EOGENETIC KARST: A DECADE LATER

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ABSTRACT: The original definition of karst development in eogenetic rocks, as presented by H.L. Vacher and J.E. Mylroie in 2002, was "we use the term *eogenetic karst* for the land surface evolving on, and the pore system developing in, rocks undergoing eogenetic, meteoric diagenesis." Since that time karst research has been extensively conducted on carbonate coasts and islands around the world. The majority of these locations are tropical to subtropical, as the carbonate rocks are still proximal to their environment of deposition. A decade later, our research has updated some facets of the original presentation. The top of the fresh-water lens was originally presented as a speleogenetic environment as a result of vadose/phreatic fresh-water mixing, primarily based on banana hole development in the Bahamas. The geochemical evidence for dissolutional aggressivity at the top of the lens was equivocal, and banana holes have been reinterpreted as flank margin caves sequentially developing in a migrating lens margin hosted by a prograding strand plain. Despite both field and model evidence of large permeability increases in carbonate rocks throughout the fresh-water lens as touching-vug porosity, mega porosity is restricted to the lens margin in islands too small to develop conduit flow. In larger islands (and continental carbonate coasts such as the Yucatan), conduit cave and flank margin cave mega porosity co-exist as independent flow systems. Conduit flow systems are a major contributor to progradational collapse systems, which produce most subaerial caves on Bermuda and most blue holes in the Bahamas. Conduit/lens interactions remain a research frontier, especially where the conduit is perched on non-carbonates before reaching the lens. The flank margin cave morphological pattern is the result of volumetric dissolution, hosted in eogenetic rocks by the high value (~30%) of primary porosity. In telogenetic rocks, where such 3-D dissolution occurs it is the result of the carbonate rock having conditions that mimic eogenetic rocks. In Croatia this mimicry is achieved by a paleotalus facies, in New Zealand by a high density fracture system produced by tectonics. The New Zealand example is instructive, as the telogenetic rocks involved there are Oligocene, in tectonically quiescent Florida the same age rocks are eogenetic.

Figure 4: During glaciations, eustatic sea-level fall changes small islands into big islands. Meteoric catchment area increases by the square, but the discharge perimeter increases only linearly. This input/output imbalance leads to the development of conduit caves as well as flank margin caves.

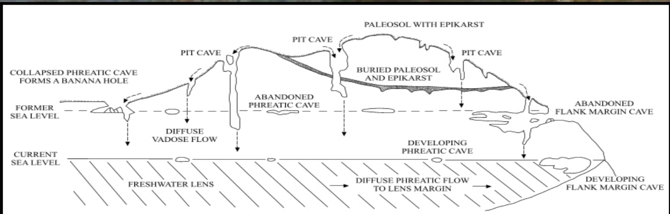


Figure 1: This cartoon portrays banana holes as forming at the top of the fresh-water lens, and when the overlying rock is thin (left in image), collapse leads to surface expression. The proposed mechanism (Harris et al., 1995) was that vadose/phreatic fresh-water mixing created the dissolutional aggressivity to create the voids. Geochemical data taken from the top of the lens failed to clearly demonstrate the necessary dissolutional potential, making the model uncertain.

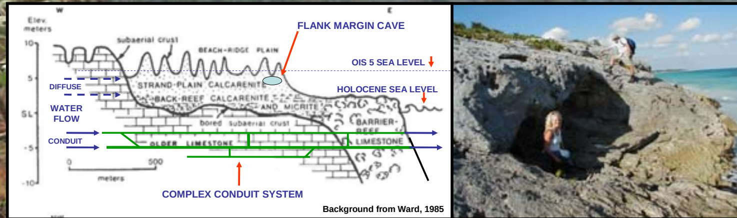
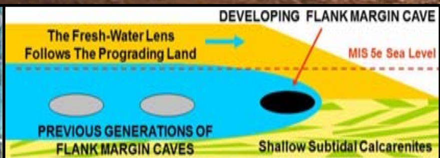


Figure 5: In Quintana Roo State, Mexico, flank margin caves developed on the coastal periphery during MIS 5e, while large conduit cave systems simultaneously drained the platform interior, a dual hydrologic dissolutional system.

