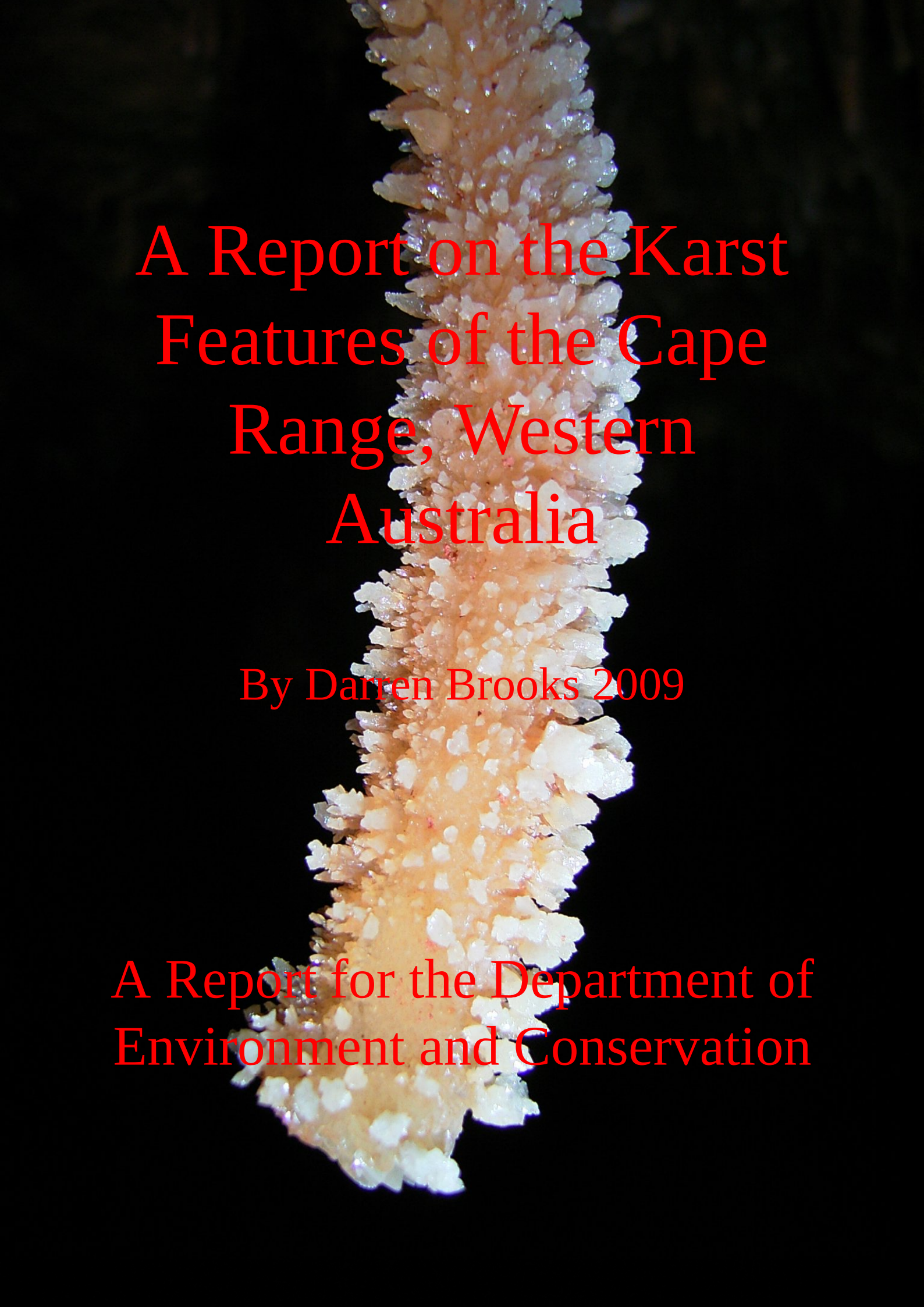


A Report on the Karst Features of the Cape Range, Western Australia

By Darren Brooks 2009

A Report for the Department of Environment and Conservation

A Report on the Karst Features of the Cape Range, Western Australia

Darren Brooks. January 2009.

Location and description of caves and other karst features.

To simplify the geology of the Cape Range limestones, there are three layers comprising the major uplift sequences. In ascending order, from deepest and oldest to shallower and younger, these are the Mandu Calcarenite, the Tulki Limestone and the Trealla Limestone. The fourth major component of cave bearing limestones is the Bundera Calcarenite, comprising the coastal plains and consisiting mainly of shallow marine and aeolian deposits. These limestones are of Tertiary age (24-25 m.y.a.). The Trealla Limestone has largely been eroded from the top of the range and the Tulki Limestone forms the majority of the cave bearing limestone. The Mandu Calcarenite is exposed in the gorges, particularly on the eastern side of the range. (Condon1968, Playford *et al*. 1975a,b, van de Graaff *et al*. 1980)

In comparison to tropical limestones, the Cape Range limestones are poor in surface solutional features such as karren and pillar karst. Minor examples of karren and enclosed pools (kamenitza) can be found on the Tulki Limestone.

All of the limestones contain caves. The majority of recorded caves fall within the confines of the Tulki Limestone (Humphreys 1991).

Many of the caves located within the Tulki Limestone of the Cape Range exhibit features indicating that there was once significant, continuous influx of water. Deep, circular, vertical shafts are often encountered on peaks of ridges (eg. C-207). More often entrances are located near the head of a dry stream bed and these entrances harvest a small amount of inflow from annual rains (eg. C-254). Rarely are vertical entrances encountered in deep valleys as these are invariably filled with sediment (eg. C-678). In addition, the troglofauna now living in the caves are clearly evidence of once much wetter surface conditions. The troglofauna, generally, are related to species inhabiting the forest floor of the wet tropical regions.

There are some extensive horizontal systems (eg. C-126, C-163 Wanderers Delight). These occasionally lead to perched water pools that receive recharge from major rainfall events associated with tropical depressions. C-163 has multiple-level passage development indicating several periods of solution and deposition.

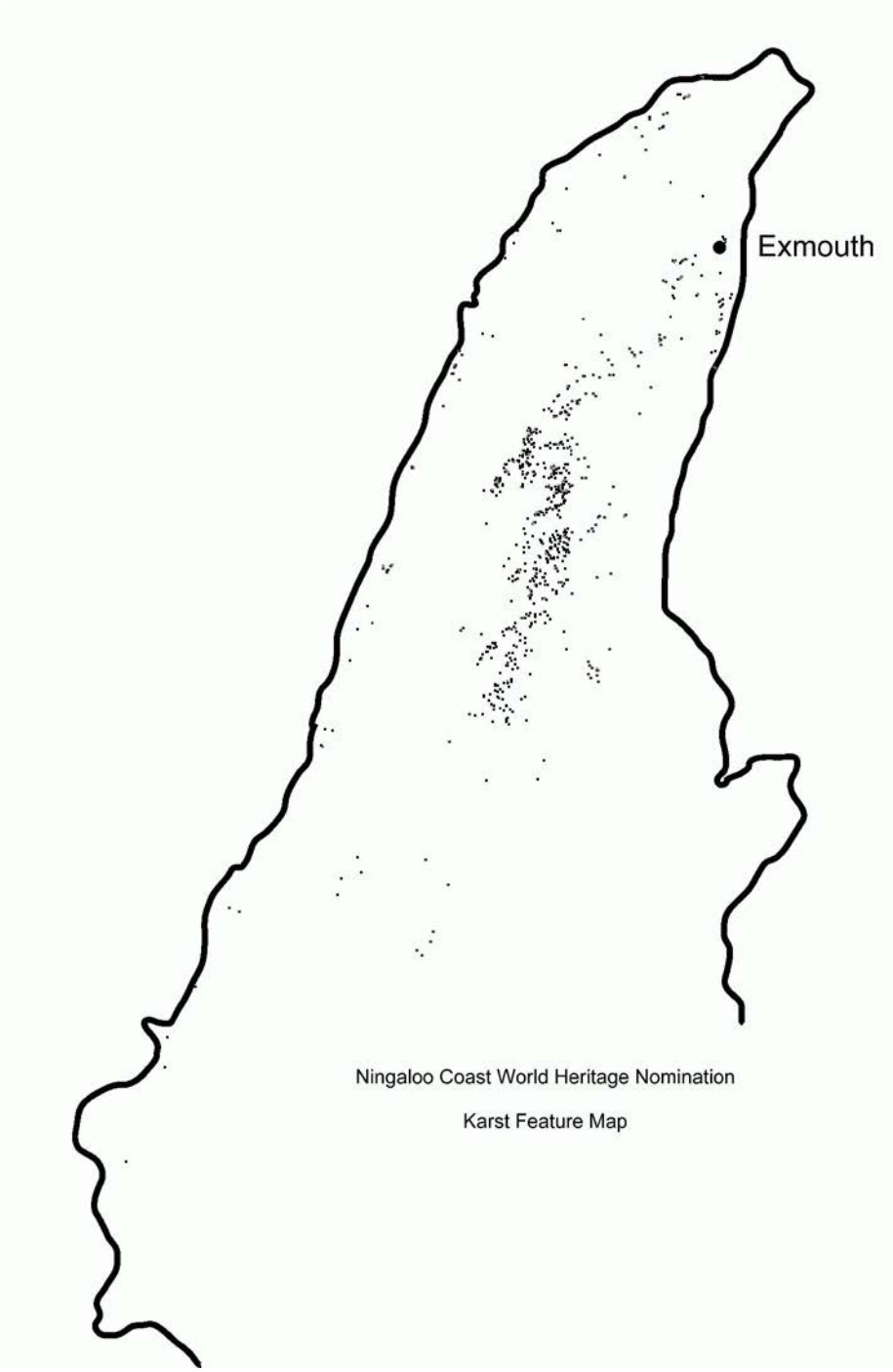
There are many rock-shelter type caves in the sides of gorges and on the edges of the eastern and western escarpments. Many of these have been used in the past for indigenous practises (habitation and ceremonial). One site in Mandu Mandu Gorge has had material dated to approximately 30,000 years before present, indicating long term occupation based on a maritime economy (Morse, 1988). Many rockshelter caves have fairly extensive horizontal chamber and passage development and appear to be drainage channels, possibly originating from bedding seepage, that have been intersected by gorges.

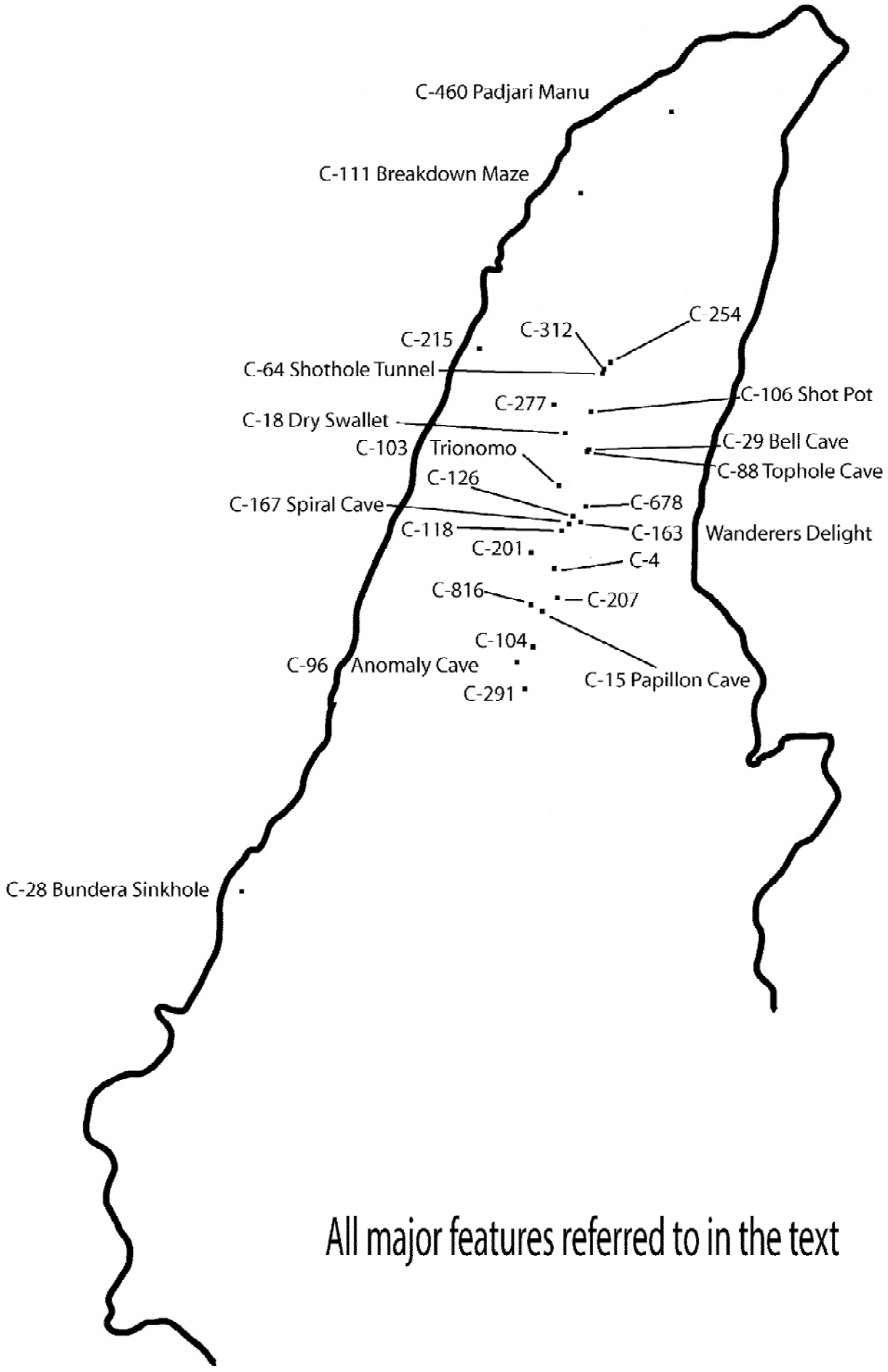
It would appear that all deep caves are formed in the Tulki Limestone. This is evidenced by vertical entrances which are either blocked or lead to a passage or network of drainage passages. That these horizontal passages are in Tulki Limestone is evidenced by the fossils of the irregular urchin *Echinolampas westralensis* which is a good marker species (Humphreys 1991 – K. McNamara; pers.comm. 1989) for this limestone.

A significant number of caves are located on the coastal plains themselves. Many of these give access to the anchialine environment (eg. C-28, Bundera Sinkhole). The numbered features on the western coastal plain extend further south than the southern limit of the Cape Range proper.

There are hundreds of depressions on the surface of the Cape Range. Approximately two hundred have been numbered but pre-1989 practises were inclined towards cave numbering and exploration. Since 1990 the number of dolines and other depressions numbered have increased significantly. It is expected that this trend will continue as many previously bypassed depressions are included in the karst numbering list.

