In the Blink of a Magic Eye

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To improve our understanding of the caves in the Kelly Hill Conservation Park, a reasonable place to start is by locating all the cave entrances within the Park. That's what the South Australian Speleo Council working group have been trying to do over the past couple of years, taking advantage of the brief opportunity for improved visibility resulting from an extensive wildfire in late 2019 / early 2020. The opportunity was taken at the time to carry out extensive high resolution airborne photographic and LIDAR recording of the Park's ground surface, and we have been following up by taking advantage of modern and extremely capable GPS location devices to ensure that the records are far more permanent and accurate than was previously possible.

Hopefully there will not be another opportunity to gather such a photographic record for many decades, but we now have so much new data that we can expect to continue analysing that for decades anyway.

Why Bother?

Why bother? Perhaps the first question we should ask ourselves is why we should even bother. There is a well decorated tourist cave with a few chambers, and the bush is really pretty when it's not on fire, but if there is any general public perception at all, it would be that maybe the cave goes for a couple of hundred metres and that's about it. Is it possible we do not fully appreciate what we have? Should we be assuming it must fit squarely in the category of being a nice little experience to have for half an hour or so before we go to the pub for lunch.

Lunch sounds good, actually, but I am posing the question because I believe we should bother. Despite several thrilling discoveries I have already been fortunate enough to participate in over the last 60 years of my involvement with Kelly Hill, we have barely scratched the surface, let alone plumbed its depths. Without taking anything away from Kelly Hill, the same could be said for many karst areas around Australia, and one of the reasons is that not only is caving technology, lighting and equipment, getting better, but also so is the science becoming ever more fascinating. Kelly Hill has tended to miss out from time to time because of logistical and transport difficulties when it is so much easier to hop in your car and drive to any of quite a large number of caving areas accessible to South Australian cavers. Even more before COVID19 effectively closed the Western Australian border. As perverse as it may seem, the really awful fires of a couple of years ago have focussed a spotlight on the western end of Kangaroo Island in general and Kelly Hill in particular that has every chance of re-writing our understanding and appreciation of this undervalued coastal karst.

At the last count the surveyed length of what has hitherto been regarded as the main Kelly Hill cave system was more like 2 kilometres than 200 metres, and the airflows tell us that there is a lot more yet to find. Since the fire, we have found many new entrances, and at least one significant new cave system, with promise of more to come. If that isn't enough to convince you, then consider the quality of the decoration, with its propensity for mega-helictites."Trogs Delight" (Figure1) and a number of others found in Kelly Hill are reminiscent of the perhaps better known "Epstein Sculpture" in Western Australia's Easter Cave, rare as hen's teeth but characteristic of coastal calcarenite caves, along with other distinctive forms of decoration (Figures 2, 3 and 4).

The Shark Hook

The Kelly Hill Tourist Cave recently lost its famous shark hook. There is little doubt it was shattered by vibration generated by scaling of the roof in the nearby entrance tunnel area in an operation more suited to a mine than in close proximity to displays of fragile decoration. This particular ill-fated speleothem suffered some damage previously but had been restored. In retrospect it is perhaps surprising it survived so long. There must have been considerable vibration transmitted through the rock when the artificial entrance staircase tunnel was initially driven down about 20m from the surface and only just around the corner from the Shark Hook. Possibly a resonant frequency combined with a particular mass distribution and crystal structure singled out that particular speleothem. It is of course essential, particularly for a show cave, that safety assessments are made from time to time and remedial work carried out as necessary, but advice from cave specialists balancing this against protection of the values of the resource itself should also be an essential part of the process. It is never going to be easy but needs to be done better.

The shark hook was found shattered soon after the scaling work was carried out, and the shattering did not appear to be a legacy of the prior repair work. The pieces were carefully collected and stored in a container in the caves office so that further reconstruction and reinstatement could be carried out in due course. It was this action of caring that ultimately sealed its fate, when the fire swept through and the entire office burned to the ground. Because the building had asbestos cladding incorporated in the construction, the men in white suits went to great pains to clean up the site thoroughly along with any remnant treasures it had contained. Now all that remains of the shark hook are the multitudinous photographs, souvenir teaspoons and fridge magnets (Figure 5). But not quite. Out in the so-called southern extension of Kelly Hill there is a large highly decorated chamber known as the "Back of Woop-Woop". In one area of that chamber there is an extensive display of exquisite helictites, and one of those helictites could almost be a stunt double for the shark hook.

