ANDYSEZ No 53
LATERITE KARST

– Ken Grimes & Andy Spate

In the last issue of the ACKMA Journal (No 72, p. 26) Kent Henderson referred to the 'Mystery Craters' near Bundaberg, Qld, and quoted from the blurb handed to him at the site.

The blurb is (as often) rather misleading: the mystified '200 internationally renowned geologists' would have been casual visitors who were making impromptu guesses without the advantage of a detailed study or of familiarity with the region's geology. We wonder how many 'non-internationally renowned' geologists visited? It must be a major tourism destination!

Fig 1: Small composite pit at the 'Mystery Craters' – showing smoothly rounded outlines and a bridge, which fits better with a solutional origin rather than collapse.

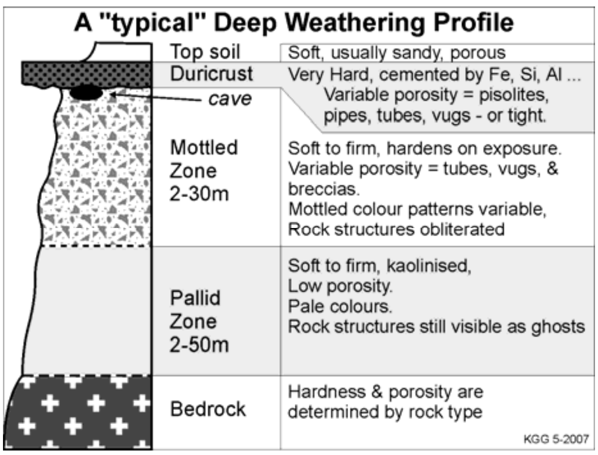


Fig 2: Schematic section through a typical laterite deep weathering profile.

The two 'official' studies, by Kay (1972) and Robertson (1979) of the Geological Survey of Queensland, were also brief, but at least had the advantage of local knowledge. Both identified the holes as being sinkholes in the mottled zone of a laterite. They attributed them to collapse into cavities formed by water flow in the underlying rock, and Robertson specifically assigned this to piping of clay particles (a process known to produce pseudokarst caves and sinkholes), and referred to other reports of sinkholes in laterites. They are interesting and not common, but are certainly not unique.

Piping may well have contributed to the formation of the holes, but more recent work suggests that solution is also important in laterite terrains (e.g. McFarlane & Twidale, 1987; McFarlane & others, 1995), and the holes might be solution dolines or pipes rather than collapse. This fits better with the shape of some of the pits at the 'Mystery Craters' that have rounded hollows and bridges (Fig 1).

These holes are just one form in a broad range of karst-like features found in laterites and known as *Laterite Karst*. These are well-developed in tropical Australia and some were inspected during our recent North Australian Karst field trip (which concentrated on non-limestone karsts). This trip will be the subject of a future ACKMA Journal article.

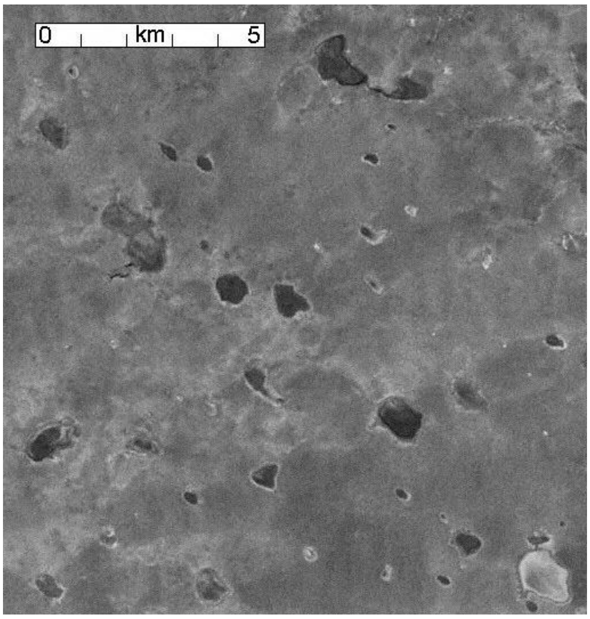
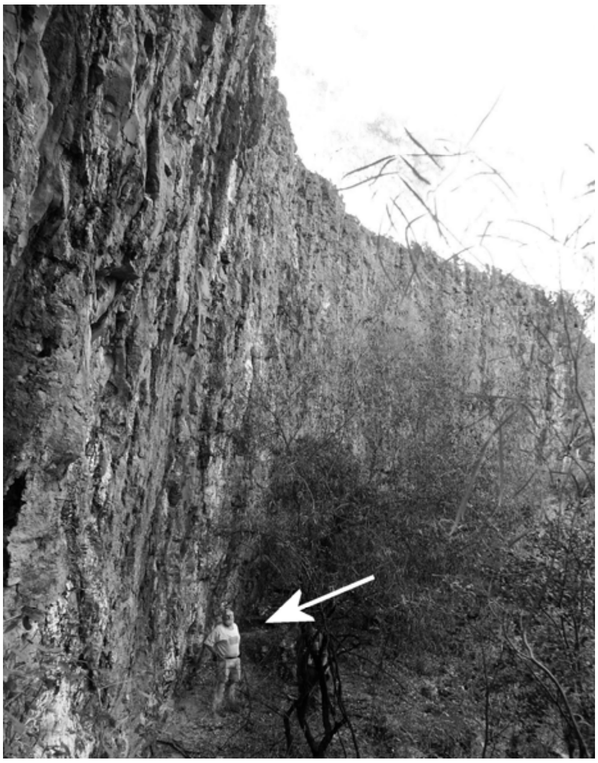


