell material (Cerion) in the paleosols is yielding a series of dates that will help produce a chronology of denudation events. See Carew (this volume) for a further discussion of this topic.

Paleosols are abundant on the island, and often associated with trace fossils of plant roots and animal burrows. The major paleosol sites are at Rocky Point, Grahams Harbor, Crab Key, Snow Bay, Sandy Point Plantation Quarry and Western French Bay. In some areas, such as Crab Key, paleosols have developed on eroded Pleistocene coral heads, and the entire sequence is below current mean tide. This indicates the complexity produced by sea level change and karst denudation over a relatively short geologic time span.

The study of cave conduits yields additional data about surface conditions. Calcite speleothems (stalagmites are preferred) can be dated by Uranium/Thorium disequilibrium measurements. This provides a minimum age for the conduit as it can be no younger than the secondary calcite deposits within it.

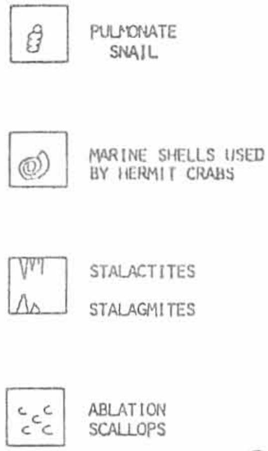
Maximum conduit age can be determined from amino acid racemization dates of shell material within the wall rock. These two dating methods allow delineament of a time window, during which the conduit formed. The cave conduits were developed by meteroic water percolating into the limestone, then moving laterally to the sea. This lateral movement occurred within the phreatic zone of the fresh water lens. The fresh water lens is "base level", and its position is determined by the level of the seawater on which it floats. As sea levl changes elevation, the fresh water lens changes elevation as well, and cave conduit horizon elevation will also shift. Measurement of ablation scallops on the walls of the cave conduits provides data on the direction and velocity of water flow (Curl, 1966), which along with conduit cross section yield the conduit discharge. Since the catchment area of the island is fixed, within a small range even as sea level fluctuates, estimates of meteoric recharge at the time of cave formation may be made. This leads to boundary conditions for the nature of the regional climate at that time. Figure 1 is a diagrammatic representation of the data sources for cave conduit study.

Major cave conduits are found at Lighthouse Cave, Deep Hole Cave, and the Sandy Point area. These features have provided a wealth of data, and are marked on the index map. For a more complete description of the caves and karst features of San Salvador, see Mylroie, 1980.

The history of cave conduit development in the Bahamas is idealized in Figure 2. The elevation of cave conduit development

FIGURE 1

DETERMINATION OF THE HISTORY OF CAVE CONDUIT DEVELOPMENT



Amino acid racemization age dating of pulmonate snail shells and hermit crab transported marine shells gives a date for the age of the eolian calcarenite. This age is a maximum value for the age of the cave conduit, which cannot be older than the rock it is formed in. Uranium series age dating of calcite deposits (stalactites and stalagmites) gives a minimum age for the cave conduit. Uranium series dating can determine the rate of growth of calcite deposits, a measure of climatic conditions at the time of deposition. Ablation scallops reveal water flow direction and velocity, which also has climatic implications.

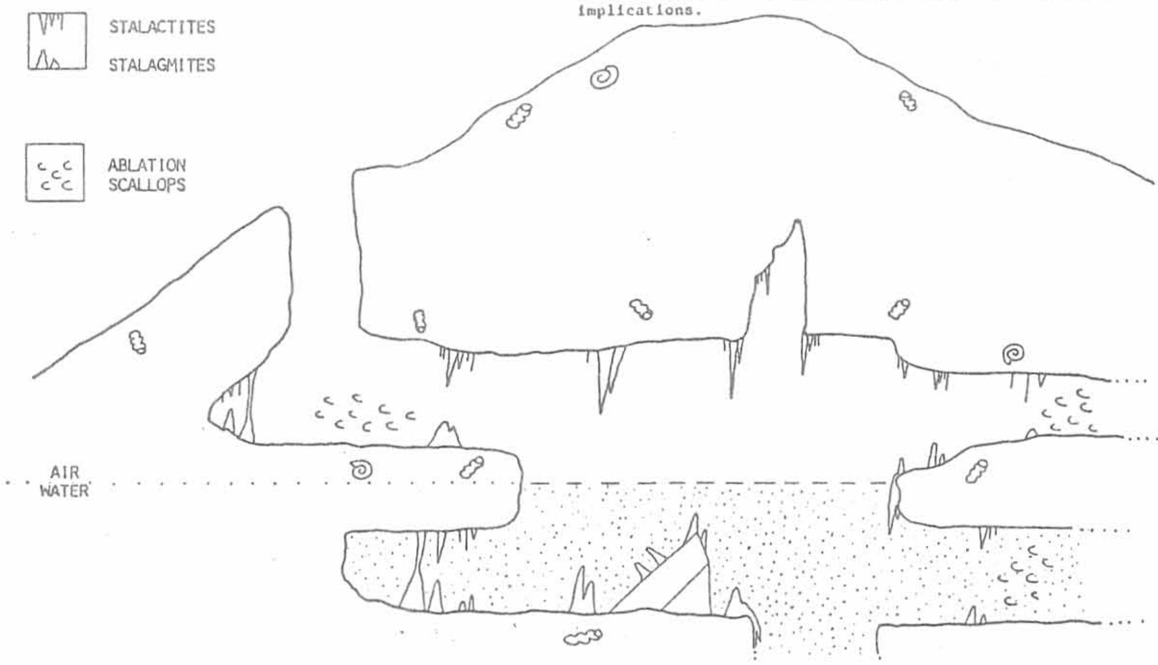
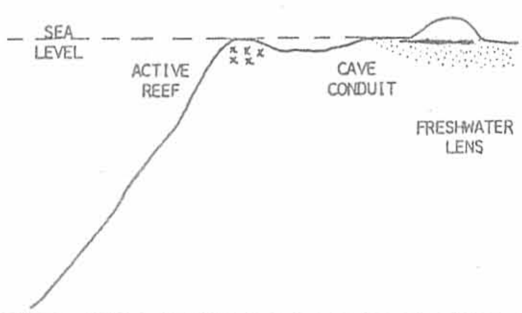