Yes, we should bother about Kelly Hill. There is no doubt we should bother, and it's no bother at all, really. I am not going to explain, just yet, anyway, what I mean by the term "coastal calcarenite caves", but instead refer you to an excellent new book entitled "CAVES Processes, Development and Management" by Professor David Gillieson, which not only explains the properties of calcarenite, but puts it into context with other forms of limestone. It is not strictly a new book, but an extensively re-written and updated version of the original. It should be on the bookshelves of every serious caver and cave manager. If your bookshelves, like mine, are overflowing, load it on to your phone, so you can even take it caving

and read it in the dark. I am saying this purely and simply because I find the book so comprehensive, so well referenced, and so hard to put down, and not because David himself is an active and valuable contributor to the current post wildfire South Australian Speleo Council review of Kelly Hill and Flinders Chase karst.

I might be introducing here ideas that may be new to some Kelly Hill cavers. I could have benefitted from them myself 60 years ago at the inception of my involvement with Kelly Hill, but back in those days much of the research that provided the foundations for these ideas had not yet been conducted. It wasn't until some fifteen years after I became interested in caving and Kelly Hill that I saw the research vessel Glomar Challenger in the Western Australian port of Fremantle prior to it departing to drill holes in the ocean floor along the coast of Antarctica. That historic voyage made a significant contribution to the research upon which the now well accepted phenomenon of continental drift was based, and which also has a direct bearing on Kangaroo Island coastal karst.

Even in dune limestone cave entrances don't occur randomly. They are associated with caves formed by karst processes, and in particular the development of subterranean drainage systems.

So how do we pin down more precisely the location of subterranean drainage systems? In the case of Kelly Hill the place to start is by looking at the more traditional surface drainage systems feeding water towards the Kelly Hill Park, and then consider what is likely to have happened to that drainage when the area was progressively covered by Aeolian calcarenite. To the West of the Park we have a shallow valley, containing the South West River, cutting through Grassdale Station, now also part of the Park, and reaching the sea at Hanson Bay. To the east of the Park, the Stunsail Boom River similarly cuts right through the broad river flats of the Stunsail Boom property, before finally penetrating a ridge of coastal dunes to get to the sea. In both regions the rivers themselves cut through shallow soils and low dunes laid down post Permian. Most of the southern coast of the Park is comprised of limestone cliffs perhaps 20 to 50 metres in height supported on a lower rock platform approximately at sea level and made up of Kanmantoo Group metasediments interspersed with occasional intrusions of granite.

I find the subject of Geology fascinating, especially where it provides clues to the formation of cave systems. When I first joined CEGSA back in the early 1960's the Group was privileged to be strongly supported by the late Brian Daily who not only wrote dozens of erudite papers on South Australian geology but wrote them in such a way that non-specialists such as I could read and at least think we understood them. Brian had much to do with Kangaroo Island, which was considered geologically to be an interesting extension of the Mount Lofty Ranges. He was lead author of the geology chapter in the first edition of a wonderful publication produced first in 1979, updated with a second edition in 2002, by the Royal Society of South Australia (Inc.) entitled "Natural History of Kangaroo Island".

Most of the geology of the western end of the Island was either buried under other geology or situated part way down an inaccessible cliff, so instead, Brian and his colleagues tended to spend much of their time sorting out the complex geology of the Dudley Peninsula and the north coast of the Island close to Kingscote. Several species of trilobites associated with Cambrian sediments have been found at Emu Bay and elsewhere on Kangaroo Island, and one such species, Balcoracania dailyi has even been named after Brian.