Other numbered features, although small in size and few in number (eg. Man Made Wells) may have great significance for the study of stygofauna as they give access to the aquifer which may not generally be accessible. They are also a historic component of the european settlement of the region and also are often located near to natural wells and soaks previously used by the fauna and the former aboriginal inhabitants of the region, the Jinigudira.





All major features referred to in the text

Classification by size, depth and the major features.

Before delving into the material suggested by the title, it should be mentioned that the karst of the Cape Range contains many caves that are not recordable. These caves are not enterable by humans due to their size but indeed are the major habitat of the troglofauna. Small tubes, joints, cracks, interstices and slightly larger voids (from a fraction of a millimetre in diameter to several centimetres in diameter or width) are an integral part of the network of caves of the Cape Range through which the gases, liquids and fauna can pass.

The *recorded* features of the Cape Range can be broken into two major groupings.

Actual **caves** are features enterable by the average sized adult. The features may range from approximately 2 metres long or deep to caves that extend for hundreds or thousands of metres horizontally and up to 90 metres vertically.

Dolines are karst features that form by surficial solution or collapse of cave chambers. Dolines may have sloping or vertical sides and may be extremely shallow and of a few metres diameter or may be very large, in the range of tens of metres deep and hundreds of metres in diameter.

Over two thirds of the recorded karst features are actual caves and nearly a quarter are dolines. Note that many caves have dolines as entrances but only dolines without caves are recorded as dolines. The other disparate features (such as Man Made Wells) are attended to elsewhere in this report.

In the following table all caves with a depth of 50m or more and all caves with a length greater than 100m or more are recorded. Although length or depth factors as described above are common in their individual right, there are few caves with a significant combination of the two. Five caves are considered to be major features by this combination of criteria.

Although many caves are within the range of 30m to 50m deep, most of the caves in the Cape Range are vertical in nature with little or no horizontal development. Under these circumstances the criteria of length would seem a better measurement of *size*. Thus all caves over 100m in length are to be included in the category of major caves.

However, size alone does not necessarily mean that a cave is important. Aspects such as scientific importance (in regard to minerals, fauna), social impact, palaeontological and archaeological significance and hydrological disposition can be regarded as important as, if not more so, than it's physical size. Hence the table of major features also contains a subset of features regarded as important due to one or more of these factors. Maps of all caves are included in the attached appendix. The exception is C-460 where cultural and indigenous sensitivities preclude the publishing of a map or images of this cave.

Wanderers Delight, C-163, stands out as a significantly well developed horizontal system and also marks highly on the depth column. Several long and deep caves also contribute to the drainage system of Wanderers Delight. C-126 receives a large amount of inflow at times and it is thought this cave drains into Wanderers Delight from the north. Spiral Cave, C-167, also takes significant inflow at times and its easternmost drainage arm is barely 100m from the westernmost extension of Wanderers Delight. Ripple deposits on the silt floors of the passages in C-126, C-167 and C-163 give a clear indication that these caves share a very similar flow pattern to the south and east. Together, these caves, and other more minor features, drain a large basin (uvala) containing many depressions on the top of the Cape Range a dozen or so kilometres south of Charles Knife Road. It should be noted that the drainage from Wanderers Delight is trending towards the 'Proposed conservation and limestone management reserve', although the actual outflow point, if it exists, has not yet been discovered. The combination of the these caves adds up to many kilometres of underground drainage.

Cave No.	Length	Cave No.	Depth	Caves with length/depth factor combined
88	100.00	246	50.00	126
106	100.00	436	50.00	163
291	100.00	591	52.00	201
29	110.00	369	52.00	207
111	120.00	609	52.00	254
678	120.00	157	53.00	
816	120.00	56	53.00	
96	150.00	435	53.50	
104	150.00	126	54.10	
207	150.00	18	58.00	
312	175.00	100	59.00	
167	198.00	720	60.00	
103	200.00	471	61.00	Other caves with special importance (major caves)
201	230.00	201	62.60	
254	285.00	477	63.00	
215	350.00	740	65.00	4 Palaeontological/social
126	546.50	83	68.00	15 Biological
64	650.00	163	69.20	18 Biological/social
163	6861.00	102	70.00	28 Biological/scientific
		254	70.70	118 Scientific
		82	74.00	460 Archaeological/indigenous
		281	78.50	
		277	82.00	
		207	85.00	

Number of caves and other karst features.

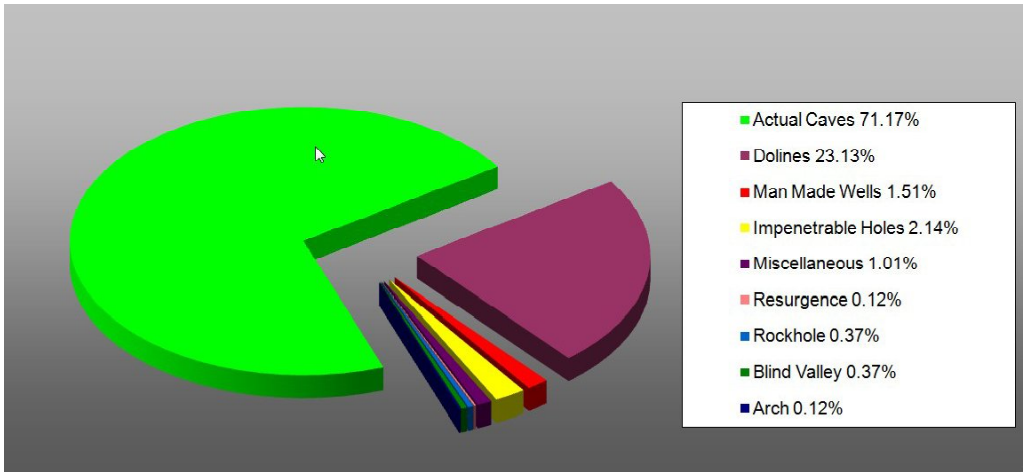
The karst features of the Cape Range were officially entered into the numbering record in 1962. The number of features was low for many years until the late 1980's when interest in troglofauna led to several expeditions to research the karst and troglofauna of the region. 1988 and 1989 both saw expeditions led by Dr Bill Humphreys of the Western Australian Museum. These trips were funded under the National Estate Program and administered by the Australian Heritage Commission (Federal Government) and the WA Heritage Committee (State Government) (Humphreys 1991).

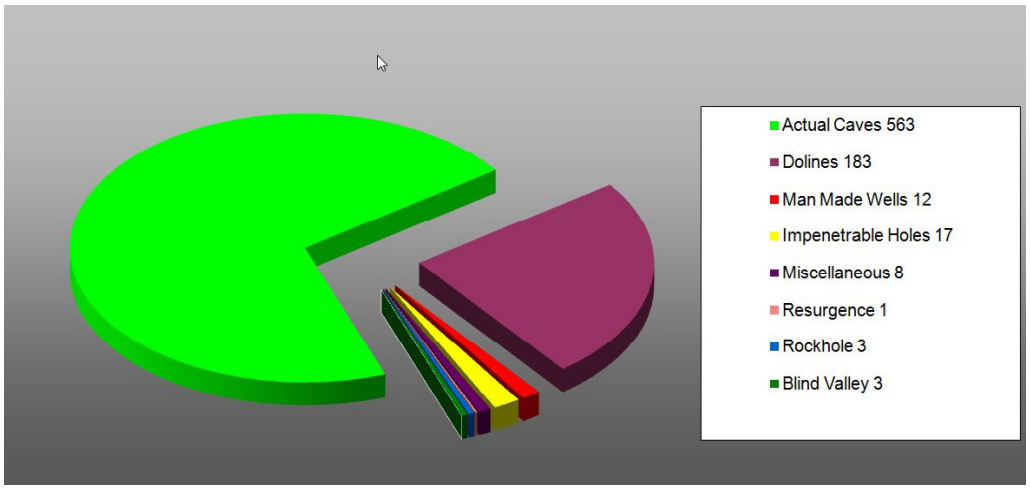
From 1990 onwards the responsibility for numbering karst features in the Cape Range area has fallen to resident cavers. As of December, 2008 a total of 791 features on the Cape Range peninsula have been numbered. The vast majority of these are caves but the ratio of dolines and other features versus actual caves has increased from 10% of dolines and other features in 1998 to 28.83% of features being dolines and other features in 2008.

All features are numbered in accordance with the ASF Cave and Karst Numbering Code (2006) guidelines put forward by the Australian Speleological Federation (ASF). The ASF is a national body with the primary objective of protecting the cave and karst environment of Australia. The numbering code consists of: a state designation; an area designation; and a number. For Western Australia the State designation is 6. For Cape Range the area designation is C. Each cave is

assigned an individual and unique number. Thus for Wanderers Delight the correct designation is 6C-163. Throughout this text, which clearly relates to only WA, the State designation is dropped in favour of just the area and number code.

The number of caves and dolines (approx' 95% of all features) continues to grow each year. The other approximately 5% of features has remained fairly static since the 1990's and the ratio of caves and other features is likely to decline in the future in comparison to the number of dolines.





Features of International Significance

The process of focussing on outstanding features of international significance has value in focussing attention on key values. These values may only exist at that site and therefore deserve such attention. However, such focus may ignore the fact that such values may not be able to be preserved in isolation without protecting the surrounding landscape and its inherent values. (eg. erecting a barrier around a cave entrance does not preclude the main body of that cave being quarried away hundreds of metres away from that entrance.) In that respect, consideration will also be given to the whole of the cave bearing karst being of representative value and that aspect will also be addressed below.

The eastern and western coastal plains contain some caves that give access to an anchialine habitat containing ancient faunal elements connected to northern hemispheric faunal elements associated with the break up of the Gondwana land mass.

The caves of the foothills and range proper contain a relictual fauna of more recent origins more properly related to a surface environment of hot, wet, tropical rainforest. The caves are now refugia

for fauna that can no longer exist in the dry, arid climate of the Pilbara landscape.

C-28, Bundera Sinkhole contains a stygofauna with many tethyan elements. The Cape Range Remipede *Lasionectes exleyi* (Yager J, Humphreys WF 1996) was discovered here and to date has not been recorded from any other site. World wide distribution of remipedes is the Bahama Islands and locations in the larger Carribean region. Bundera Sinkhole is the only deep anchialine ecosystem known in Australia (J. R. Seymour, W. F. Humphreys, J. G. Mitchell 2007).

Bundera Sinkhole has a complex stratified hydrological structure which has an influence on the distribution of the component species within the water column. There are also species of hadziid amphipods, gammarid amphipods, ostracods, copepods, a thermosbaenacean, an undescribed species of atyid shrimp of the genus *Stylifera* and the blind fish *Milyeringa veritas.* The atyid shrimp *S. lancifera*, other species of amphipods and the blind eel *Ophisternon candidum* occur within the adjacent aquifer. Of all the caves in the World Heritage nomination area, **C-28** stands out as unique in its combination of stygofauna and hydrological qualities.

Of the terrestrial caves that occur in the elevated area of the Cape Range there are many that are of high value for paleontological, biological, hydrological, scientific, historic, cultural and social aspects. In summary, many have high biological and scientific value; an increasing number have historic, cultural and social value; there is probably one cave **C-163 Wanderers Delight**, which stands out as a single example of hydrological interest as it would seem it drains the large uvala atop the central karst plaueau and appears to form the master cave for many of the lesser sinkholes and caves in the area.

In general; the anchialine environment of the western coastal plain contains an ancient crustacean fauna dating back to the breakup of the supercontinent Pangea over 180 million years ago. When the landmasses drifted apart they carried the ancestors of the Cape Range stygofauna around the globe.

Two of the Man Made Wells comprise the type localities of the only cave dwelling vertebrates in Australia. C-24 Milyering Well is the type locality of the blind fish *Milyeringa veritas* (Whitley 1960) and C-26 Tantabiddi Well is the type locality of the blind cave eel *Ophisternon candidum* (Mees. 1962).

There are over 50 species of troglobite and stygobite with at least 10 genera and one class occurring nowhere else in the world. Currently the Western Australian *Wildlife Conservation Act 1950* lists 16 species of Cape Range subterranean fauna that are rare or endangered.

The Cape Range karst contains possibly one of the richest and most diverse troglobite faunas in the world (Hamilton-Smith *et al* 1996). Many of the caves mentioned in this text are type localities of species that do not occur anywhere beyond the boundaries of the North West Cape. In some instances, that species is known to occur in only that type locality.

Many of the important fauna yielding caves of the Cape Range are of little distinction in regard to length or depth otherwise (eg. C-118).

Important subfossil deposits have been collected from several caves and archaeological digs. Many more deposits remain to be examined. There are several dozen caves with deeply incised clay deposits containing exposed subfossil material. Since European settlement, it appears that at least half of the original mammal fauna of the cape has become extinct and many identifications have

come from these collections. Collectively, there are many publications that are gradually drawing attention to the importance of caves as archives of essential paleontological and paleoclimatic data.

There occur innumerable rockshelters in the western scarp of Cape Range, few of which have been examined closely. Some that are well known for containing evidence of indigenous occupation in the past have been affected by visitation and vandalism (personal observation D. Brooks).

The unique combination of the elevated karst with vertical caves, the coastal plain of anchialine and terrestrial cave habitat and the nearby presence of the fringing Ningaloo Reef provide an environmental combination unparalled anywhere in the world.

The porous karst landform allows little surface flow of water, except in the most extreme conditions. Even in those events it is probable that there is a general flow of water through the terrestrial cave environments into the anchialine waters of the coastal plain.

In a superlative comparison between the Cape Range peninsula and Central America it has been recorded that in the lowland tropics of Central America where the research effort has been 100 times greater than in the Cape Range, a sampling of 243 caves from 8 karst provinces revealed 46 troglobitic species compared to 67 in Cape Range. Central America has 12 species of stygofauna, less than half that known from Cape Range (Hamilton-Smith *et al* 1996).

Testimonial Statements

In The Biogeography of Cape Range and in reference to it's scientific values A.R. Main states "*...the area ranks as unique and scientifically as world class. (p246)*

In Karst Management Considerations for the Cape Range Karst Province, Western Australia, Hamilton-Smith, Kiernan and Spate (August 1996) declare that "It would be of **world significanc**e even if there was no subterranean fauna; given the existence of the fauna, it can only be rated **as one of the more significant natural heritage areas of the world."** (Hamilton-Smith *et al* 1996).

