Origin of Cenotes near Mt Gambier, South Australia

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Abstract

The Southeast Karst Province of South Australia is notable for its cenotes, collapse dolines containing water-table lakes up to 50m wide at the surface and extending down to 95m below the land surface. They are developed in the flat-lying Oligocene – Early Miocene Gambier Limestone, which is exposed at the surface over much of the province. The cenotes are all characterized by collapse; they have vertical and overhanging sides and are floored by large cones of rubble, which may be overlain by finer grained sediment. Exploration and diving have revealed no major phreatic passages extending off any of the cenotes, despite the fact that typical shallow phreatic joint maze caves, both dry and water-filled, are common in the Gambier Limestone throughout the Southeast Karst Province. Collapse dolines are associated with some of these phreatic caves, but are shallower than the cenotes in that they do not have deep lakes.

The distribution of the cenotes is uneven; they are concentrated in two small areas, each ~3km in diameter, located 5km W and 10km NW of Mt Schank (a few other cenotes are scattered through the province). Within these areas they are distributed along two joint sets, a dominant set trending 320° and a subsidiary one at right angles. These are the dominant regional joint directions.

The depth of the cenotes indicates that they represent collapse into large caverns dissolved at or close to the base of the Gambier Limestone; the boundary between the Gambier Limestone and the underlying Tertiary siliciclastics lies at about 100m below ground surface around the cenotes west of Mt Schank. It has been suggested that the caverns were dissolved by acidified groundwater containing large amounts of volcanogenic CO_2, which had ascended up fractures from deep-seated reservoirs related to the magma chambers that fed the Quaternary volcanoes Mt Schank and Mt Gambier. Approximately 10km east of Mt Schank is a CO_2-producing well (Caroline); the isotopic composition of the CO_2 identifies it as magmatic in origin, and it is probably related to the Quaternary volcanics in the area.

Evidence for the influence of volcanogenic fluids on the cenotes comes from strontium isotope analyses of a stromatolite collected at ~8m depth from Black Hole, one of the larger cenotes. Stromatolites grow on the walls of many of the cenote lakes, and are large structures up to 4m long formed of calcite precipitated by the microbial communities growing on their surfaces. In cross-section the calcite of the Black Hole stromatolite shows submillimeter-scale laminations, which may be annual. Detailed sampling of one section of this stromatolite showed that overall it has a $^{87}Sr/^{86}Sr$ ratio of around 0.7088, but one sample has a lower ratio (0.7079), probably due to an input at this time of volcanic fluids, which have a much lower Sr isotopic ratio (0.7037-0.7058 for the Quaternary volcanics of the region). The layer with the anomalous $^{87}Sr/^{86}Sr$ ratio has an age of ~6000 BP, from C_{14} dates on the stromatolite either side of the layer, and assuming a uniform rate of growth. This age corresponds closely to that of the eruption at Mt Schank (6000 BP, based on recent thermoluminescent dating).

Thus the Sr isotope data show the apparent influence of volcanogenic fluids within the cenote lakes during a time of eruption. Larger amounts of fluid, including volcanogenic CO_2, could have been injected during previous eruptions, dissolving the caves that collapsed to form the cenotes.

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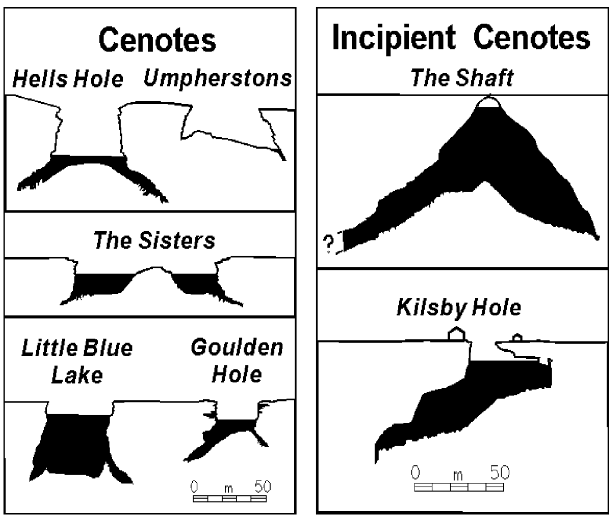

***Cenotes** (Grimes, K.G. and White, S., 1996. Field guide to karst features in southeast South Australia and western Victoria. Regolith Mapping, Hamilton, Vic.)*