Figure 2: Observations from across the Bahamas revealed that banana holes were found only in MIS 5e prograding strand plains, indicating a specific control on their development.



BANANA HOLES FORM AS THE RESULT OF MIXING SALTWATER AND FRESHWATER AT THE LENS MARGIN WITHIN A PROGRADING STRAND PLAIN.

Figure 3: The new model explains the great abundance of banana holes in the Bahamas, and their relative absence in reef-limestone islands. It also explains their small size and simplicity as immature flank margin caves, and requires no problematic vadose/phreatic fresh-water mixing geochemistry.

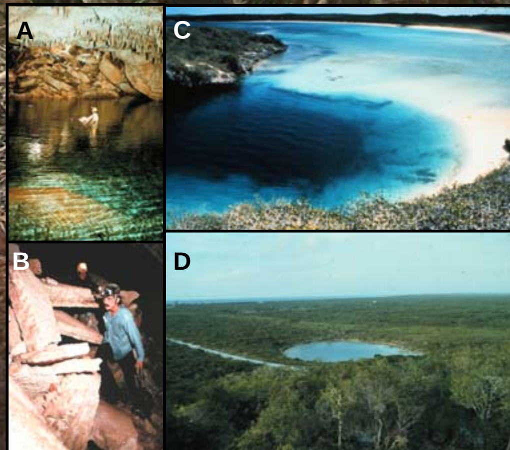


Figure 6: Many blue holes result from progradational collapse of cave chambers. A and B) Collapse chambers in Bermuda caves, continued collapse will breach to the surface (photos A. Palmer). C) Deans Blue Hole, an ocean hole with a direct marine connection. D) Watlings Blue Hole, an inland blue hole with a salinity profile from fresh to marine.

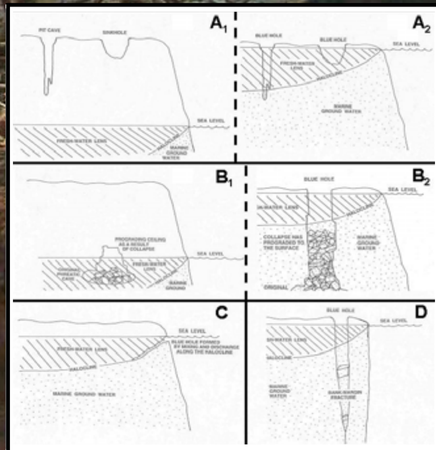


Figure 7: Methods of blue hole development. The most common type appear to be B_1 – B_2, the accommodation space for the collapse material being conduit systems formed when the carbonate platforms were very large as glacioeustasy created substantial subaerial exposure.

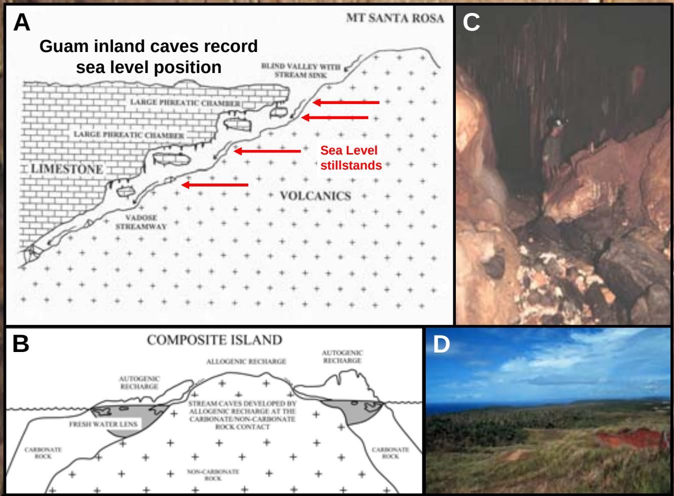


Figure 8: When non-carbonate rocks underlie island limestones, vadose stream conduit caves develop on the perching surface and deliver water to the fresh-water lens, where mixing dissolution creates large chambers. On Guam, uplift under these circumstances has created a series of fossil phreatic chambers that were abandoned after each tectonic uplift event, as vadose passages undercut those chambers on their way to the new lens position.

