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Note, the published text may have some minor differences

SYNGENETIC KARST

Syngenetic karst is a term coined by Jennings (1968) for karst features, including caves, that form within a soft, porous, soluble sediment at the same time as it is being cemented into a rock. Speleogenesis and lithogenesis are concurrent.

Jennings was describing the active karst geomorphology of the Quaternary dune calcarenites of Australia. Concurrent studies by sedimentologists of paleokarst horizons at unconformities in the stratigraphic record used the related concept of eogenetic diagenesis: processes that affect a newly-formed carbonate or evaporite sediment when it is exposed to subaerial weathering and meteoric waters (Choquette & Pray, 1970). The resulting eogenetic karst (or "soft-rock karst") is distinguished from telogenetic ("hard-rock") karst that has developed on hard indurated limestones that have been re-exposed after a deep burial stage.

The terms syngenetic and eogenetic overlap but involve different viewpoints. The former is best used for geomorphological studies of modern soft-rock karsts; whereas the latter is best retained for diagenetic studies of paleokarst porosities, where the sequence of dissolution and cementation events is much more complex. Some, but not all, paleokarst is eogenetic: the separation of eogenetic, mesogenetic (burial), and telogenetic features requires a detailed study of cement morphology, mineralogy, chemistry, and related dissolutional and brecciation features; at both the microscopic and macroscopic scale.

Some workers have applied the term "Syngenetic Cave" to lava tubes. Although that is an etymologically valid use of "syngenetic", it is unrelated to the present topic.

Syngenetic karst has several distinctive features as well as many that are shared with classical (telogenetic) karst. In the following discussion dune calcarenites in a "Mediterranean" climate are used as an initial example (Figure 1). In calcareous dunes, percolating rain water gradually converts the unconsolidated sand to limestone by dissolution and redeposition of calcium carbonate. This initially produces a cemented and locally brecciated calcrete layer near the surface (Figure 4). Terra rossa soils may also develop. Below this the downward percolating water dissolves characteristic vertical "solution pipes" (Figure 2), and simultaneously cements the surrounding sand. Early cementation tends to be localized about roots to form distinctive rhizomorphs or rhizocretions. Cementation can occlude the primary inter-granular porosity, but dissolution can generate localized secondary porosity of a mouldic, vuggy or cavernous character.

Mixing corrosion occurs where percolation water meets the water table, which is typically controlled by the level of a nearby swampy plain, which also provides acidic water. Near the coast, water levels fluctuate with changing sea levels, and further complexity results from a fresh water lens floating above sea water, which results in two mixing zones, above and below the lens (see Speleogenesis: Coastal and Oceanic Settings).

In the early stages of solution, the loose sand subsides at once into any incipient cavities, possibly forming soft-sediment deformation structures. Once the rock is sufficiently hardened to support a roof, caves can develop. Horizontal cave systems of low, wide, irregular, interconnected chambers and

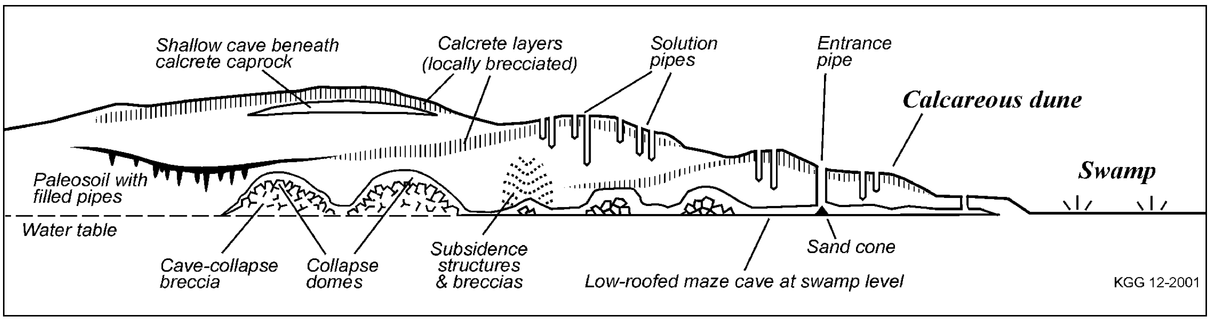

Figure 1: Features of syngenetic karst developed on a calcareous dunefield.

Syngenetic Karst: Figure 2. Solution pipes (or, more strictly, dissolution pipes) are distinctive features of syngenetic karst (Lundberg & Taggart, 1995). They are vertical cylindrical tubes with cemented walls, typically 0.3 to 1 m in diameter, which can penetrate down from the surface as far as 20 m into the soft limestone. The pipes may contain soil and calcified roots (and root growth may have occurred hand-in-hand with dissolution of the pipe). They occur as isolated features, or in clusters with spacings as close as less than a metre.