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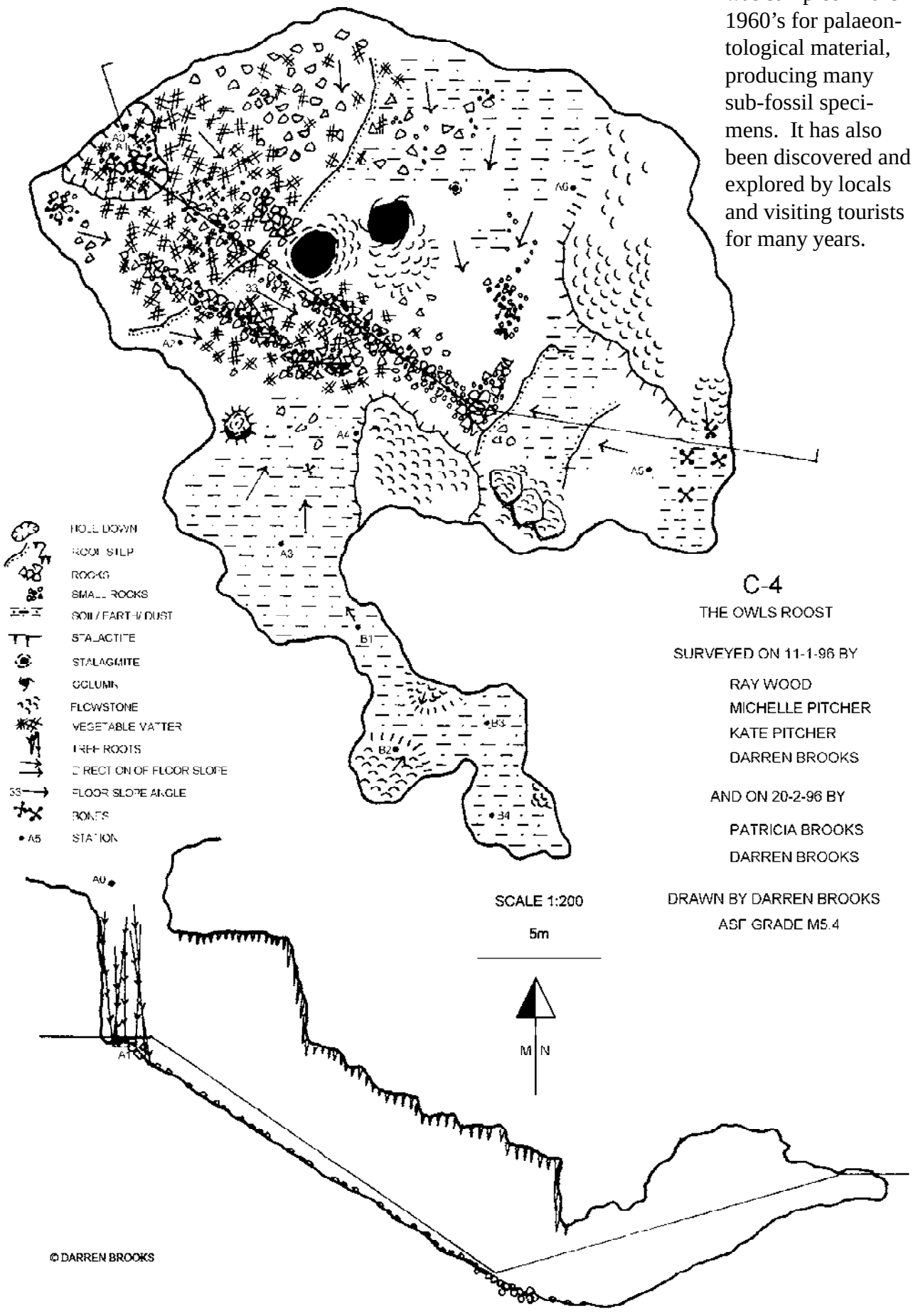
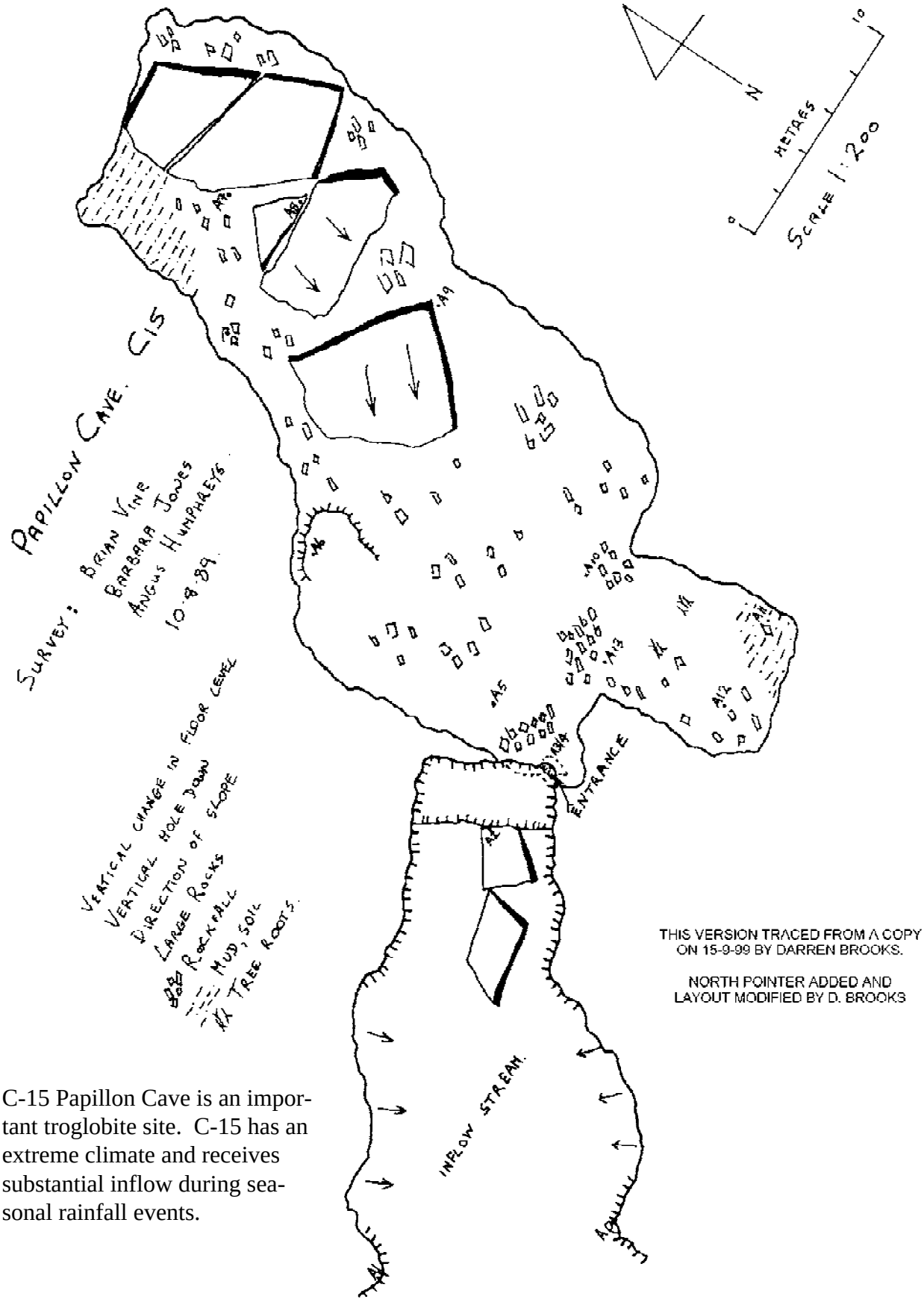
C-4 The Owl Roost was sampled in the 1960's for palaeontological material, producing many sub-fossil specimens. It has also been discovered and explored by locals and visiting tourists for many years.





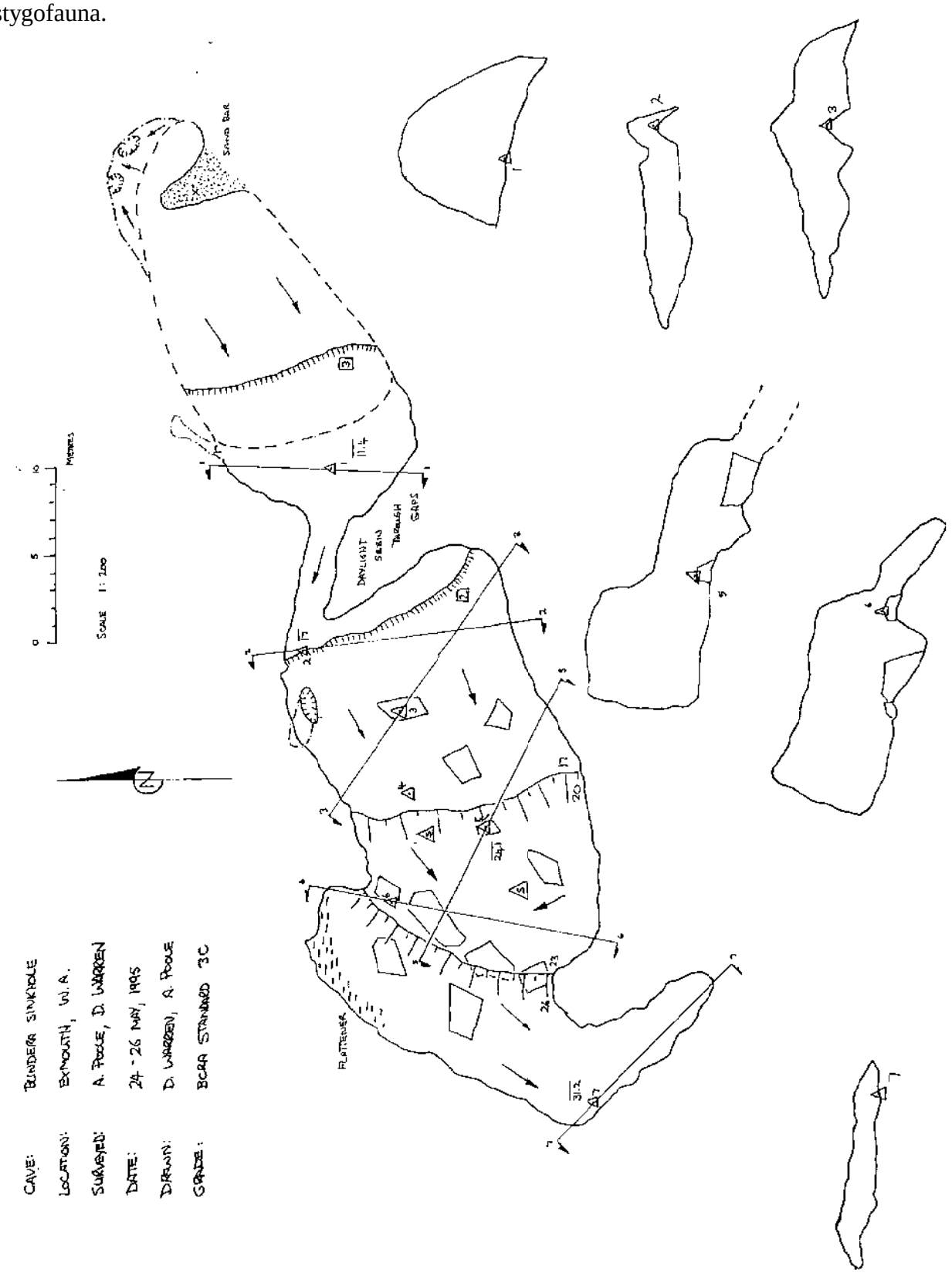
C-15 Papillon Cave is an important troglobite site. C-15 has an extreme climate and receives substantial inflow during seasonal rainfall events.

C-18 Dry Swallet entrance is regularly visited by tourists and locals. It is easily accessible with a track leading to the entrance.

C-18 Dry Swallet is a large inflow that is a favourite with walkers and 4wd drivers visiting the Cape Range. It has also undergone extensive collecting for troglofauna and occasionally contains a pool with amphipods.

C-18 is easily accessible by track and has captured the attention and interest of locals for many years.

C-28 Bundera Cenote contains many genera of crustacea including the Cape Range Remipede *Lasionectes exleyi*. It is one of the most important research and access points of the anchialine system on the western coastal plain. It also harbours a complicated water chemistry vital to the survival of the stygofauna.

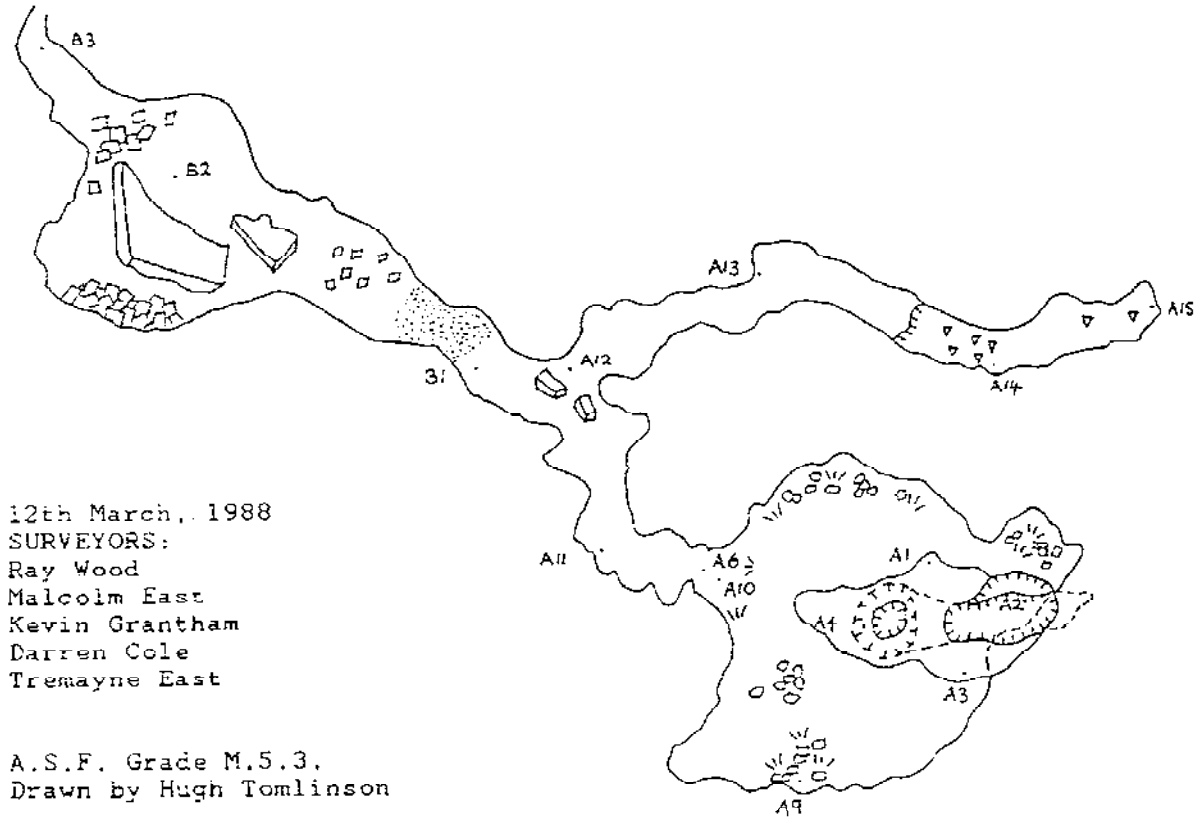


Looking over the entrance of Bundera Cenote C-28

The entrance as it looked in 1999. The cenote descends to over 32m deep. A complicated water chemistry with anoxic and hydrogen sulphide layering makes this a very sensitive site to disturbance.