Fig 3: A field of broad but shallow 'pans' (dolines) on a laterite plain in NW Qld (Landsat image).

What is karst?

Karst landforms are characteristic of carbonate rocks (limestone & dolomite) but karst-like features also occur on other rocks. Unfortunately, there is not full agreement on how to divide the non-limestone features and the processes that form them (see discussion in Grimes, 1997 and Spate, 2001).

Fig 4: Andy Spate (arrowed) shows the size of this deep collapse doline in a laterite beside the Buchanan Highway, NT.



Grimes (1997) preferred the European approach which uses the differences in the process, and in the rock chemistry involved, to distinguish between *true karst* (a three-phase reaction between solid carbonate rock, liquid water and gaseous CO_2), *parakarst* (solution of non-carbonate rocks in water – only two phases) and *pseudokarst* (processes other than solution – mainly mechanical erosion, or phase change for caves in ice or lava).

All three process groups share a set of landforms such as caves, sinkholes etc. However, many authors, especially in the USA, make only two divisions: karst and pseudokarst. Unfortunately, some of those put non-limestone solution features in true karst, while others put them in pseudokarst. Part of the problem is that for many non-limestone karsts, solution is significant but not necessarily the dominant process and it can be difficult to assess its relative importance.

Laterite karst is a special type of silicate karst (formed in silicate rocks such as sediments or granite) that in turn is a type of parakarst (solution of non-carbonate rocks). However, the chemical and physical processes involved in the formation of laterites, and deep weathering profiles in general, are quite complex (Butt & Zeegers, 1992; and see below)

Laterites and Laterite Karst

Laterites are a type of *deep weathering profile*. Deep weathering involves the intensive chemical weathering of the minerals in a rock over a long period of time (Butt & Zeegers, 1992), and north Australian landforms are renowned for their great age.