The big trouble with geology, which is based on unravelling the record of the past contained in rocks, is that half or more of the record may be missing altogether. Sedimentary rocks get laid down in an orderly fashion on the beds of seas or lakes. Some include distinctive fossils. Some have since been ground away by glaciers or even the cumulative effects of little drops of water working in concert over millennia. I am not the first to describe reading the geological record as trying to read a book out of which someone has removed and destroyed over half the pages. Nevertheless, there remains still a great deal that we can learn from geology, and that is generally more than sufficiently fascinating to compensate for the missing bits.

The Kanmantoo Group metasediments exposed along most of the coastal perimeter of the park were accumulated in a shallow sea during the Cambrian period 500 million years ago. I am not clear on everything that happened since then, but there was certainly a mountain building exercise known as the Delamerian Orogeny. Some suggest that a mountain range to rival the Himalayas, and known as the Delamerides rose up during this time. The unresolved argument concerns the degree to which the new mountains were being ground down as they formed, and therefore whether or not they rose to become a major world range before being ground down again, which is more or less their current state. A similar argument exists about other mountain ranges that were indicated to be forming in an Australian inland landscape now remarkably devoid of such features. The Kanmantoo Group metasediments of Kangaroo Island still form a low relief basement surface under much of the southern and western coast. The Permian glaciation, apparently responsible for grinding down large swathes of South Australia's more lumpy scenery about 250 million years ago, took place while Australia was still joined to Antarctica. Separation of the two land-masses with the break-up of Gondwana was well under way about 50 – 60 million years ago. What happened to the land during the Tertiary period is less clear, but it seems the southern section of the western end of Kangaroo Island was inundated during the Miocene, as was the Murray Basin at that time. A small amount of Tertiary limestone is recorded, including limestone at Mount Taylor, Kingscote and Porky Flat. There was even some identified at Kelly Hill, although I am not quite sure where. The Aeolian calcarenite at Kelly Hill, however, is of Quaternary age.

The mechanism for accumulating this limestone itself is interesting. The Quaternary period commenced around 1.8 million years ago. Prior to that it is thought that both the South West River and the combined North West River, North East River and Stunsail Boom River systems would have continually been draining the higher inland country of Kangaroo Island. It therefore makes sense that the lesser catchments intermediate to those systems would also be continuing to operate. As the calcarenite dunes accumulated at Kelly Hill and fairly rapidly concreted into place, one would imagine that the existing drainage, when operating, would have

continued to either wash away the lime sands as they accumulated, or punch through and under the dunes, or a combination of both processes. It is not clear to what extent drainage channels were originally established under Kelly Hill in shallow soils similar to the Grassdale and Stunsail Boom properties, and to what extent the Aeolian calcarenite deposits overlie or replace such soils. Since the formation of the calcarenite dunes themselves it is clear that the upstream alluvial plain at the base of the dunes in the immediate vicinity of the Kelly Hill tourist cave has built up at least a metre or so, and that water entering the dune at various points of influx along this interface has cut channels down through the sediment into the limestone.

The process has been described as "syngenetic karst" which simply means that the processes of cave formation and dune formation were both happening at the same time. The mechanisms of this process, once started, are well understood, and were described by the late Alan Hill in a CEGSA Occasional Paper written shortly after CEGSA carried out the first comprehensive survey of Kelly Hill 65 years ago. The dunes were consolidating through re-solution and cementation. Drainage water percolating through the dunes tended to form a base level of flat chambers. Large areas of flat roof in these chambers gradually shed blocks of rock in an "upward mining", in the process forming more stable arch or dome-shaped chambers. The soluble component of the break-down rocks continued slowly to be dissolved by the intermittent stream waters that were etching out the flat chambers. So far we have only considered development of the cave chambers themselves, but also within those chambers, as appropriate, various forms of cave decoration often will be simultaneously forming, at the earliest opportunity. Compared with the sometimes great age of other well-known cave systems we may form the mistaken impression that quaternary processes are too recent to give rise to any significant cave decoration. In one extensive chamber recently discovered within the Kelly Hill system large blocks of exquisitely banded flowstone occur that are of the order of 3 metres in thickness. Pushing the limits of Uranium series dating ascribes an age to this flowstone of around 750,000 years, so the chamber containing it already had considerable dimensions back then.