The entrance in 2004. This is the only known site where the remipede *Lasionectes exleyi* is known to occur. It hosts a rich and almost unique stygofauna. Much of the faunae has affinities with tethyan fauna relictuals from sites in the northern hemisphere.

SURVEYED MAP OF C-29 BELL CAVE



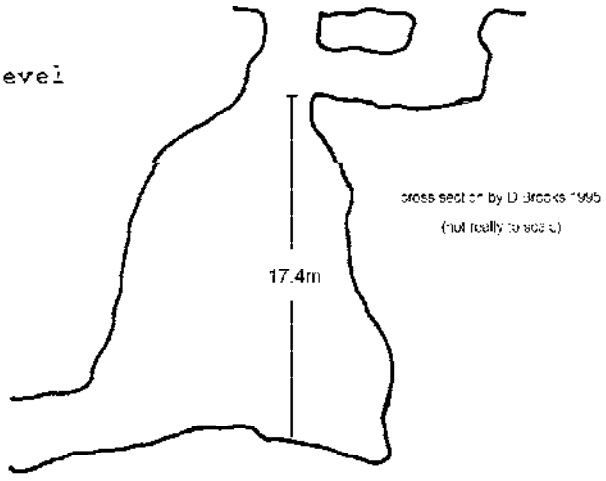
12th March, 1988
SURVEYORS:
Ray Wood
Malcolm East
Kevin Grantham
Darren Cole
Tremayne East

A.S.F. Grade M.5.3.
Drawn by Hugh Tomlinson

SCALE - 1:250

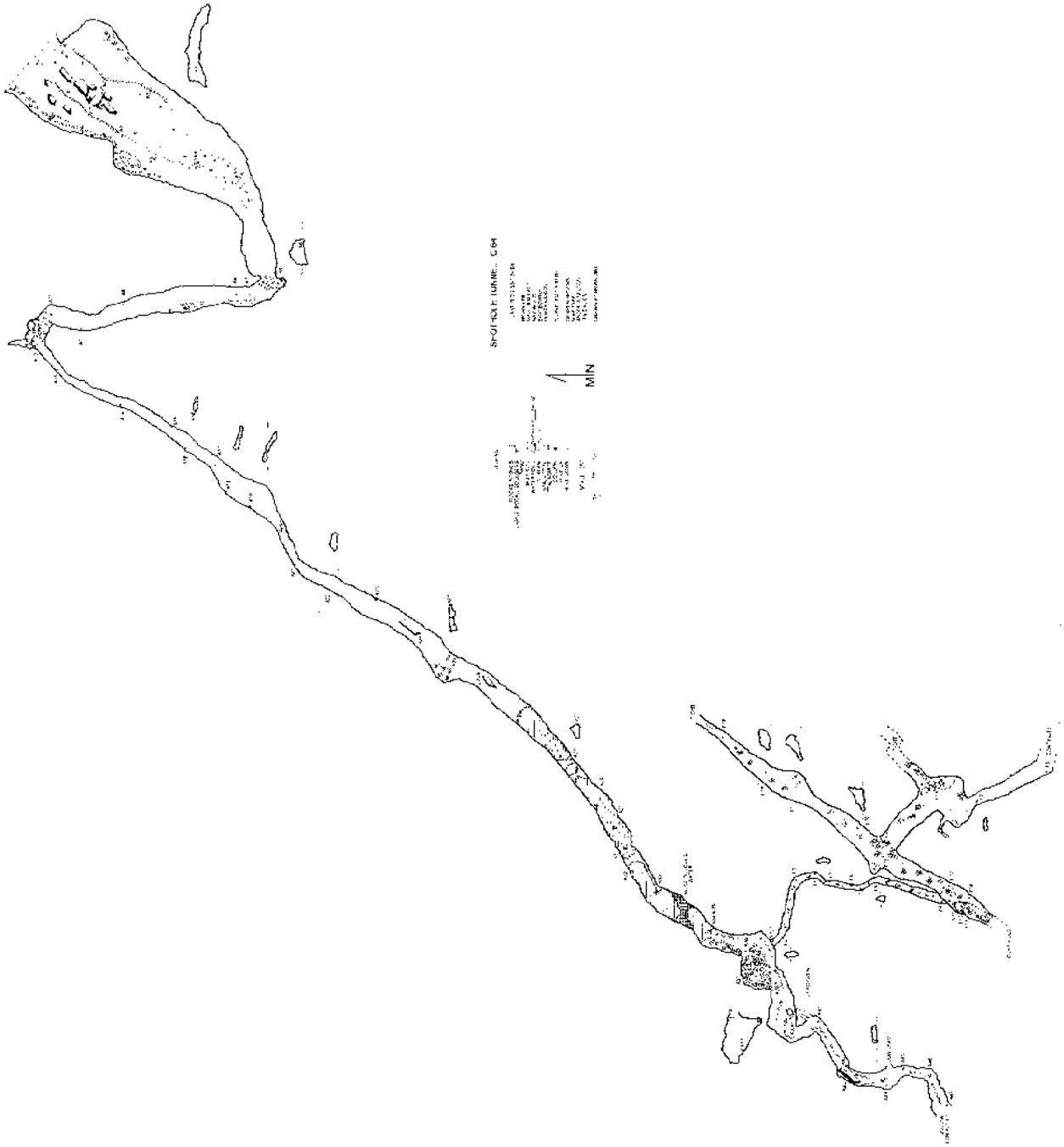
0 2 4 6 8 10m

- Sand
- Slope
- Boulders
- Stalactites
- Rocks/rubble
- Vertical hole down
- Vertical change in floor level



C-29 Bell Cave has been familiar to locals and visitors to the cape for many years. It is often used by local groups for adventure activities and training purposes. Along with many smaller caves and many dolines, its sinkhole entrance forms part an uvala located to the north side of Charles Knife Road.

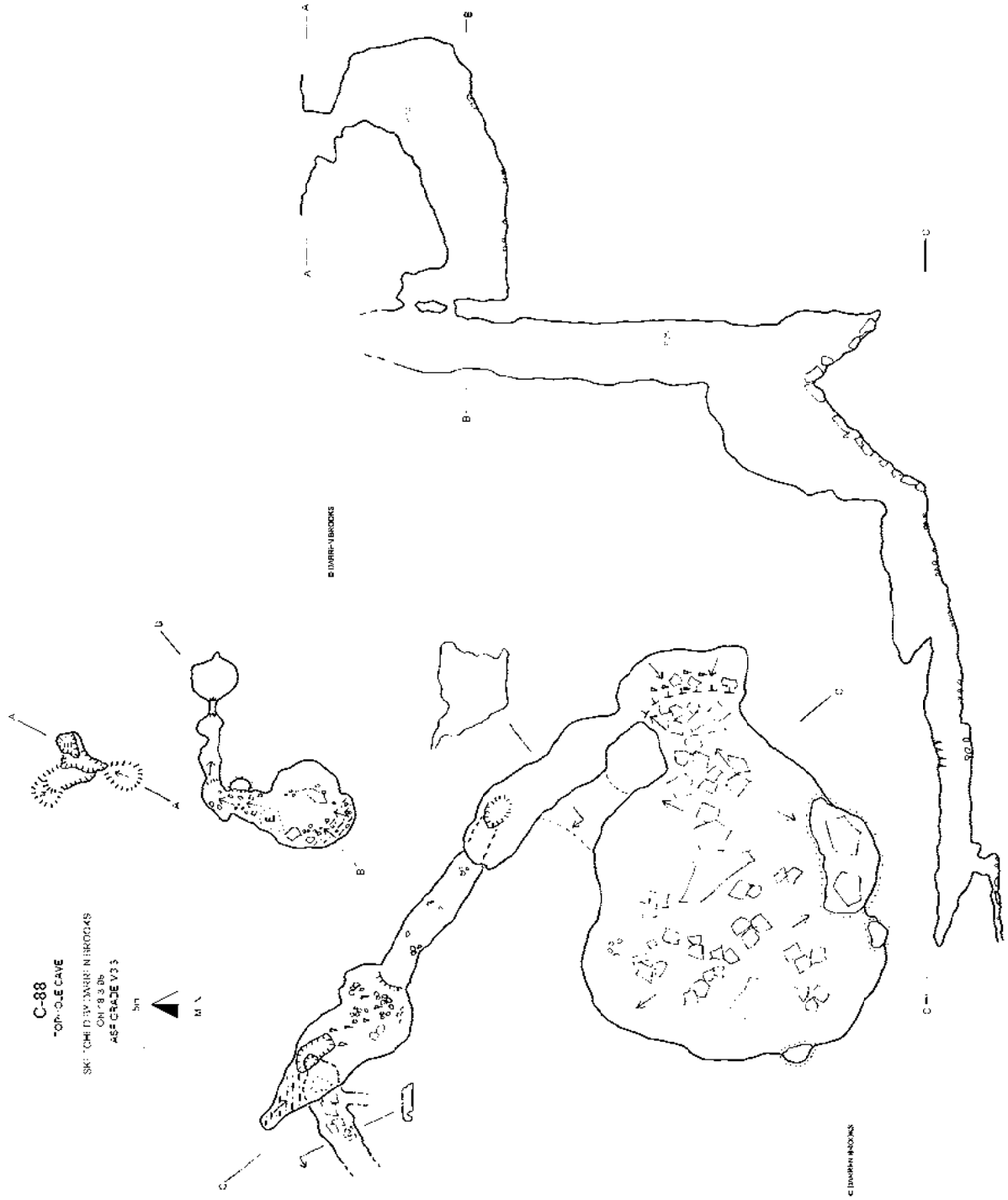
C-64 Shothole Tunnel is the only known outflow cave on the cape. Although the cave is in Tulki Limestone, the entrance rises up to flow out between the non-conformable interface between the Tulki Limestone and the Mandu Calcarenite.



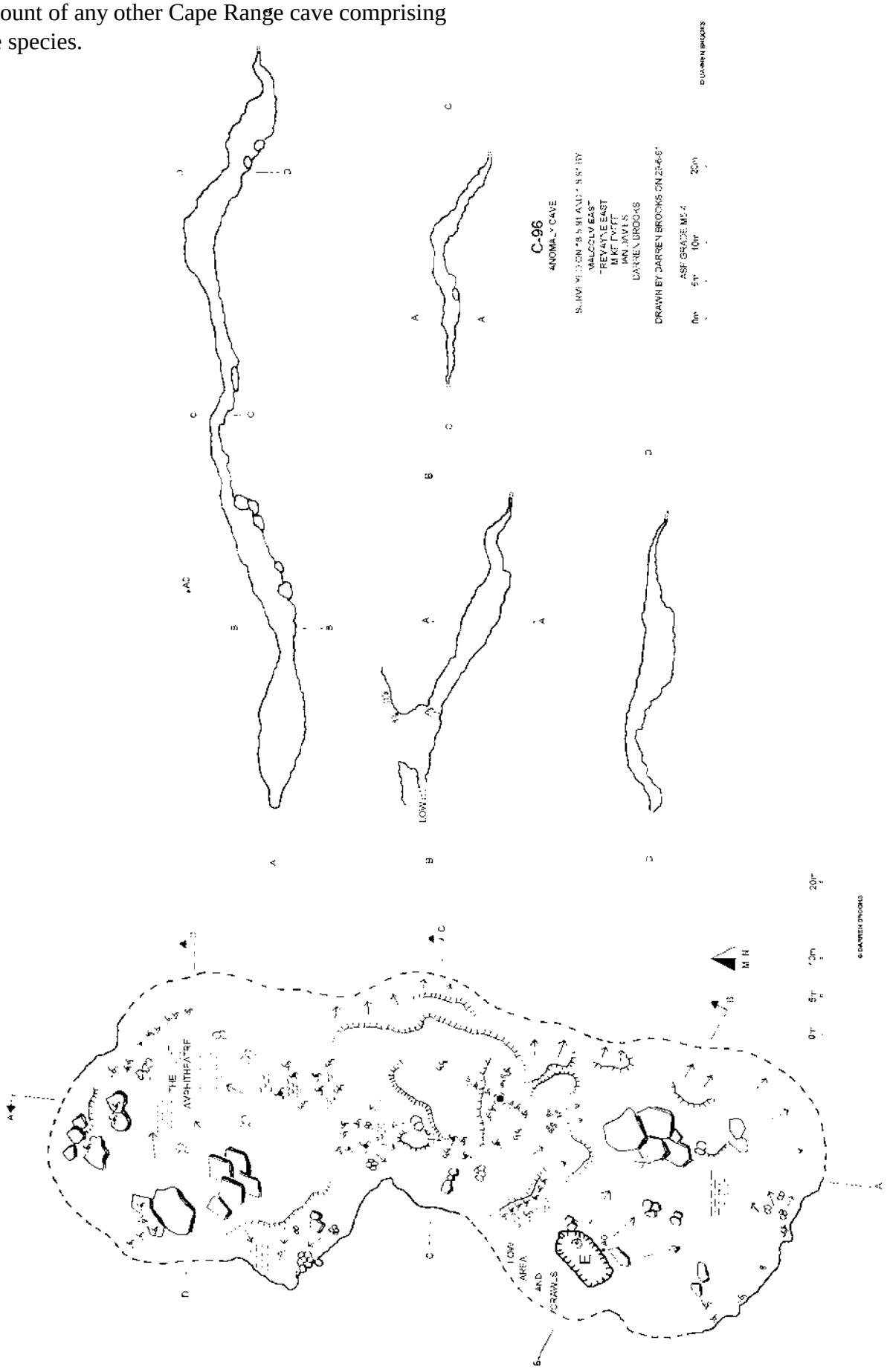
Above: looking out the entrance of Shothole Tunnel C-64. Note the whitish, powdery linestone. The entrance is sandwiched between the chalky Mandu Calcarenite and the harder Tulki Limestone above.

Below: this cave leads to water filled canals of unknown extent due to an impassable fissure under the water surface. This is the only known outflow cave on the Cape Range. This perched water aquifer is one of only four known sites to contain freshwater amphipods.

C-88 Tophole Cave is part of the Bell Cave uvala complex.