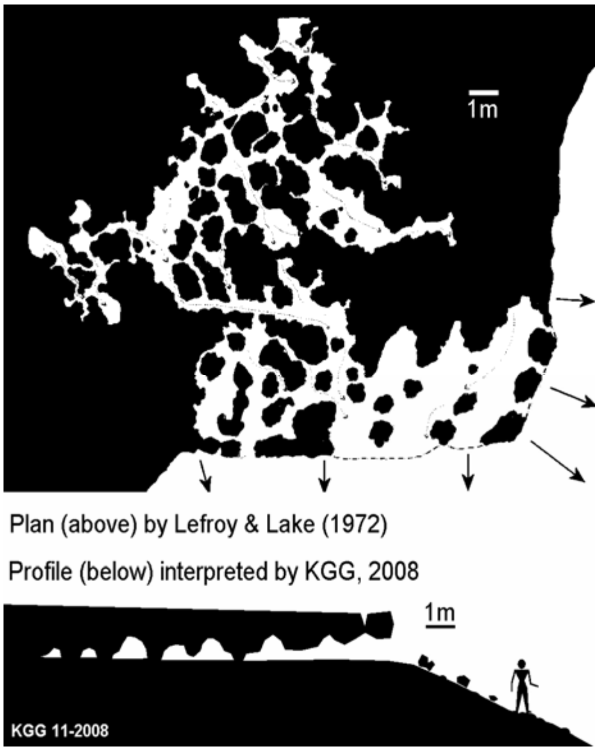


Fig 6: The small laterite maze cave at Chittering, WA. From a map by Lefroy & Lake (1972), a pair of school students who explored and mapped the system as a science project. Ken Grimes has added an interpreted profile. Note the scale bar; many of these passages would be inaccessible to a 'standard-size' adult caver!

The minerals are converted to new forms which may be soluble, and can be removed in solution (analogous to karst); or may be softer, such as clay minerals, or crumbly, such as residual sand grains, and can be washed out of the rock by flowing water – a process called *piping*.

Both processes produce cavities and other karst-like forms. Localised precipitation of the dissolved material forms hard bands known as *duricrusts* – these are responsible for many of the mesas seen in inland Australia~~,~~ and provide a solid roof that caves can form beneath.

Figure 2 shows a 'typical' deep weathering profile. But there is a lot of variation between and within profiles and in their depth, which can exceed 100 m but is more usually 20-30 m. Secondary (karstic) porosity is most common in the mottled zone and within the duricrust, but again there is much variation.

Strictly speaking, the solutional process and resulting features would be classed as 'silicate karst' (or parakarst) and the mechanical erosion (e.g. piping) classed as a form of pseudokarst. But both processes tend to occur together and the general term 'laterite karst' is therefore useful.

Laterite karst shows a stronger analogy with the syngenetic karsts (in soft porous calcarenites) than with the classical 'hardrock' karsts – both laterites and syngenetic karsts have simultaneous solution and cementation and show the influence of caprocks (duricrusts) on cave development.

Fig 5: A small cave in a deep weathering profile beneath a duricrust
(one of the Barry Caves, Barkly Highway, NT).

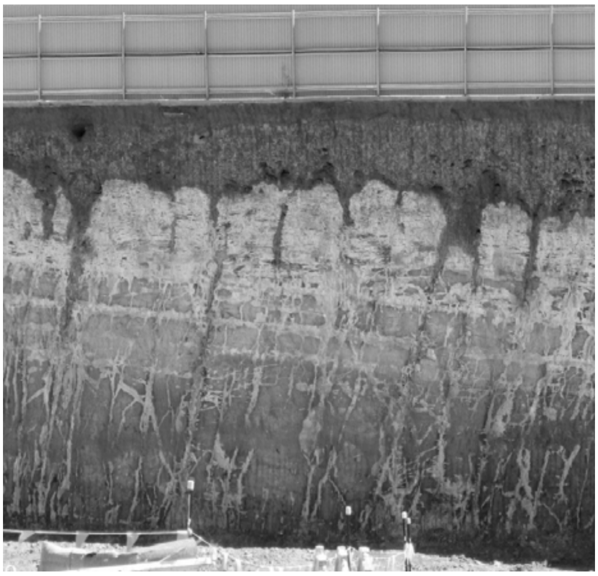


Fig 7: A red soil buries a laterite 'epikarst' surface with soil-filled grikes separating clints or small pinnacles. Beneath is a mottled zone in which the mottles are elongated bands following joints and small solution tubelets (c.f. Fig 10). A building site excavation in Darwin, NT, about 9m deep.

The resulting landforms vary from broad-scale (shallow dolines, or 'pans' up to 2 km across) through a variety of meso-scale features such as caves, solution pipes and pinnacles to smaller-scale tubelets, vughs and breccias.

Large-scale Laterite Karst features

Large scale laterite karst features include the broad but shallow pans, up to 2 km across (Fig 3) that are a distinctive feature of many flat tropical plains which overlie a lateritic deep weathering profile. McFarlane & others (1995) describe examples from near Darwin, NT. These pans are sometimes associated with shallow flat-bottomed and unchannelled valleys that are called 'dambos' in Africa.

The hollows are assumed to be solution dolines resulting from the removal of material in solution, together with resulting subsidence of the topsoil, i.e. silicate karst. But once they have formed, deflation (wind erosion) of seasonally dry pan surfaces may help to deepen and extend them.

