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Large-Scale Fracture and Breccia Development Associated with Paleocave Systems and Associated Suprastratal Deformation

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Collapsed paleocave systems and associated suprastratal deformation produce large scale brecciated and fractured bodies of rock. Systems may range from isolated, single, cave passages to coalesced, collapsed-paleocave systems composed of numerous passages and associated deformation covering hundreds of square kilometers. Most major collapsed-paleocave reservoirs, such as the Lower Ordovician Ellenburger reservoirs in West Texas, are associated with large-scale coalesced paleocave systems.

Large-cave systems commonly form at composite unconformities in carbonates. The general pattern of cave systems may reflect previously established regional fault, fracture, and bedding-plane patterns. Cave systems begin producing cave-related breccias and fractures early in their history and continue to produce more breccias and fractures with burial (Figure 1).

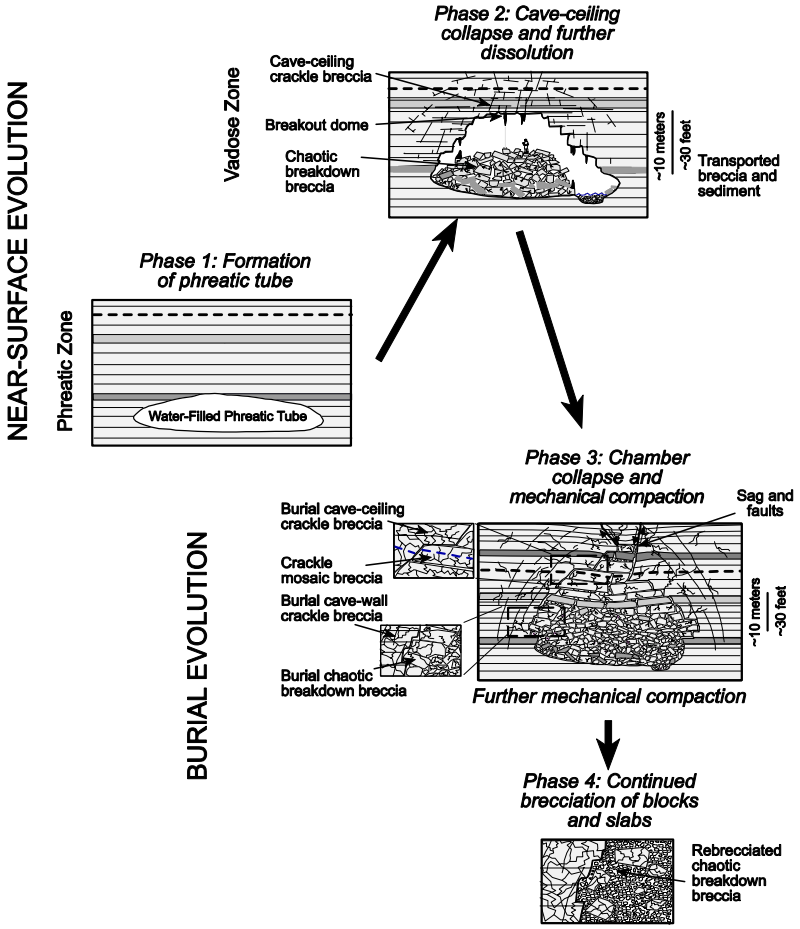

Figure 1. Evolution of a cave passage with burial. Modified from Loucks (1999).

The paleocave system and associated pore network evolve with burial (Figure 2). Larger vugs and caverns are more common in the shallower subsurface, and fine interclast pores and crackle- and mosaic-breccia fractures are more common in the deeper subsurface.

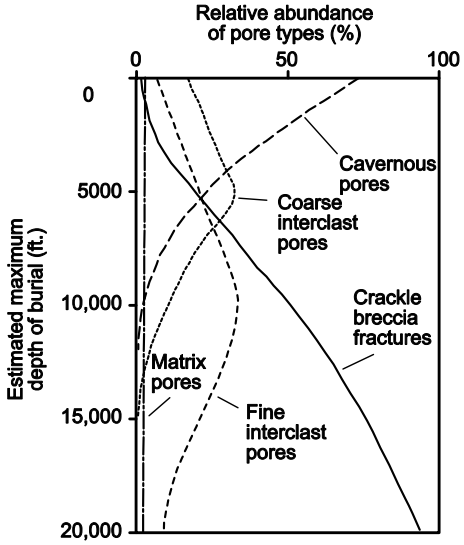

Figure 2. Evolution of pore types with burial. Modified from Loucks (1999).

A striking feature of these buried, coalesced, collapsed-paleocave systems is the large-scale, intensely brecciated and fractured carbonate bodies that are formed by coalescing of the collapsed-paleocave system (Figure 3). These collapsed-paleocave systems are major aquifers in a background of generally low-porosity carbonate strata.

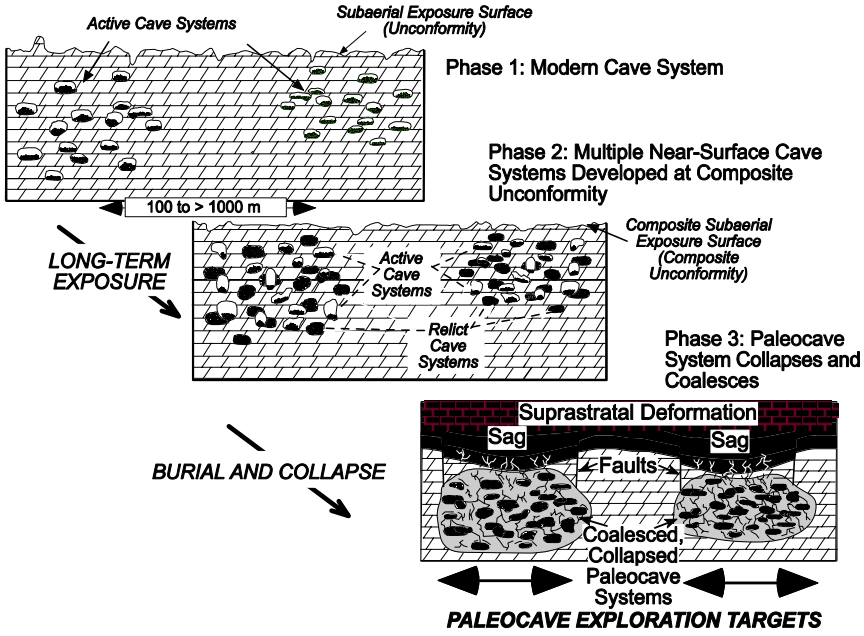

Figure 3. Schematic diagram showing stages of development of a coalesced, collapsed-paleocave system. Multiple cave-system development at a composite unconformity may be necessary in order to produce a high density of passages. As the multiple-episode cave system subsides into the deeper subsurface, wall and ceiling rocks adjoining open passages collapse and form breccias that radiate out from the passage and intersect with fractures from other collapsed passages and older breccias within the system. The collapsed-paleocave systems are prime exploration targets. Modified from Loucks (1999).

Above the coalesced, collapsed-paleocave system, hundreds of meters of strata can be crackle-brecciated, folded, and faulted (suprastratal deformation; Figure 3). The result is megasag, which is a response to the collapse and compaction of the paleocave system. These features can be mapped from seismic and wireline-log data. The collapse of cave systems, therefore, affects not only the host-rock strata, but also, in many cases, as much as several hundred meters overlying strata. The pore network associated with suprastratal deformation might form potential reservoirs under proper trapping and sealing settings.