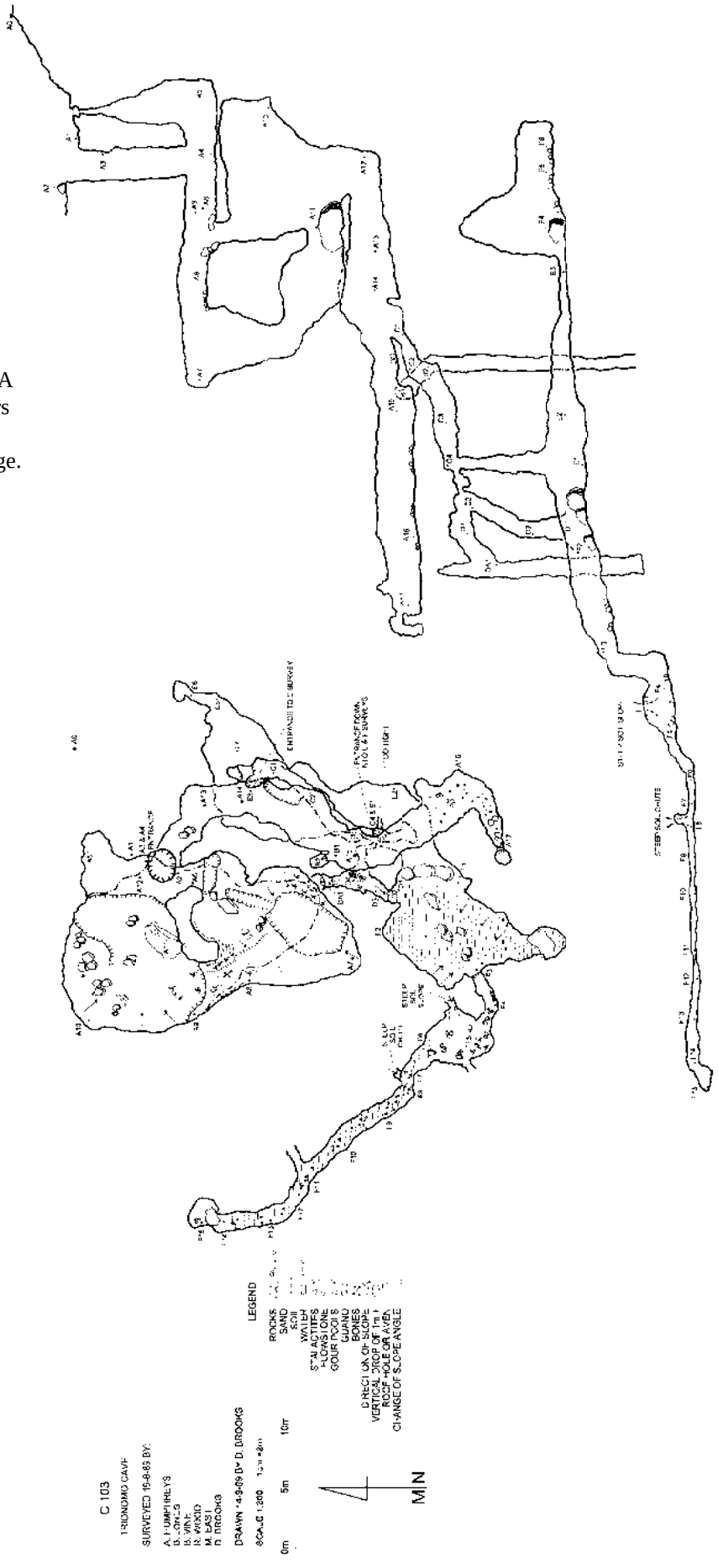
C-96 Anomaly Cave has had a high social impact due to its use as a tourist visitation cave by local businesses. It is also an important bat site with the highest bat count of any other Cape Range cave comprising three species.

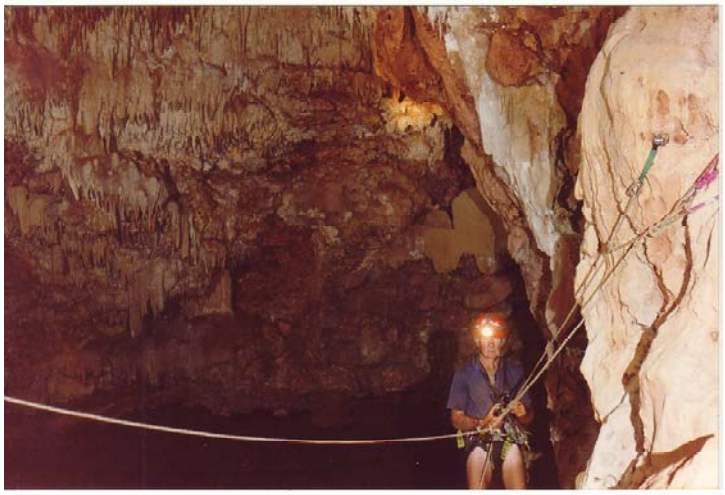


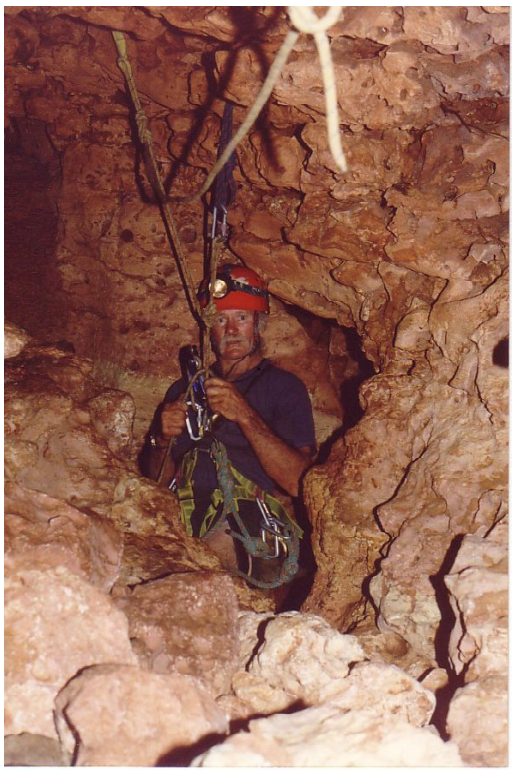
C-96 is important for its visitation by tourists over the past twenty years and also for its bat population. Several species of bats are known to frequent the cave.

C-96 also has areas of pristine decoration.

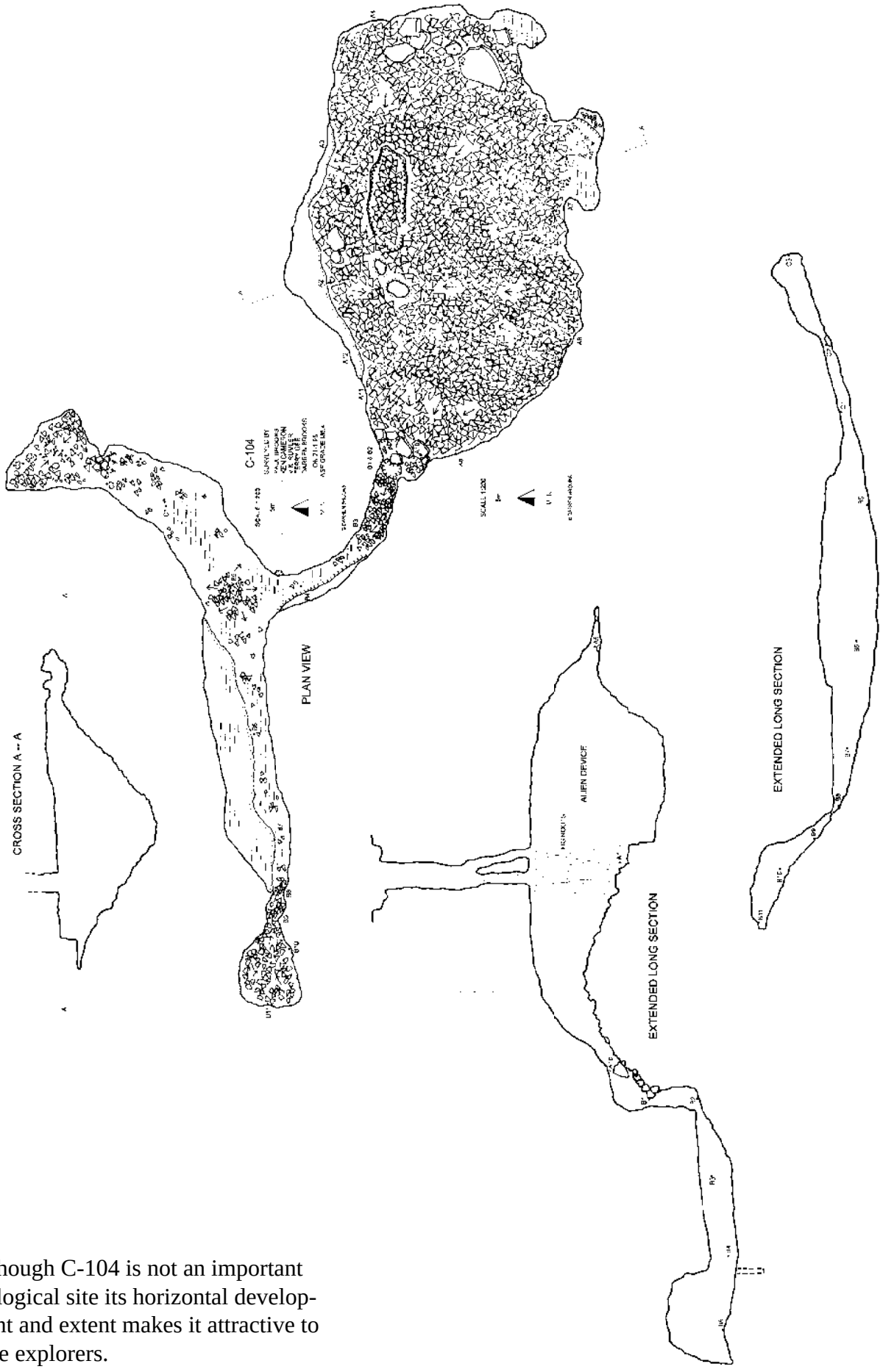
C-103 is a multilevel cave with access to a perched water table. A genus of melitid amphipod occurs in this and in the pools of three other caves within the Cape Range.



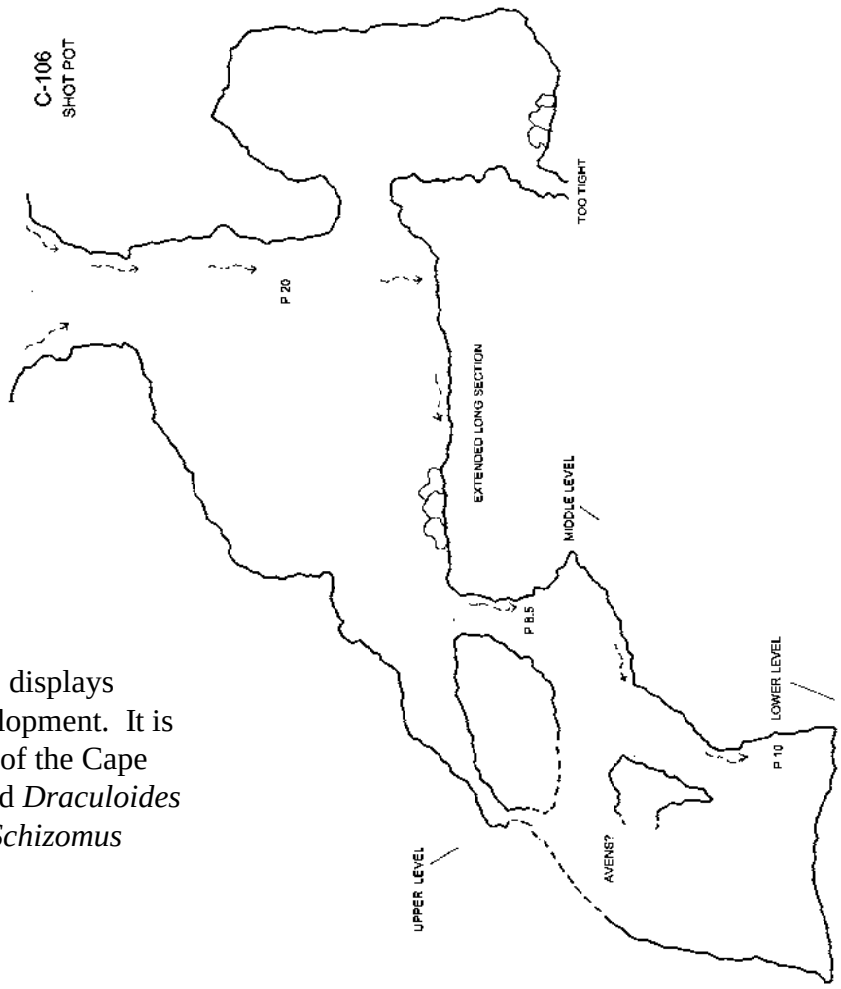




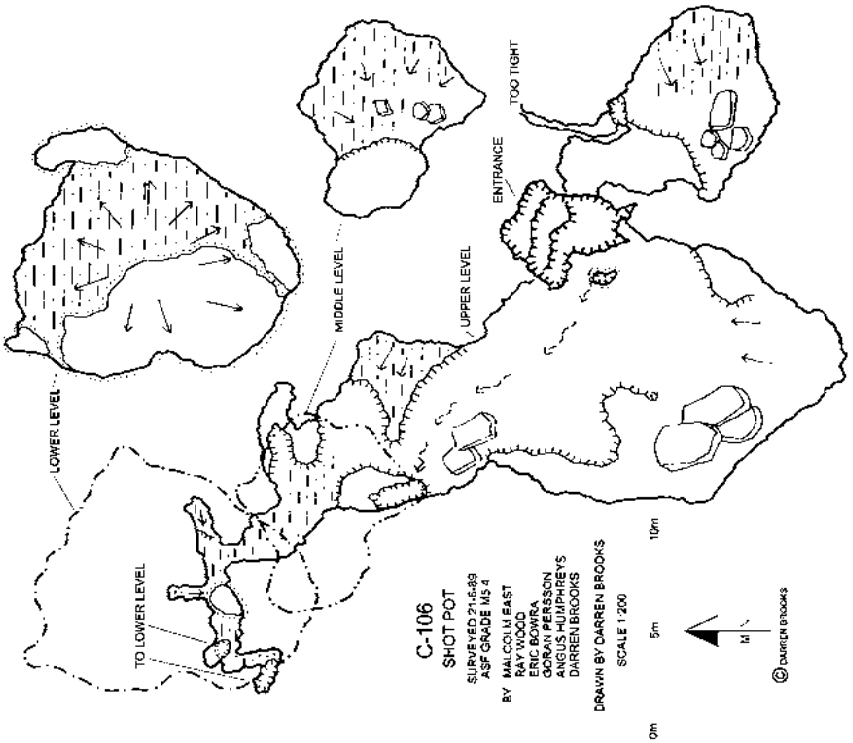
C-103 Trionomo not only offers vertical caving opportunities, it also contains a remote pool of water at the end of a very tight crawl passage. This provides one of the four access points to the perched water table in the Cape Range.