What has not been so clearly appreciated perhaps by most cavers otherwise aware of karst processes, is the important role played by cyclic climate change. Ice ages in the early part of the Quaternary recurred at intervals of about 41,000 years, attributed to synchronicity with the Milankovic cycles governing variations of the Earth's wobble and orbital distance from the Sun. Over the last million years the cycle has changed to more like a 100,000 year period. That still adds up to many ice ages over the full 1.8 Million year duration of the Quaternary. The development of the thick blocks of flowstone already described above should span something like the last 8 ice-age cycles. Possibly at some time in the future someone might have the means and opportunity to interpret the spacing of the bands in this flowstone, and through correlation with known information about some of the ice ages, even fill in a few of the blanks.

The particular importance of these ice ages is that they were accompanied by a lowering of sea levels (see Figure 6), exposing large quantities of lime sand off the shore of Kelly Hill and other similar coasts. It is suggested that strong onshore winds were then responsible for intense periods of dune building, during which time, exactly because of those very same ice ages, the surface stream flows would have reduced markedly and perhaps even stopped for extended periods. There are indications that these periods of low, or minimal, flow have been offset in past interglacials by wetter periods than we are currently experiencing.

The most recent ice age occurred between 18,000 and 10,000 years ago, and during that time the sea level dropped over 150 metres. Over the last 700,000 years only a small amount of time has been spent with higher sea levels than now, about 120,000 to 140,000 years ago, but the average sea level over the full 700,000 year period has been about 55 metres lower. Since past climates have had a part to play in karst processes at Kelly Hill, we must expect that anthropogenic climate change will also impact those karst processes in some manner.

The Magic Eye

Some years ago I became aware of "Magic Eye" pictures, or autostereograms composed of subtly changing repeating dot patterns that unconsciously fed the brain on encoded depth information. It was possible to stare at the image for long periods without seeing anything but the repetitive pattern. Even so, something must have been going on somewhere in the brain, and a three-dimensional image would start to flicker into existence, and often take on a surprising vividness and reality. Having seen it once, your brain usually remembered enough to see it more easily the second and subsequent times, and it turned out, for me and some others obviously similarly wired up, to be quite an amazing experience.

That is the closest analogy that I can conjure up to explain an experience that I have recently had as a consequence of simply staring for long periods of time at a precious old topographic map of the Kelly Hill Conservation Park. Another analogy that might help would be the experience I shared with others who looked at our globes of the earth and noticed the way the east coast of the Americas along the western side of the Atlantic Ocean followed so well the West Coast of Africa and Europe on the eastern perimeter of the Atlantic. Half a century ago, after much ocean floor drilling, and mapping of the mid-Atlantic ridge, somebody joined the dots and the theory of continental drift was confirmed. We all became instant experts on giant jigsaw puzzles that made up the once-supercontinents Pangaea and Gondwana. I am trying to make the point about the difference between seeing with your eyes and actually seeing with the full bit, including your brain, when the light switches on in your head, if you get my continental drift.

I have been clocking up late nights poring over the detailed and very revealing topographic contour data, until, very much like the image first springing to life in front of one's eyes when viewing a Magic Eye picture, all the pieces drop into place, and suddenly the whole region starts to give up its secrets.

The process is not quite as automatic as that invoked in the brain by a Magic Eye picture pattern, but there is no doubt in my mind that it follows some of the same steps. The photographic imagery itself is not intrinsically three dimensional in nature, but contains

clues such as shadowing, light and shade along ridge lines, and so forth, that may initially be ambiguous, but eventually when interpreted correctly make the most sense. In complex terrains, the ambiguity may be quite severe. Up until now we have been closely inspecting the visual data looking often near the limits to small scale resolution for unambiguous signs of entrance dolines, windows or solution pipes. Even these are not always obvious from the air, so it helps when we are already familiar with the feature on the ground and can then confirm the provenance of the aerial image. Such classic examples are the "K11" and "Little K11" entrances, the "K 1"entrance and so forth. Some other so-called "new" entrances are also unequivocal, but equally there are plenty of known cave entrances, such as " K3 ", where the initial dark zone is hidden by overhanging low cliff on the side of a relatively gentle depression, that may not be at all visible in the airborne data. This is where the separate topographic information immediately provides the important 3D component of the dataset, and can even confirm whether a particular shape is a local ridge or valley, summit or closed depression, which in turn can start to delineate adjoining and possibly related features, drainage lines and so forth.

