KARST and CAVES of the OTWAY BASIN
(Southeast South Australia and Western Victoria)

- Ken Grimes

The 13th Australasian Conference on Cave and Karst Management will be held at Mount Gambier, Southeast South Australia, in April 1999, centering on Naracoorte Caves. This review provides an overview of the 'soft-rock' karst and caves of the Tertiary and Quaternary limestones of the region. Subsequent issues of the ACKMA Journal will cover detailed cave descriptions (tourist and wild), the fossil fauna at Naracoorte, volcanic caves of west Victoria, and management of the karst and groundwater.

GEOLOGICAL BACKGROUND

The caves are in two types of limestone, both relatively young and soft: the Tertiary limestones of the Otway Basin (Figure 1), and younger Quaternary calcareous dune limestones.

The ***Tertiary limestones*** were deposited in a shallow sea that flooded the region about 20-30 million years ago. This limestone is relatively soft in the subsurface but develops case hardening and calcrete cappings on exposure. It is locally well jointed with a dominant north-west trend. The Tertiary limestones are similar to those in the Nullarbor and there are similarities in the cave styles also, though here we have none of the huge passage systems that occur in the Nullarbor.

The ***Quaternary dune limestones*** are a series of calcareous sand ridges which formed as coastal dunes along old shorelines during an overall retreat of the sea during the Quaternary (the last 2 million years). In South Australia they form discrete, linear, north-west trending ranges, which extend northwards beyond the limit of the Otway Basin to overlie the (non-calcareous) sediments of the Murray Basin.

In Victoria the distribution of the dune limestones is less regular, and east of Portland they are mainly restricted to a belt along the modern coast, though some older ridges (without karst) occur further inland. These Quaternary limestones are similar to those on Kangaroo Island (e.g. the Kelly Hill caves), the Eyre Peninsula, and the coastal areas of West Australia (e.g. at Augusta, Margaret River etc.).

The dune ridges are now partly consolidated calcarenites (sandy limestones) and contain syngenetic karst features in which caves and solution pipes developed at the same time as the sands were being cemented into a limestone (see this month's ANDYSEZ). The dune limestone has well developed bedding which can be a very obvious feature of some cave walls. In contrast to the Tertiary Limestone it shows little or no jointing. Just to confuse things, some caves are developed mainly in the Tertiary limestones but have their entrances in the overlying dune limestones (via solution pipes, roof windows, or collapse dolines).

HYDROLOGY

The Tertiary Limestone forms the major aquifer in the region. The Gambier Limestone has been referred to as one of the best aquifers in Australia. However, it will be a major job to keep it that way in the face of growing demand, and the continuing threats of pollution from a variety of sources (see later). Much of the groundwater from the Mount Gambier area is discharged in major springs on the coast, and divers have entered caves below some of these.

The interaction of uprising hot volcanic magmas and the groundwater in the limestones were responsible for the steam-driven explosions that formed the large crater lakes of the region such as Blue Lake at Mount Gambier, and Tower Hill crater near Warrnambool.

The aquifer is karstic, but as the limestone is also quite porous a well developed water table exists. During glacial periods the lowering of sea levels would have caused a significant drop in the groundwater levels in the coastal parts of the region - as shown by submerged speleothems and mudcracks in some South Australian caves.

DOLINES AND CENOTES

The most spectacular surface karst features are the ***collapse dolines***, especially those in the Mount Gambier area that extend below the water table to form ***cenotes***. These have formed by the collapse of large phreatic caverns. Figure 2 shows several typical cenotes and related features: in the Gambier area the watertable is lower and the collapse dolines have relatively shallow lakes (e.g. Hells Hole & Umpherstons), however, nearer to the coast the water levels are higher and we find deep lakes (e.g. Little Blue Lake). The Shaft is an example of the situation before the roof of a large flooded collapse dome falls in to form a cenote - the present entrance is a narrow solution tube through which all the dive gear has to be lowered.

An interesting feature of some of the cenotes is the existence of stromatolites: columnar or platey underwater calcareous growths formed by algae. These have been found as deep as 25m, and also extend 2m above the present water level - implying a higher watertable at some time in the past.

