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## Quaternary Coastal Dune Limestone Karst

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During the Quaternary, many coastal parts of the world experienced deposition of elongated shore-parallel dunes, often formed from reworked shallow-marine biogenic carbonate sediments or ooids. These dunes cement rapidly, many of the early Holocene dunes are already cemented, and are termed aeolian calcarenite or aeolianite. Carbonate dune systems are found in a wide variety of environments world-wide, but they are most extensive between 20° and 40° latitudes in both hemispheres.

Internally the dunes typically show large-scale aeolian cross-bedding deposition discontinuities marked by palaeosols or, less commonly, shallow-marine or swamp sediments. The general topography comprises subdued ridges and swales, which are remnants of the original coastal carbonate dunes. Karst development on such dune ridges is dependent on several interrelated conditions. The ridge must have a sufficiently high proportion of soluble material that is pure enough for the solution processes not to be impeded by insoluble residue left after solution has occurred. The higher the proportion of carbonate the more likely karst features will develop. Adequate and aggressive moisture must be available for dissolution but due to the high rock porosity and permeability the percolation of water is not dependent on the presence of fractures. Similarities exist with karst formed in geologically young marine calcarenites as the main lithological characteristics of both types of rocks are similar: high permeability and matrix porosity, and weak cementation.

Compared to older and more lithified limestones, the surface karst on coastal dune limestone is less well-developed due to the limited consolidation of the rock. Karst features such as collapse dolines and caves are similar to those developed in older, better cemented limestones, but have specific morphological characteristics: two common plan forms; simple single linear passages or chambers and single-level spongework maze systems, and vary in length from a few metres to several kilometres of passage. There are distinctive karst features e.g., solution pipes (vertical dissolutional tubes), ceiling bell holes, and the presence of root moulds and/or rhizomorphs. Some caves have extensive arrays of speleothems. Most have walls and ceilings with moonmilk.

Karst formation in coastal dune limestone begins concurrently with cementation/lithification; in geological terms, these karst processes are rapid, occurring over thousands of years. The early phase is generally characterised by caprock formation with cave development being limited to shallow caves beneath the caprock. Solution pipes can form during this phase, even within still unconsolidated sand. The late phase is characterised by a sufficient level of cementation to support extensive cave formation.

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