Finally, we can perhaps quite painstakingly combine the two datasets, perhaps on paper, and certainly in the first instance within our mental imagery, to build up a comprehensive drainage construct which very quickly yields for us a consistent picture of what is happening right across the Kelly Hill Conservation Park.

Let us start first with the drainage system that we don't know all that much about, but we think we know best. The catchment starts well to the north of the south coast road. It is bounded on the west by tributaries to South West River, which drains into Hanson Bay, and to the east by tributaries to North West River which joins with North East River to form the Stunsail Boom River just before it crosses the South Coast Road and finally makes its way to the coast. In between these two quite distinct catchments is an area of land stretching 5 to 6 kilometres north of the South Coast Road and about 5 to 6 kilometres west to east. The western portion of this land forms the catchment for Little Terror Creek which flows into the eastern portion of the Grassdale property, now added to the park, and the eastern portion of the land drains via several channels into the main Kelly Hill Cave influx as well as a number of minor influxes along the base of the dune system immediately to the east of the main influx.

The relationship between all of these influxes can be quite complex, and has been made even more so by earthworks associated with culverts installed under the South Coast Road as it has been upgraded. The main influx is far more developed than the minor influxes, and still receives significant but ephemeral flows. This influx is characterised by water passing through rock-pile. It can easily be temporarily blocked by accumulations of sticks and leaves swept into it, and when that happens a shallow lake overflows back along the base of the limestone ridge and the excess water flows into several of half a dozen minor influxes up to a few hundred metres further to the east. It is not altogether clear where the water flows once it has gone underground. Underground watercourses are found in several caves up to a kilometre or more to the south of the tourist cave, including K11 and K88, but there is a further 5 kilometres or so of calcarenite dune between that location and the south coast, and there is little doubt that the water must make its way somewhere underneath that country.

In the middle of last century the show cave was established as the nucleus of a National Pleasure Resort, an evocative name for a facility operated by the State Tourism Board. The reserve so created stretched for 3 km along the South Coast Road. It extended south for about 1.5km in the east to include the entrance of K11, and about 3km in the west to include a large lagoon. Further to the south was a large section of un-allotted crown land, and further to the east along the road was a block of several thousand acres leased in perpetuity to a Mr Flavel. Eventually Flavel's land was purchased and added to the park. The un-allotted Crown Land was also included in the park, but separately designated as a Wilderness Protection Area. While both of these critically important acquisitions increase the conservation status of the area in total, the ongoing distinction between conservation park and wilderness protection area tends to perpetuate the notion of separate objectives for each distinct parcel of land, rather than giving due recognition to the intrinsic interconnectedness of the karst drainage and associated attributes of the whole area. It is especially clear that the already noted extent of the catchment north of the South Coast Road potentially makes the karst drainage within the total area vulnerable to any inappropriate practices that might be undertaken within that northern catchment. Whether this vulnerability can be adequately managed by placing and ensuring compliance with reasonable constraints on permitted practices within the northern catchments is a matter for future consideration.

South and to the East of the main catchment for Kelly Hill Tourist Cave, but west of the North West River/ Stunsail Boom catchment there is another distinct catchment, consisting of about 4 square kilometres of almost flat plain north of the South Coast Road and another 5 or so square kilometres of similar country to the south of the South Coast Road. About a kilometre east of the Kelly Hill Tourist Cave the edge of the calcarenite dune system cuts back in a south-easterly direction and at the base of the main dune ridge there are a couple of closed depressions, one of which fits the description given by Harry Hansen, the first Ranger at Flinders Chase, as taking water during flood conditions. A portion of the hilly dune country to the west of this feature also contributes to its catchment. While there is no record of floods sufficient to trigger this mechanism in recent times, bear in mind the previous discussion about periodic glacial cycles and wetter inter-glacial periods.