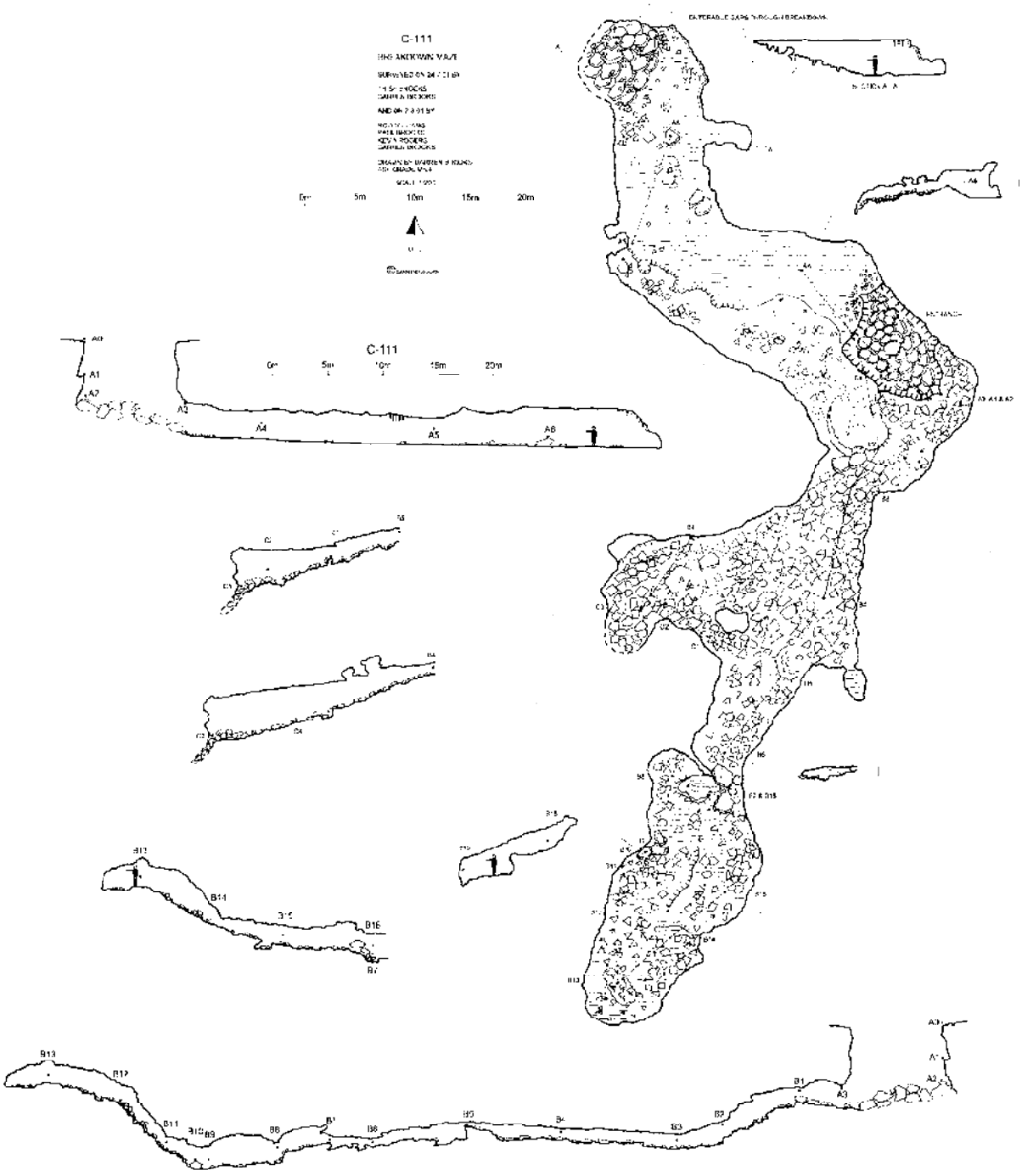
Although C-104 is not an important biological site its horizontal development and extent makes it attractive to cave explorers.



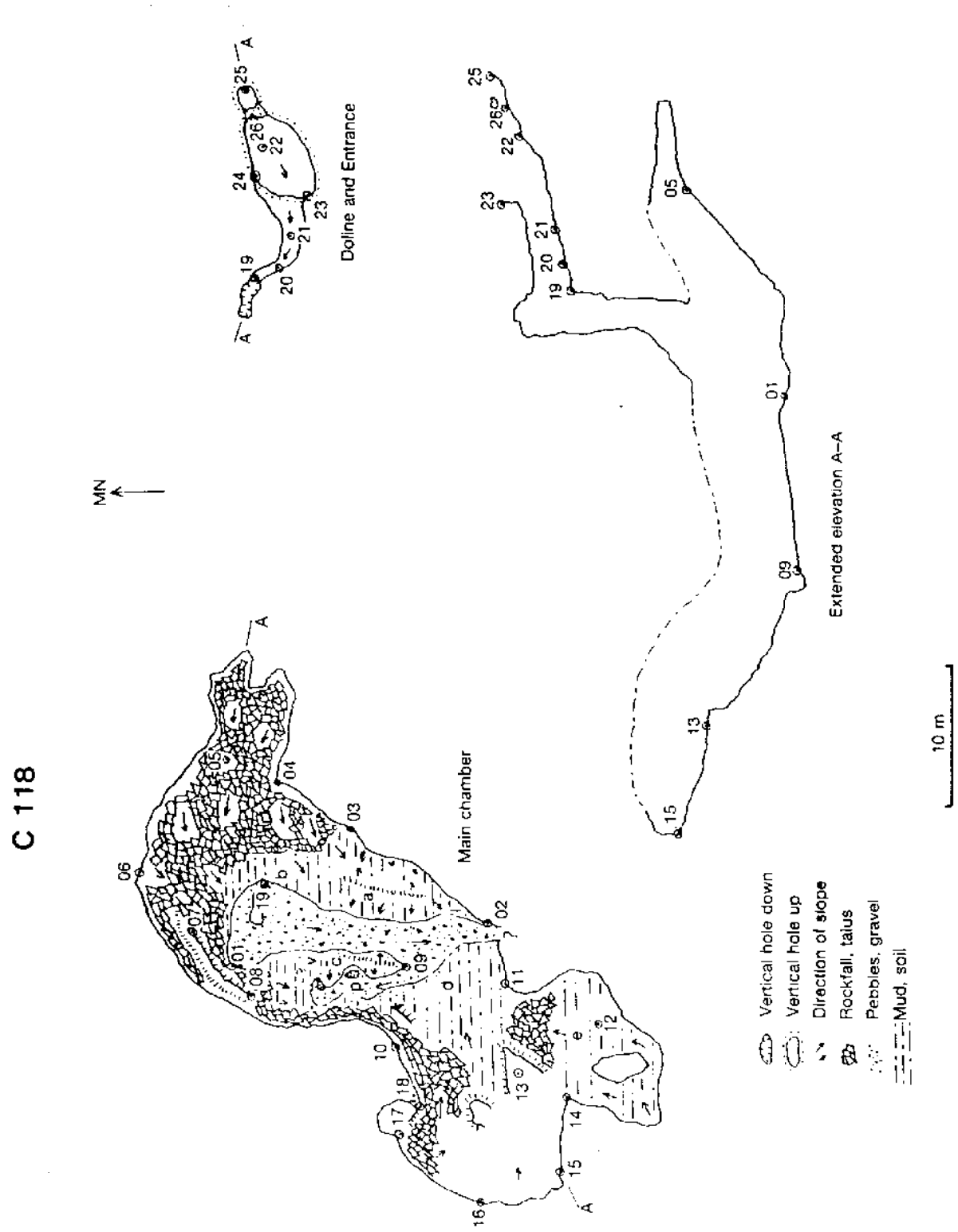
Shot Pot, C-106, displays multi-level development. It is the type locality of the Cape Range Schizomid *Draculoides vinei* (formerly *Schizomus vinei).*



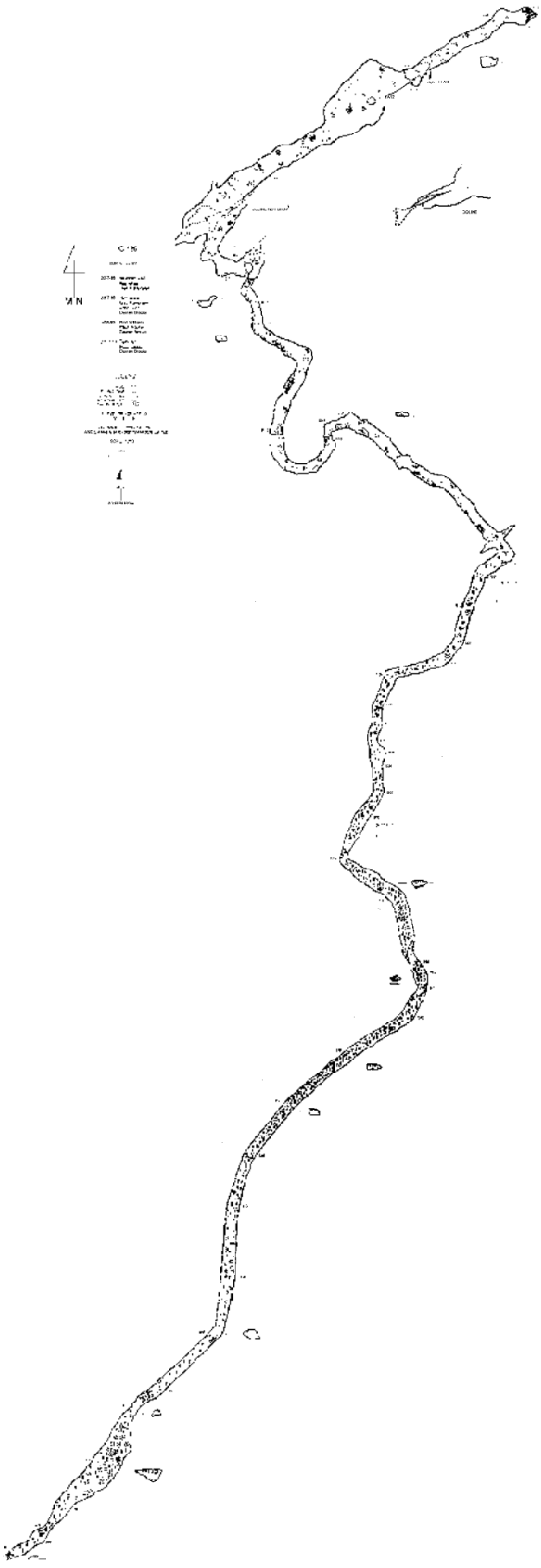
C-111 Breakdown Maze, located on the western coastal plain, contains an important troglobite community. Two sympatric species of blind cave millipede (*Stygiochiropus communis* and *S. sympatricus*) occur here.



C-118 holds an important place in the biospeleological history of the Cape Range. It contains a diverse troglobite community and a fauna community regeneration experiment has been carried out here. It is the type locality of the blind cave cockroach *Nocticola flabella.*

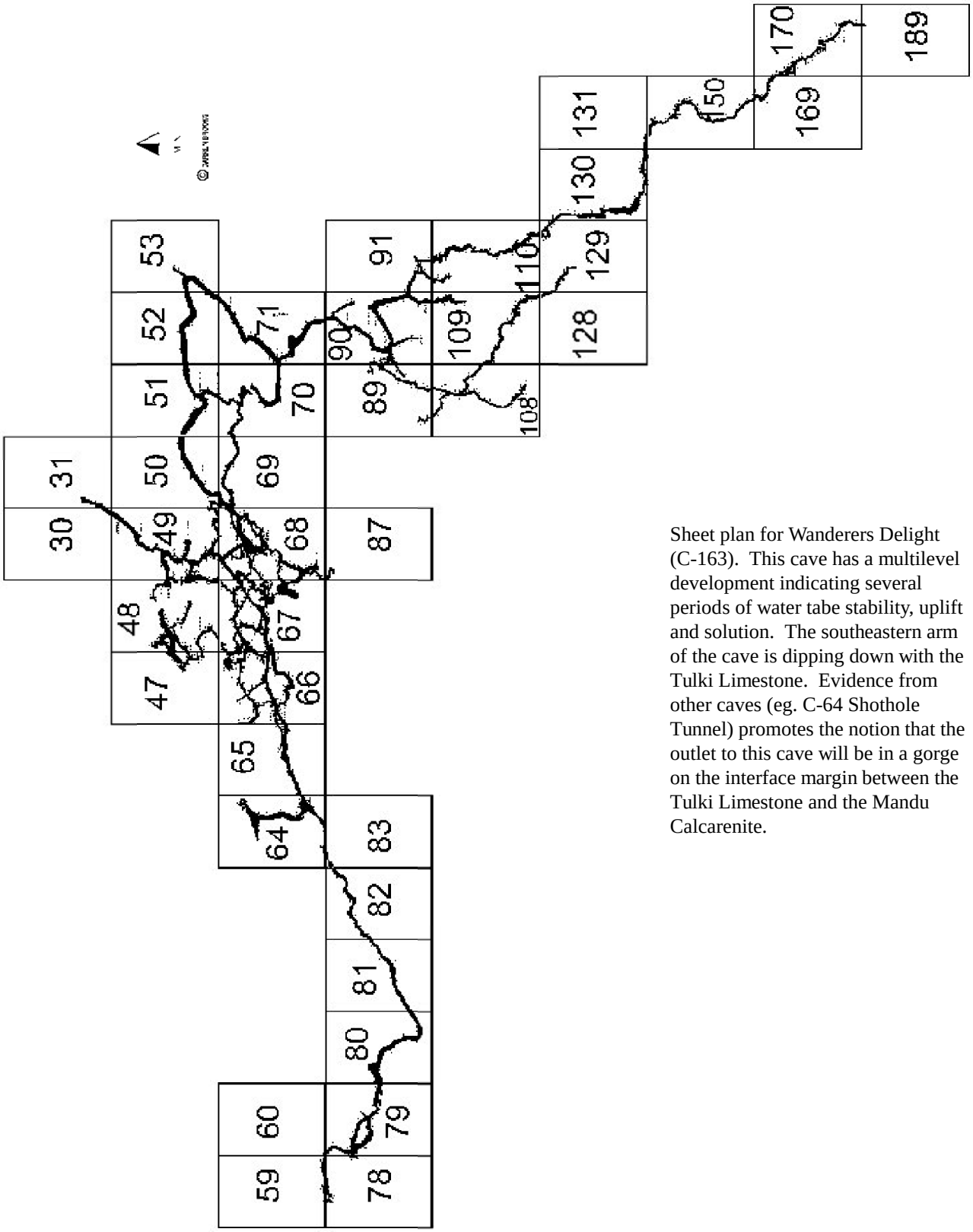


C-126 is located to the north of Wanderers Delight (C-163) and Spiral Cave (C-167). Evidence indicates it is probably part of a major drainage system diverting water into the gorges to the south east.



Extensive cobbled passage of crawling height typify the horizontal sections of C-126.