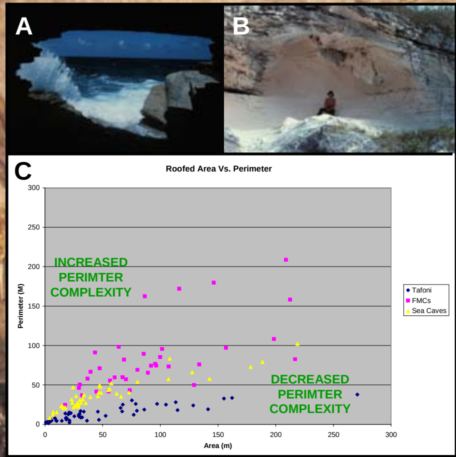


Figure 10: Differentiating flank margin caves from sea (littoral) caves, and from tafoni, is critical for sea level and paleo-hydrology interpretations. A) Sea cave, North Point Member, San Salvador. B) Tafoni, North Point Member, San Salvador. The North Point Member is ~5,000 years old, and therefore cannot host Pleistocene flank margin caves.
C) Attempts to differentiate the three cave types by map morphology has had some success.

***Facies changes*: The fresh-water lens flow pattern reflects the permeability in the host rock. As a result, the dissolution patterns of both matrix flow and fracture flow can be found in the same cave, as in the Miocene carbonates of Mallorca.**

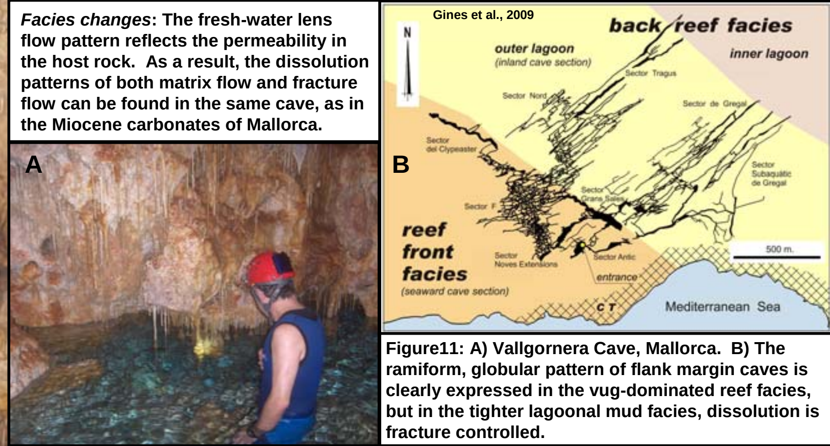


Figure11: A) Vallgornera Cave, Mallorca. B) The ramiform, globular pattern of flank margin caves is clearly expressed in the vug-dominated reef facies, but in the tighter lagoonal mud facies, dissolution is fracture controlled.

***Paleotalus or breccia facies*: In these units, although the clasts are made up of teleogenetic carbonate rock of low matrix porosity, flow occurs around the clasts in 3-Dimensions, mimicking the flow in porous eogenetic rocks, as can be seen in the Adriatic carbonate islands of Croatia.**