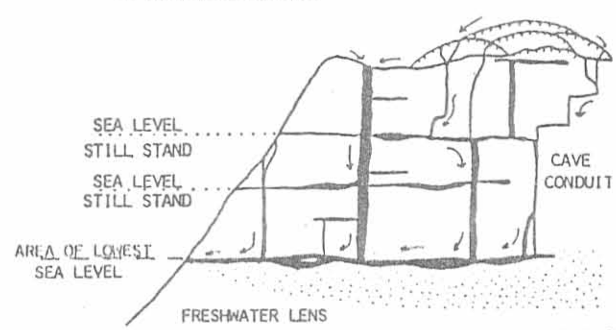
FIGURE 2

PLEISTOCENE HISTORY OF CAVE DEVELOPMENT IN THE BAHAMAS

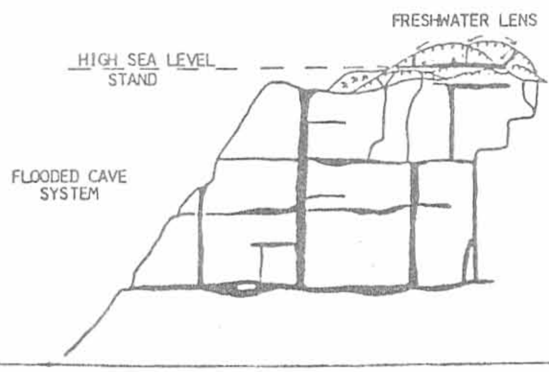
STAGE I: Stable, pre-glacial conditions. Cave development is dependent on land being available and supporting a freshwater lens.



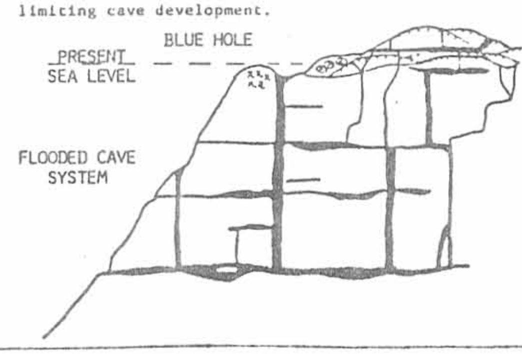
STAGE II: Falling sea level promotes increased dune formation and exposes the entire carbonate platform. The freshwater lens drops with each lowering of sea level, producing cave conduits at numerous horizons.



STAGE III: Interglacial high sea level stands produce limited cave development at elevations above present sea level. Cave conduits from lower sea levels become flooded.



STAGE IV: Present conditions. Numerous sea level fluctuations have produced a multi-level fossil cave system at many horizons. This allows freer access of tidal sea water pulses to the interior of the island by way of the fossil caves. On smaller platforms, this agitation may disrupt the freshwater lens, limiting cave development.



is tied to sea level position. Caves that are airfilled today are reported from throughout the Bahamas (Mylroie, 1978) and formed during a past, higher sea level, most likely at an interglacial time. Flooded solution conduits containing subaerial calcite speleothems are also found through the Bahamas (Williams, 1979), recording cave development and subsequent draining during glacial low sea level stands. Systematic study of conduit size, age and elevation can reveal the exact manner of sea level change. The data currently available suggests that sea level change occurred as discrete jumps during the Pleistocene, and can provide data on the episodic nature of ice advance and retreat.

As sea level has fluctuated up and down through the Pleistocene, the Bahama Islands have become riddled with solution conduits at a variety of levels, and conduit complexity has increased with time. Despite the dramatic tidal flushing seen in some Bahamian blue holes, on large islands the fresh water lens still develops, with a stable boundary with the underlying salt water even in submerged conduits (Williams, 1979). In smaller islands, such as San Salvador, tidal motion and flow through flooded cave passages in the interior of the island partitions the freshwater lens, limiting conduit development and integration for the future.

In conclusion, the study of surface and subsurface karst features in the Bahamas may be a key to understanding Pleistocene climate in the area. Cave conduits provide an excellent data source for glacial eustatic sea level change. The data are all preliminary, however, and much work is needed to describe and validate the Pleistocene geologic history of the area.

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