There is a third, more complex catchment, as illustrated in Figure 7. The large lagoon about 3 km southwest of the Kelly Hill Tourist Cave is rarely seen with large quantities of water these days, but is in itself evidence of wetter times in the past. The lagoon is bounded to the south behind coastal calcarenite dunes and appears to take drainage from the more westerly portion of the old National Pleasure Resort. The aerial photography and topography clearly shows the lagoon draining towards the sea at both the eastern and western ends. At the western end the drainage from the lagoon makes its way under overflow conditions towards the adjacent flood plains alongside the Southwest River in Grassdale, and thence to the sea at Hanson Bay. At the eastern end,

the drainage proceeds down a short channel (that would presumably have filled with sediment by now without being kept clear by periodic flow) where it appears to dive underground. It looks as though it once re-appeared in a smaller lagoon, these days almost permanently dry, before taking two separate courses as it progresses through and under some of the highest dune country in the entire park. A few hundred metres further to the east, the easternmost drainage channel is aligned with a closed depression about 30 metres deep.

The relationship between all of these features suggests they functioned normally when the main lagoon itself was more active during wetter conditions. Even if no immediate access is available to cave tunnels which may have been active at the peak of the wetter period(s), there may exist evidence of, or sections of, such tunnels that confirm such past activity. This also supports the notion of wetter periods feeding an eastern influx. It would be great if we could find conclusive evidence straight away, but in any event the indicators are so strong that both of these areas are prospective for a close and thorough investigation.

Because of the need to book ferries and accommodation well ahead, planning is already in place for several visits this year. Like the newly discovered Phoenix Cave, much is rising from the ashes.

Figure 1: "Trogs Delight" with a younger version of the Author, for scale.

Figure 2: Dense decoration reasonably common in Kelly Hill.