Fields of shallow dolines and uvalas are extensive in South Australia and extend into the westernmost part of Victoria. Isolated doline fields also occur further east, e.g. beside the Great Ocean Road northwest of Peterborough.

These shallow hollows generally have sandy or muddy floors and rarely have cave entrances. Instead we find cave entrances typically in collapse dolines, via solution pipes (which may have a small conical subsidence doline above them), in small outcrops of calcreted caprock, or in cliffs along streams or on the coast.

SOFT-ROCK CAVES

The caves in the region are dominantly phreatic in origin, i.e. formed by slow moving groundwater below the water table. The limited local relief means that vadose (stream flow) features are extremely rare in South Australia, but some vadose streams occur in the caves of the Glenelg River gorge in Victoria and also further east in the Warrnambool and Timboon regions. Many of the primary phreatic caverns and passages have been modified by breakdown to form collapse domes and rubble filled passages.

Cave diving has demonstrated the existence of extensive underwater cave systems in South Australia, and it appears that in the southern part of the Lower Southeast area the bulk of the cave development may be below the present water table.

Typical syngenetic cave forms in the dune limestones are shallow horizontal systems developed beneath the caprock or at the level of an adjoining swamp. They have multiple entrances (often via solution pipes or the collapse of the surface crust) and an irregular outline of chambers, pillars and short connecting passages, generally with a roof height less than one metre throughout. The walls are often difficult to see (and map) as they are out of reach where the roof slowly drops to floor level. Breakdown tends to modify this original structure so that many of the caves are now mainly collapse domes with only small remains of the original solutional system visible at the base of the walls.

The caves in the Tertiary limestone are similar but generally have larger chambers and passages, and also show better joint control, with many fissure style passages. Many are partly or wholly submerged (Figure 3).

Speleothems are generally not abundant - a consequence of the frequent destructive collapse. However, there are some spectacular exceptions to that rule - and these include extensive and very delicate forms - especially clusters of long straws and soft deposits of moonmilk. Cave coral is well developed. Still pools may be partly covered by calcite rafts.

The generally horizontal development with soft sandy floors make the caves of the region easy to explore. However they are not without their challenges: tight, vertical, solution pipe entrances; unstable sand and rubble cones; confusing mazes; and extensive crawlways - not to forget the ultimate challenge of water-filled sections reaching to depths in excess of 80m!

CAVE BIOLOGY AND ARCHAEOLOGY

There are two maternity sites for the little Bentwing Bat (*Miniopterus schreibersii*) - one near Naracoorte and the other at Warrnambool. Several caves along the Glenelg River host the (locally) rare Large Footed Bat (*Myotis adversus*). The cenotes and big springs contain an interesting aquatic fauna and flora (including funny little crustaceans called syncarids, and the stromatolites mentioned above). Fur seals occupy some of the sea caves near Portland.

The solution pipes form excellent pitfall traps and thus bone deposits of Quaternary age have been found in a number of caves. The most important, and world famous, bone deposit is in the Victoria Fossil Cave at Naracoorte, but other significant sites have been found in both states, including some underwater bone deposits in the cenotes. The Tertiary limestones in the Mount Gambier area have bands of flint nodules which make excellent stone tools. Evidence of aboriginal mining of flint is seen in several caves, as is also aboriginal art in the form of scratch marks and finger marks.

MANAGEMENT OF THE KARST AND GROUNDWATER

I will summarize only the main headings here: we hope to have someone write a more detailed description of the karst management problems and solutions in a future issue of the ACKMA Journal. Thanks to Kevin Mott for checking this section and providing some additional information.

Water Supplies

There may be a growing problem in maintaining supplies in the face of increasing demand for both private, agricultural and industrial usage. Water quality can be compromised by pollution from a variety of sources: stormwater, sewer and septic drainage in the towns, farm activities (in particular wastes from the dairies and piggeries.), and some major industries such as those involved in the timber industry (treatment of mill timbers, paper pulp, cellulose etc.). In the past, abattoirs have been a source of pollution with some still a cause for concern. Cheese factories also introduced major pollution plumes into the aquifer and these are still travelling through the system.

Of increasing concern is contamination of the groundwater from diffuse sources such as grazing. Several studies are being undertaken by CSIRO to look at the effects of this diffuse contamination. In some areas, particularly in the north, increased salinity from clearance and irrigation is becoming a greater problem.