Syngenetic Karst: Figure 3. Subsidence structure in syngenetic karst. Thin horizontal beds of a beach calcarenite were partly cemented into individual plates that then subsided and rotated as dissolution undermined them. Continuing cementation stabilized the tilted beds before the present cave formed.

passages (see Salt Pond Cave figure in Speleogenesis: Coastal and Oceanic Settings) form, either in the zone of maximum solution at the water table, or by subsidence of loose material from beneath stable calcrete layers. Flat cave roofs are common: either marking the limit of solution at the top of the water table, or where collapse has reached the base of an indurated (caprock) zone. Where a shallow impermeable basement occurs, its topography may concentrate water flow along buried valleys to form linear caves.

Sizable caves can form in less than 100 000 years. Surface dissolutional sculpturing is rare, as there is little solid rock for it to act upon. However, some sculpturing can occur on exposed calcrete layers.

The subsidence of partly-consolidated material can form a variety of breccias and sag structures; these can be further cemented as diagenesis continues (Figure 3). Mantling breccias can occur as part of the surface soil (Figure 4). Within the caves breakdown of the soft rock is extensive. In many cases, rubble-filled collapse domes largely supplant the original dissolutional cave system at the water table. Subsidence may reach to the surface to form dolines. In paleokarst exposures, these collapse areas would appear as both discordant and concordant (intrastratal) breccias. In extreme cases mass subsidence of broad areas can generate a chaotic surface of tumbled blocks and fissures.

Variations can occur in different climates or sediments. For example, calcrete is supposedly best developed in semi-arid climates, whereas dissolution and brecciation are more abundant in wet climates. Sequences of marine sediments undergoing cyclic emergence can develop syngenetic breccia layers and karst surfaces at the top of each cycle. In coarse-grained sediments, preferential dissolution of aragonite fossils (e.g. coral) can form a coarse mouldic porosity. Where soluble evaporites are interbedded with carbonates, they may be removed completely to undermine the overlying carbonate beds and form extensive intrastratal brecciated layers (see separate entry, Evaporite Karst). However, such breccias can also form in later mesogenetic and telogenetic settings, so are not necessarily eogenetic.

Dissolutional porosity generated during the eogenetic stage of paleokarsts can direct water flow and further dissolution during the later mesogenetic and telogenetic stages (see Inception in Caves), and also host ore minerals or hydrocarbons. See Sulphide Minerals in Karst; Hydrocarbons in Karst.

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See also **Evaporite Karst; Paleokarst; Speleogenesis: Coastal and Oceanic Settings**

Syngenetic Karst: Figure 4. Calcreted, multi-generation, mantling breccia in dune calcarenite. The large, 20 cm clast contains at least two earlier generations of smaller clasts. Note the blackened pebbles: some authors have suggested that these may indicate carbon derived from fires (Shinn & Lidz, pp. 117-131 in James & Choquette, 1987).

Works Cited

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Further Reading

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A well-illustrated review of karst and related meteoric diagenetic features. Many, but not all, of the examples are of syngenetic karsts.

James, N.P. & Choquette, P.W. (editors) 1987. *Paleokarst*. New York: Springer-Verlag.

The Introduction has useful summaries of meteoric diagenesis and breccias. Many of the paleokarsts described in this book are at least partly eogenetic in origin.

Klimchouk, A.B. & Ford, D.C. 2000. Lithological and structural controls of dissolutional cave development. In *Speleogenesis: Evolution of Karst Aquifers*, edited by A.B. Klimchouk, D.C. Ford, A.N. Palmer and W. Dreybrodt, Huntsville, Alabama: National Speleological Society

Page 56 describes breccias in interbedded sulphates & carbonates, but not all these are syngenetic. Page 60 discusses diagenetic stages, including the eogenetic stage.

Lundberg, J., & Taggart, B.E. 1995. Dissolution pipes in northern Puerto Rico: an exhumed paleokarst. *Carbonates and Evaporites*, 10(2): 171-183.

A review and case study of "solution pipes" — a distinctive feature of syngenetic karst.

Moore, C.H. 1989. *Carbonate Diagenesis and Porosity,* Amsterdam and New York: Elsevier.

A detailed review of carbonate and evaporate sediments and the evolution of their secondary porosity. Chapter 3 describes the tools used to determine the nature and timing of solutional and cementation events. Chapter 5 discusses evaporites. Chapter 7 discusses meteoric diagenesis (both eogenetic and telogenetic).

Mylroie, J.E., Jenson, J.W., Taborosi, D., Jocson, J.M.U., Vann, D.T., & Wexel, C. 2001. Karst features of Guam in terms of a general model of carbonate island karst. *Journal of Cave and Karst Studies,* 63(1): 9-22

Their model involves eogenesis (i.e. syngenesis) in young, porous limestones exposed by uplift or sea-level change.

White, S. 2000. Syngenetic karst in coastal dune limestone: A review. In *Speleogenesis: Evolution of Karst Aquifers*, edited by A.B. Klimchouk, D.C. Ford, A.N. Palmer and W. Dreybrodt, Huntsville, Alabama: National Speleological Society

A recent case study from Australia.