Figure 3: A reasonably representative scene in Kelly Hill

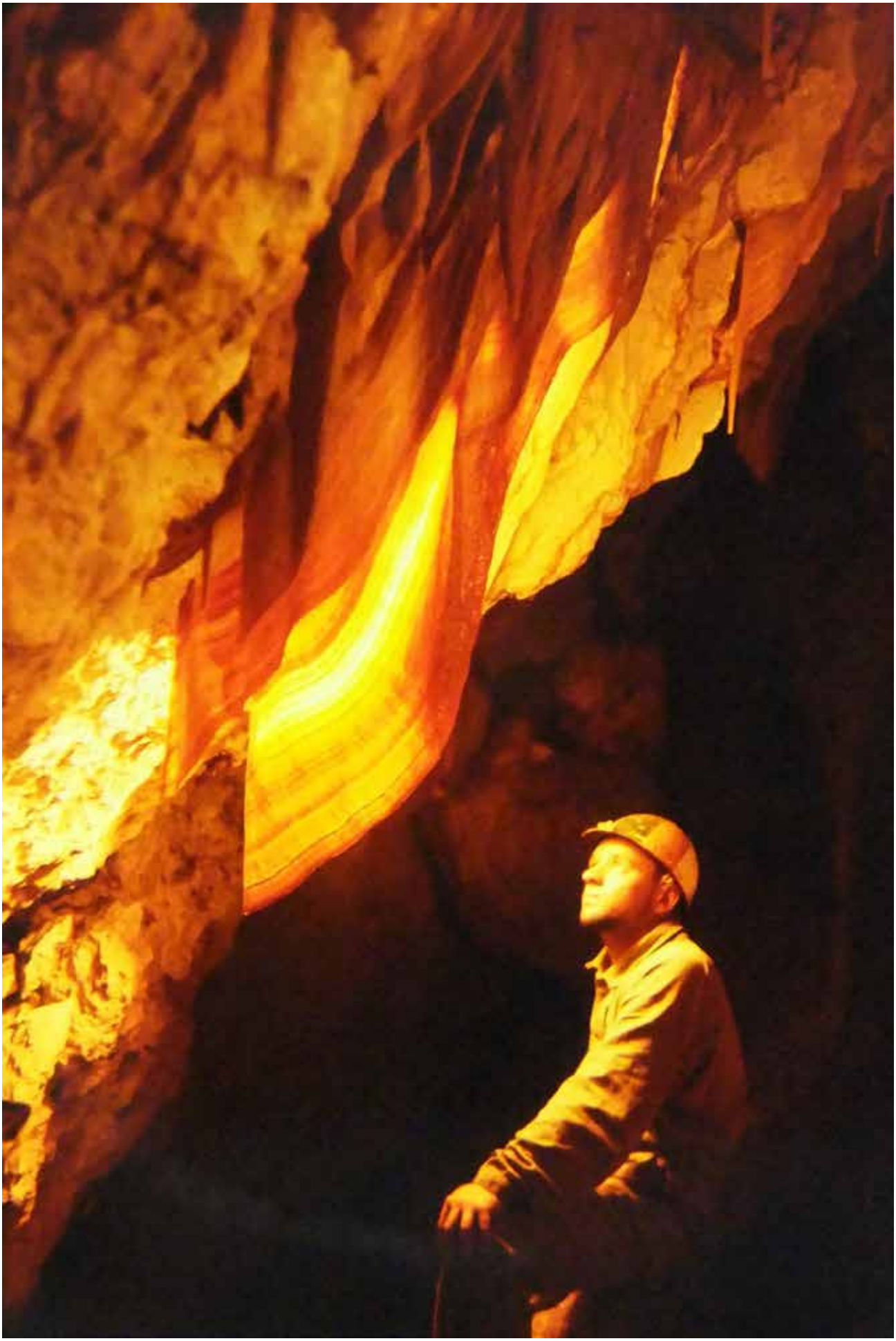

Figure 4: Professor Tom Wigley in earlier days admiring a group of shawls in the "Trogs Delight" chamber, Kelly Hill.

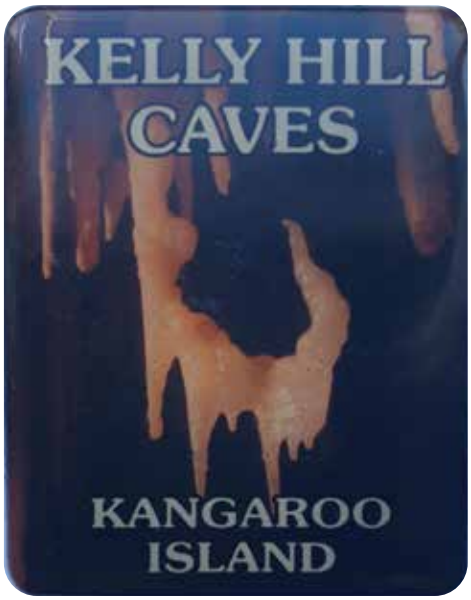

Figure 5: The Shark Hook Fridge Magnet. Unfortunately now a collector's item.

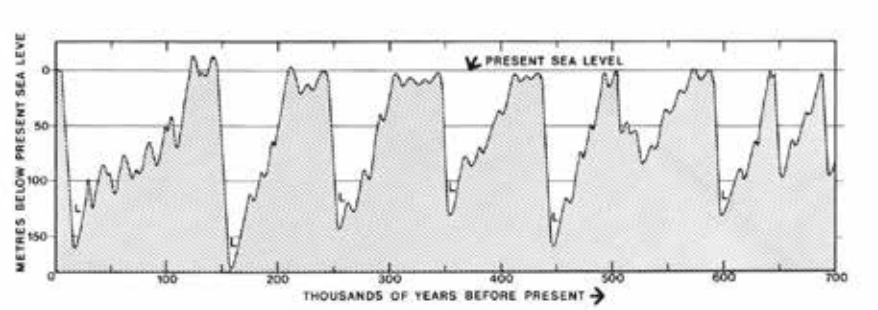

Figure 6: Historic Sea Level Change. After Chris C Von Der Borch, in Natural History of Kangaroo Island, 2nd Edition, published July 2002 by the Royal Society of South Australia (Inc.)