Although regulatory controls exist under the Environment Protection Act these only cover large scale operations. Small scale operations come under a general duty of care and are usually only scrutinized when there is a direct complaint.

Often a number of small, badly run, operations can cause more problems than the reasonably run large ones. Unfortunately, these small operations have more severe budgetary constraints so the owners are more reluctant to upgrade, despite programs of public education.

Surface karst

The main problems here have to do with introduction of pollutants into the aquifer via the dolines, cave entrances and "runaway holes". Direct damage to dolines and cave entrances also occurs from forestry and agricultural activities. Many dolines and entrances have been, and still are, used as rubbish dumps. There have been major clean-ups of some dolines and caves, for example: Engelbrecht Cave in the town of Mt Gambier is now a tourist cave, and Rendelsham Cave near Millicent has recently been cleaned up and developed as a recreational area. The stromatolites that grow in the cenotes may be endangered by water pollution - either directly or indirectly by the growth of surface algal mats which block the sunlight.

Swimmers in some of the spring ponds have caused damage to the aquatic vegetation. Ripping of limestone for increasing irrigation activity can disturb karst pavement areas and change the hydrology. Subsequent irrigation or intensified land usage will also have an impact from increased fertilizer applications.

Caves

Management problems within the caves are mainly related to people access, and the damage that results therefrom. About a third of the known caves in South Australia are on crown land (mainly State Forests), I do not have handy figures for Victoria. The region has four sets of show caves: Several caves at The Naracoorte Caves, and also Tantanoola Cave, Engelbrecht Cave in Mount Gambier, and Princess Margaret Rose Cave on the Glenelg River. There are no show caves in the volcanic region, but two lava caves at Mount Eccles are open to the general public and access steps have been put into one of these. Cave (and cenote) diving is a special activity in the Mount Gambier region that is stringently controlled by a certificate and permit system. Beneath pine plantations evapotranspiration is much higher than elsewhere and this can drop the local water table by several metres, drying up pools and speleothems. A few caves have been intersected by quarries; one of these became a major fossil bone site - with the quarry operations continuing beside it. A worry with syngenetic karst caves, and to a lesser extent with those in the Tertiary Limestones, is stability. "Soft-rock caves" are not as strong as the typical "hard-rock" cave of the east coast, and so roof fall is statistically more likely. Cavers have to be a bit more careful about bumping the roof, and cave managers should do regular inspections of their tour caves.

FURTHER READING:

EMMETT, A.J., & TELFER, A.L., 1994: Influence of karst hydrology on water management in southeast South Australia. *Environmental Geology* 23: pp 149 -155.

GRIMES, K.G., 1994: The South-east Karst province of South Australia. *Environmental Geology* 23: pp 134-148.

GRIMES, K.G., WHITE, S., & PIERCE, M., 1994: Limestone caves of Southeast South Australia and western Victoria. *Australian Caver* 137: pp 7-14.

HOLMES, J.W., & WATERHOUSE, J.D., 1983: Hydrology. *in* TYLER M J, TWIDALE C R, LING J K, and HOLMES J W (eds) 1983 Natural History of the South East. *Royal Society of South Australia, Adelaide*, pp. 49-59.

THURGATE, M., 1966: Stromatolites of the karst lakes of the Mount Gambier Region. *ACKMA Journal*, 23: pp 29-33.

TYLER, M.J., TWIDALE, C.R., LING, J.K., & HOLMES, J.W. (eds), 1983: Natural History of the South East. *Royal Society of South Australia, Adelaide*. 237pp.
[includes articles on geology, hydrology, karst, cave fossils, etc.]

WELLS, R.T., & PLEDGE, N.T., 1983: Vertebrate fossils. *in* TYLER M J, TWIDALE C R, LING J K, and HOLMES J W (eds) 1983 Natural History of the South East. *Royal Society of South Australia, Adelaide*, pp. 169-176.

WHITE, S., 1989: Karst features in Pleistocene dunes, Bats Ridge, Western Victoria. *Helictite*, 27(2): pp 53-71.

WHITE, S., 1994: Speleogenesis in aeolean calcarenite: a case study in western Victoria. *Environmental Geology*, 23: pp 248-255.