Speleothems decorate a ledge in C-126.



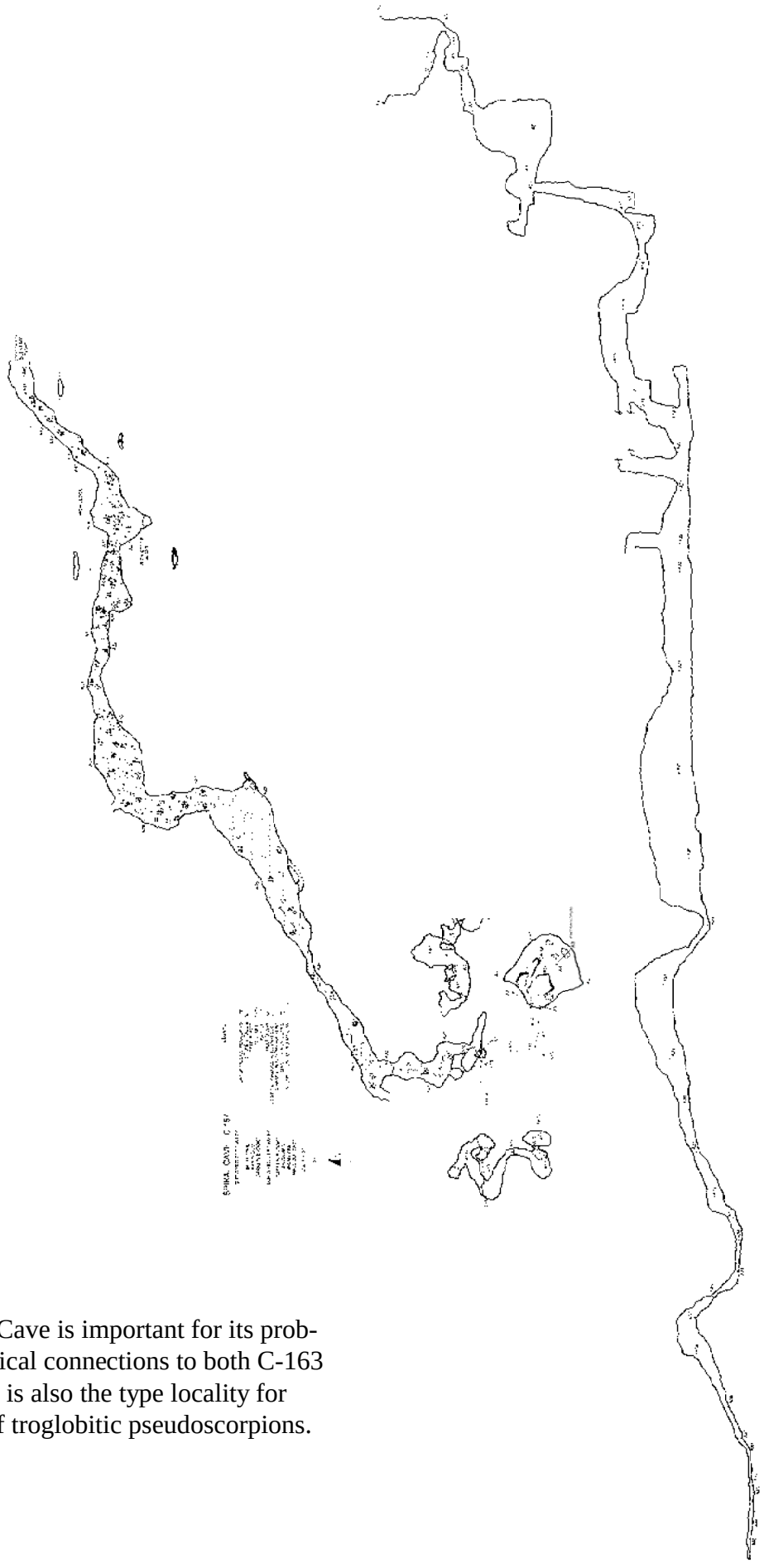
Sheet plan for Wanderers Delight (C-163). This cave has a multilevel development indicating several periods of water tabe stability, uplift and solution. The southeastern arm of the cave is dipping down with the Tulki Limestone. Evidence from other caves (eg. C-64 Shothole Tunnel) promotes the notion that the outlet to this cave will be in a gorge on the interface margin between the Tulki Limestone and the Mandu Calcarenite.

Above: Wanderers Delight C-163 has discoloured speleothem material in the entrance caused by exposure to daylight.

Left and below left: A feature of Wanderers Delight is the extensive canal system and many water pools.

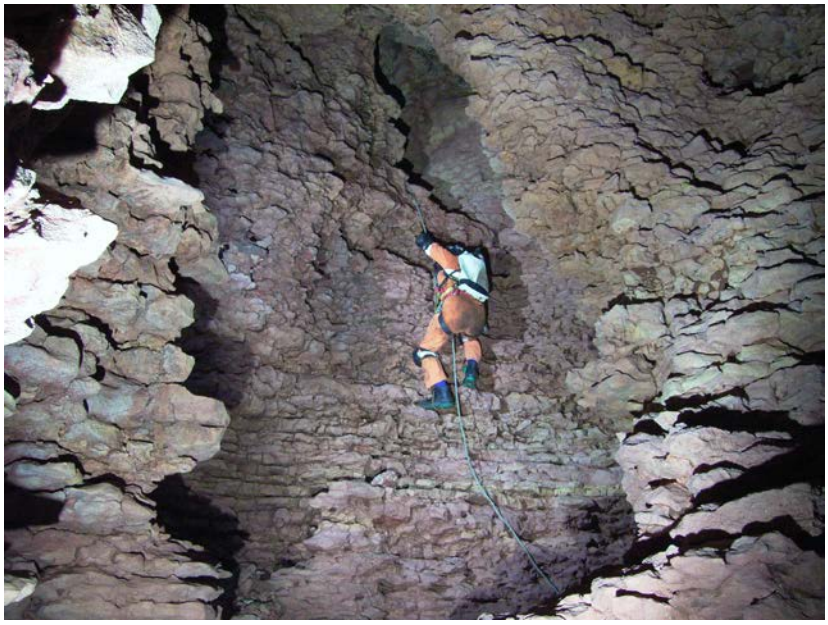
Below: C-163 also has areas of extensive good decoration, such as The Peacepipe.

Wanderers Delight contains good quality decorations in its further recesses.



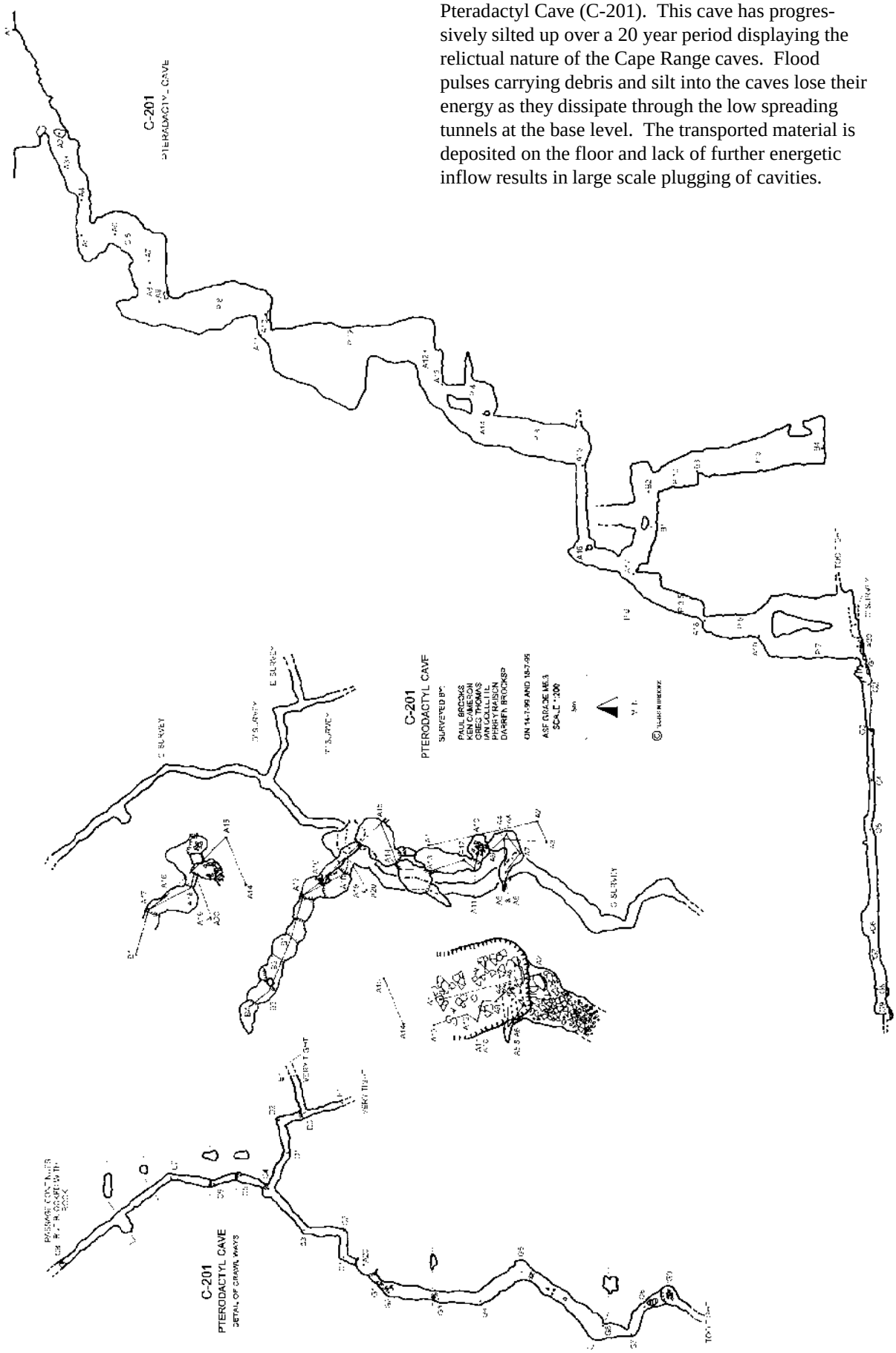
C-167 Spiral Cave is important for its probable hydrological connections to both C-163 and C-126. It is also the type locality for two species of troglobitic pseudoscorpions.

Spiral Cave shows interesting passage morphology with clearly defined layering of the Tulki Limestone.



C-167 aslo offers a challenging sporting aspect to Cape Range caves.

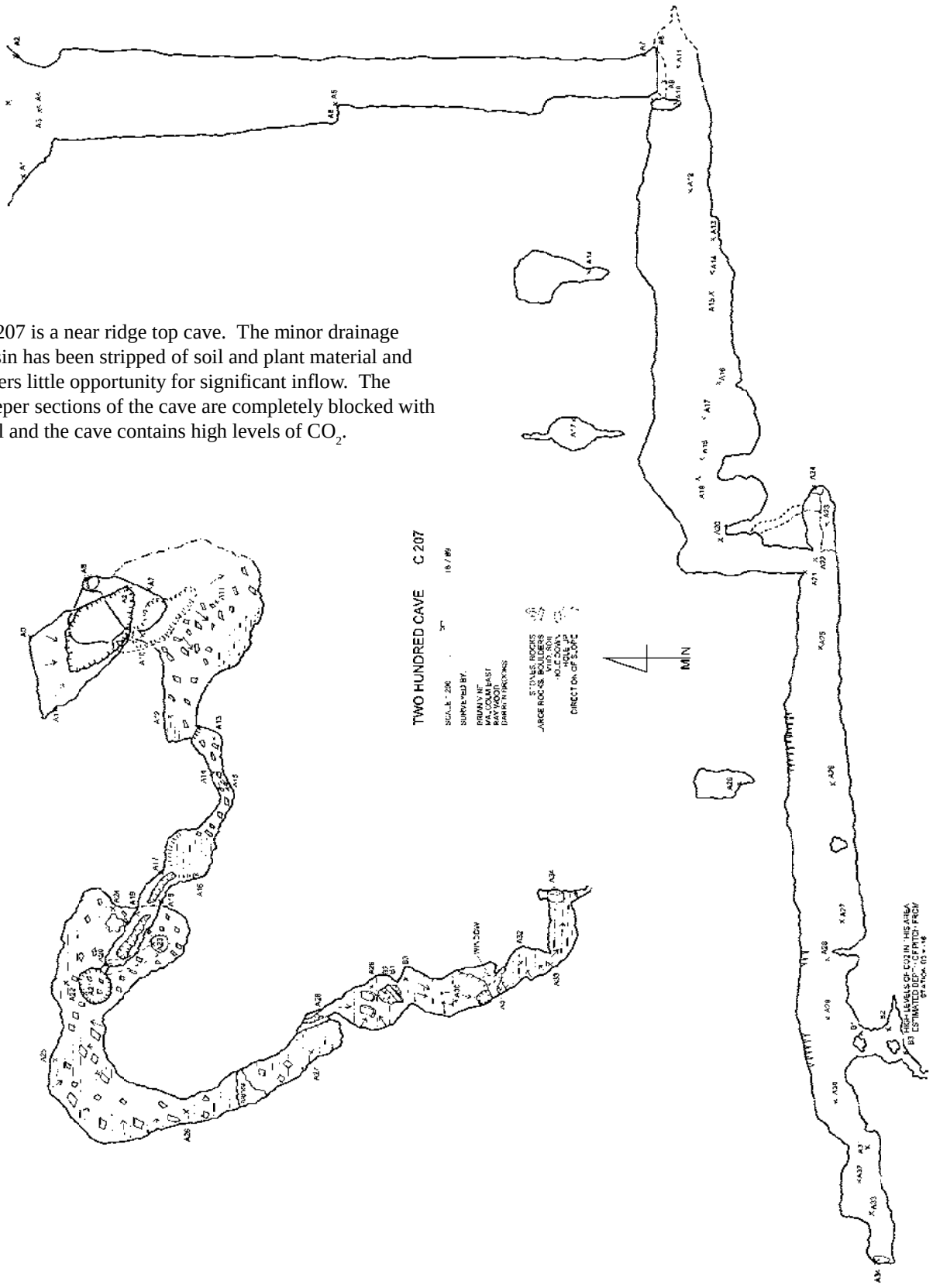
Stratification of the Tulki Limestone is evident here with black manganese deposits on the exposed faces of the rock.



Pteradactyl Cave (C-201). This cave has progressively silted up over a 20 year period displaying the relictual nature of the Cape Range caves. Flood pulses carrying debris and silt into the caves lose their energy as they dissipate through the low spreading tunnels at the base level. The transported material is deposited on the floor and lack of further energetic inflow results in large scale plugging of cavities.

C-201 Pteradactyl Cave is primarily a vertical cave but large rounded boulders and cobbles form the floors of low crawl ways that eventually become clogged with debris.l

C-207 is a near ridge top cave. The minor drainage basin has been stripped of soil and plant material and offers little opportunity for significant inflow. The deeper sections of the cave are completely blocked with soil and the cave contains high levels of CO_2.