Large collapse dolines occur in laterite beside the Buchanan Highway of the Northern Territory (Fig 4, and see McFarlane & Twidale, 1987), but as the laterite there is underlain at a depth of 50-100m by a limestone formation it may be that these are subjacent karst features rather than due to silicate solution.

Medium-scale features

Caves typically occur in the softer weathered material beneath the duricrusts, which provide a hard roof. Solution, piping and other weathering processes remove the soft material to form small caves (Fig 5), most of which are better termed 'rock shelters', but some can be complex mazes such as the one at Chittering, WA (Lefroy & Lake, 1972 – see Fig 6).

As well as caves, medium scale laterite karst features include smaller solution and subsidence dolines (including those at the 'Mystery Craters', where the covering soil was removed by the farmer), subsoil grikes and vertical solution pipes, pinnacles, and polygonal walls associated with pipes or very large scale mottled patterns. These can produce an irregular epikarst surface beneath a soil cover (Fig 7).

Fig 8: Tall laterite pinnacle in White Mountains NP, Qld. 50% of these had hollow cores. Note standard Queensland field safety gear of the 1970s (thongs & stubbies, at least he has a hat!).

Fig 9: Comparison of a hollow laterite karst pinnacle at White Mountains (right) with a similar limestone pinnacle in syngenetic karst at Nambung, WA (left). Both pinnacles have a central solution pipe and a harder rim and are about 1 m high.

Good examples of laterite pinnacles occur in the White Mountains NP, Qld (Fig 8). These include both solid and hollow forms, and probably resulted from a focussed vertical flow of water that first dissolved a solution pipe, then cemented a rim around it.

At Castle Rock on the Stuart Highway, NT a dense field of coalescing solution pipes has left irregular pinnacles between them – this is a different type of pinnacle to the hollow ones at White Mountains.

These solution pipes and pinnacles show a strong analogy with similar features in the syngenetic karsts – eg the Nambung Pinnacles (Fig 9).

The laterite pinnacles and pipes have also formed at the same time as the host deep weathering profile was developing, i.e. syngenetically. Both probably formed from focussed vertical water flow through a porous sediment.

Small-scale features

Small scale laterite karst features include three-dimensional networks of small solution tubelets and vughs, which may be infilled with nodules, clay, silica (opal) or left open (Fig 10). These are analogous with the ‘anastomosing tubes’ which are the first stage in the formation of limestone caves.

Pockets or bands of brecciated (broken up) material can occur adjacent to cavities formed by solution or piping. This is analogous to the formation of breakdown chambers in caves, but at a smaller scale.

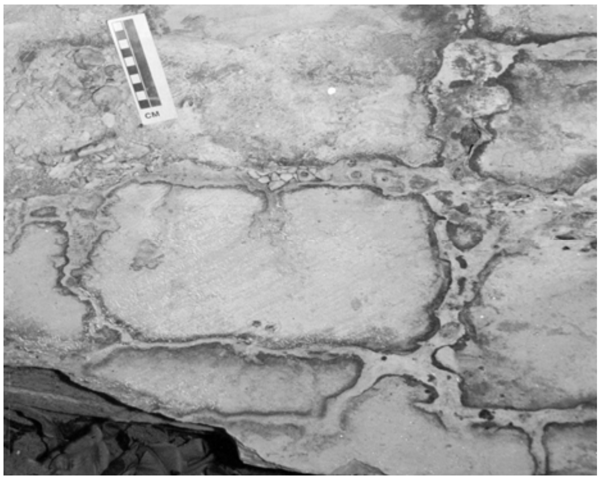


Fig 10: A network of small solution tubelets in a laterite mottled zone of the sea cliffs at Darwin, NT. The tubes have dark ferruginised rims and patches of nodular fill. 10 cm scale-bar.

Conclusion

This all-too-brief introduction to Australian laterite karst describes some of the processes operating in laterite terrains and provided examples of large and small laterite landforms.

Fieldwork conducted by both of us over a period of more than thirty years demonstrates the ubiquity of karst-like forms in northern Australia.

The ‘Mystery’ Craters of Bundaberg are just one part of this spectrum of landforms. Hopefully, to readers of this Journal at least, the mystery has been removed.

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