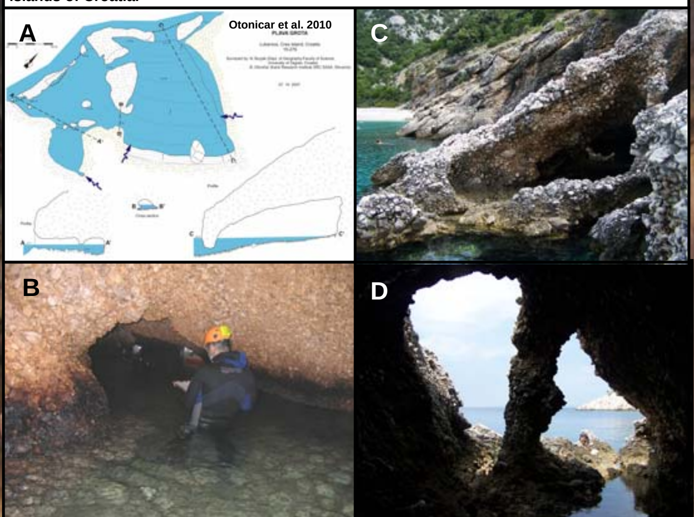


Figure 9: Plava Grota. A) Map of the cave, which still receives fresh-water input (arrows). B) Interior of the cave, showing dissolutional arches imposed on the talus/ breccia. C) Entrance to Plava Grota, talus/breccia host rock obvious. D) Pillar formed in the talus/breccia by dissolution; such architecture is typical of flank margin caves and is rare in sea caves.

***Fractured and brecciated facies*: In these units, strong tectonism has created a joint and fracture fabric in some rocks of minimal matrix porosity that allows them to transmit fluid in a closely spaced 3-Dimensional array, again mimicking porous eogenetic carbonates. The telogenetic Oligocene limestones of coastal New Zealand display this phenomena very well, creating caves with a ramiform pattern typical of flank margin caves, albeit with joint influence displayed.**

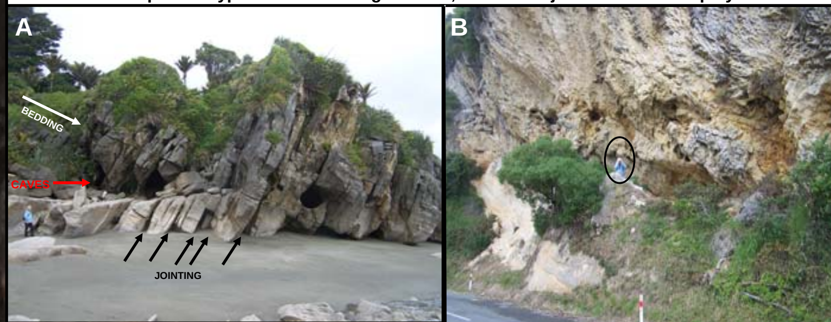


Figure 12: A) Tube City Cave, New Zealand. High density jointing has created a multitude of flow paths, mixing caves formed on a level horizon. B) Pohara-Tarakohe, Oligocene Takaka Limestone, showing a horizon of dissolution voids crossing dipping bedrock structure.

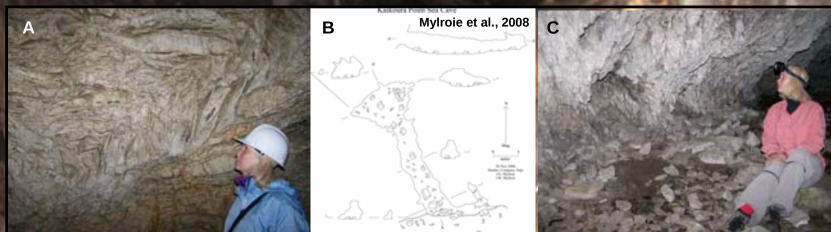


Figure 13: Kaikoura, South Island. A) Highly distorted and fractured limestones, Maori Leap Cave. B) Map of Kaikoura Point Sea Cave, a flank margin cave. C) Interior wall of Kaikoura Point Sea Cave, with highly fractured limestone, which still supports dissolution pockets. Note small size and angularity of the collapse pieces, evidence of multiple fracture-flow pathways in the rock.

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