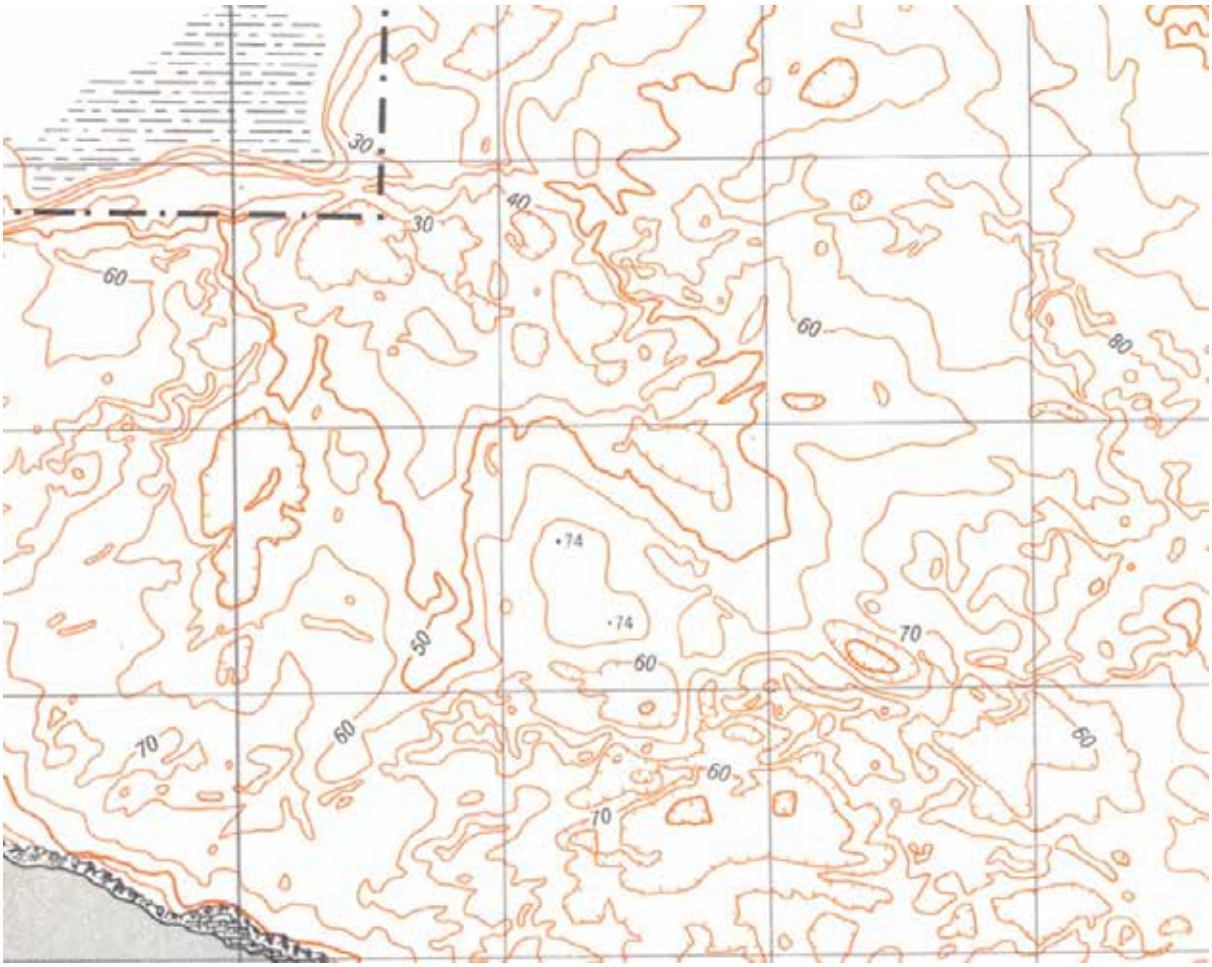

Figure 7: Excerpt from Grainger 1:50000 topographic map, sheet 6226-II, early compilation copy, showing interesting contours to the South-east of the Grassdale Lagoon. Strong lineations linked to the South-east corner of the lagoon are evident as well as deep closed depressions. Contours are at 10 metre intervals, and closed contours have tick marks on the down-slope side of the contour line. Grid-line spacing 1 kilometre.