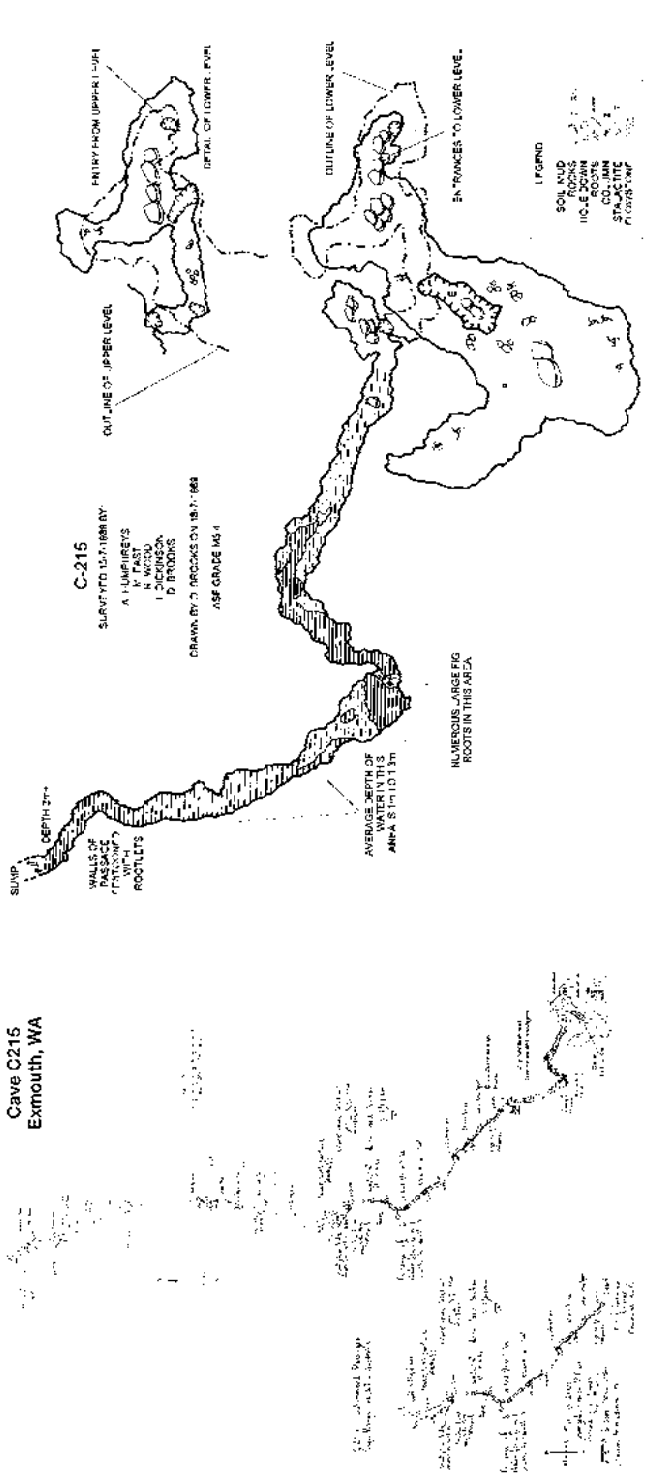


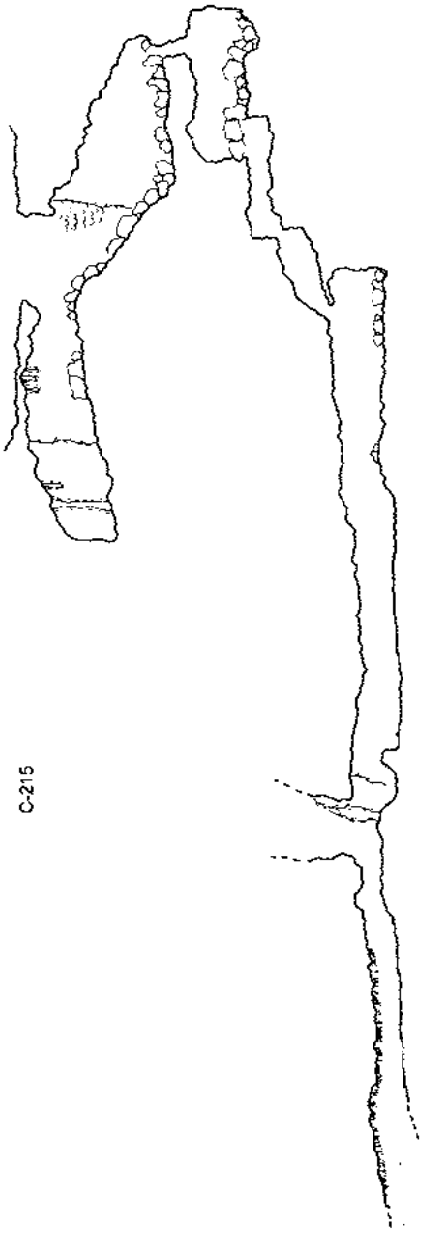
Left: the entrance to C-207 is perched high on a ridge. The surrounding landscape has been eroded and dissolved by weathering

Right: the 50m deep entrance shaft has been formed in the past by regular, heavy inflow consistent with a much wetter climate.

Virtually no work has been carried out on cave minerals in the Cape Range caves. This extrusion is believed to be an example of gypsum.

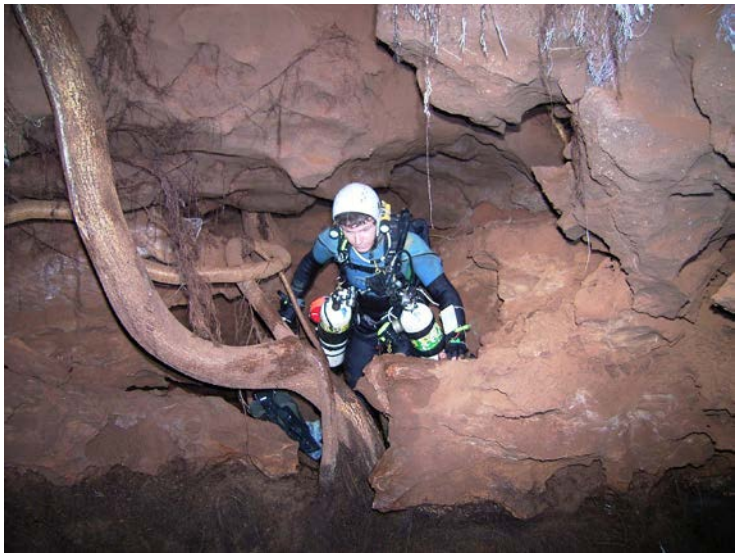
An ancient soil floor can be seen perched above the person in the orange helmet. The walls are partially lithified soil incised to 4m depth.





The entrance to C-215 is located in the foothills of the western coastal plain. The cave goes well down below the surface level of the plain. The cave contains aspects of fauna from the range and the coastal aquifer. In this cave the blind fish *Milyeringa veritas* and the blind millipede *Stygiochiropus communis* may be seen virtually side by side. The cave also contains two sympatric species of schizomid (*Draculoides julianneae* and *Bamazomus vespertina*).

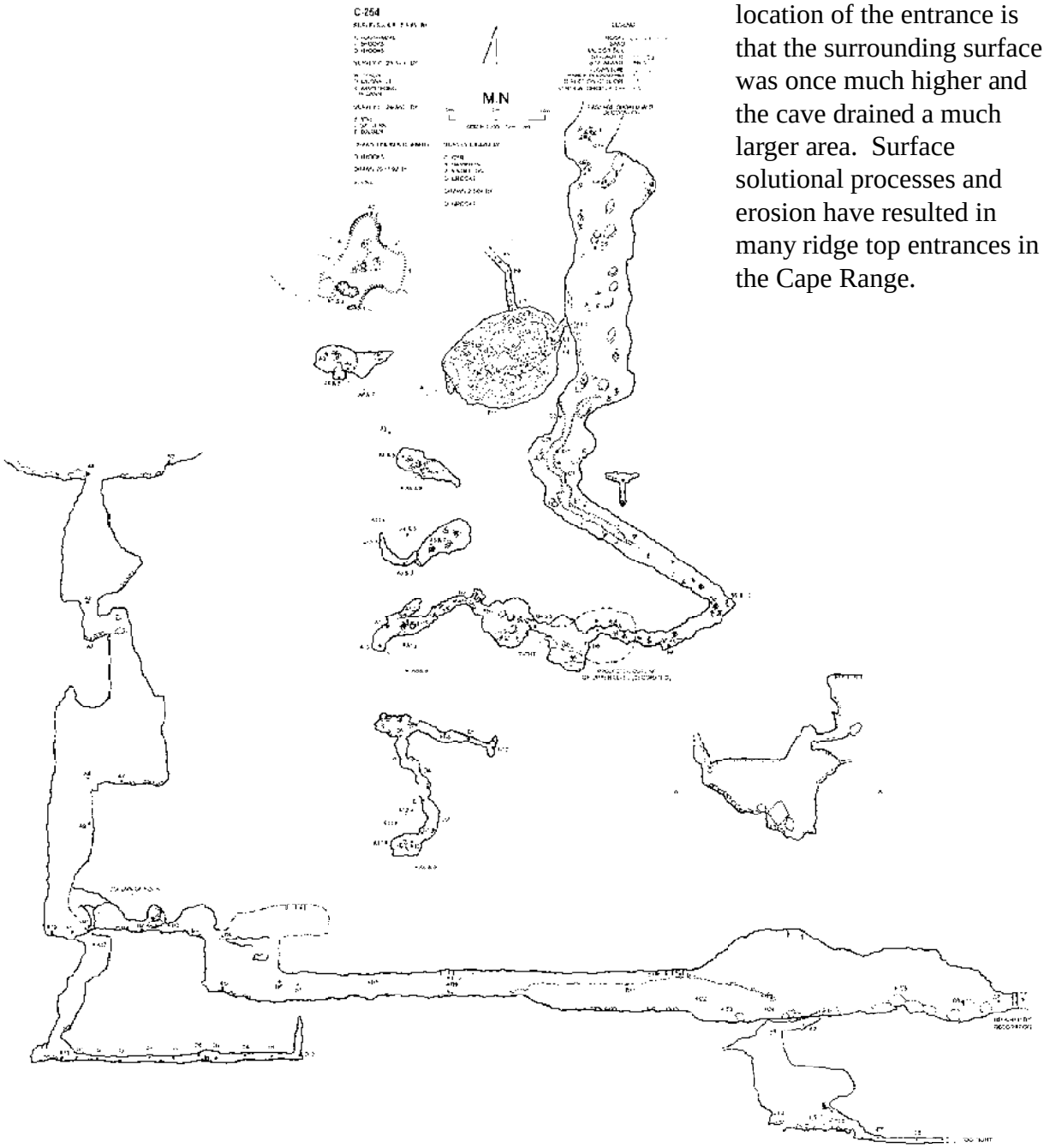
Right and below: C-215 has extensive underwater conduits. Cave divers have explored over 300m of underwater passage to a depth of nearly 22m The cave is believed to continue deeper.



Below left: The blind cave fish *Milyeringa veritas* is easily observed in C-215.

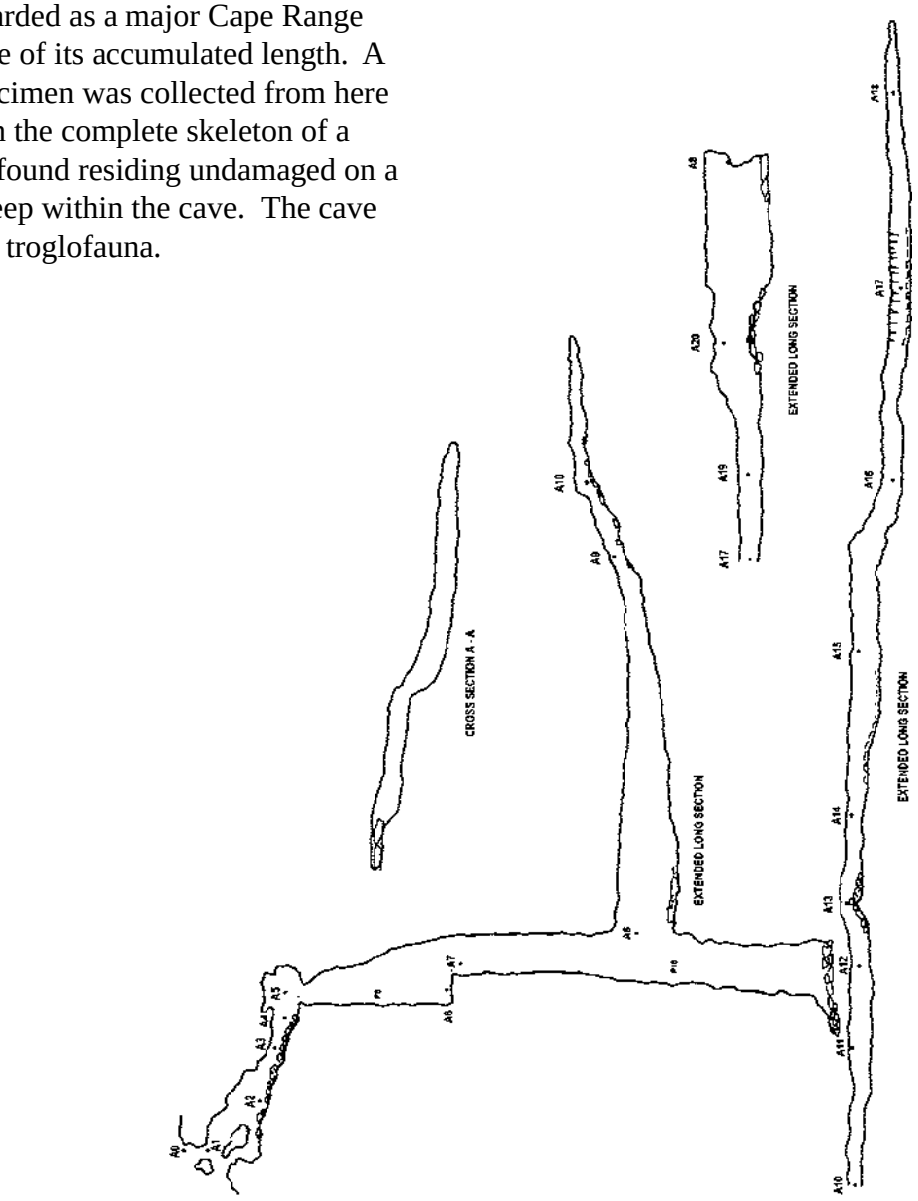
Below: The combination of a constant influx of organic matter and tree roots growing down in the cave make C-215 a rich troglobite and stygobite habitat.

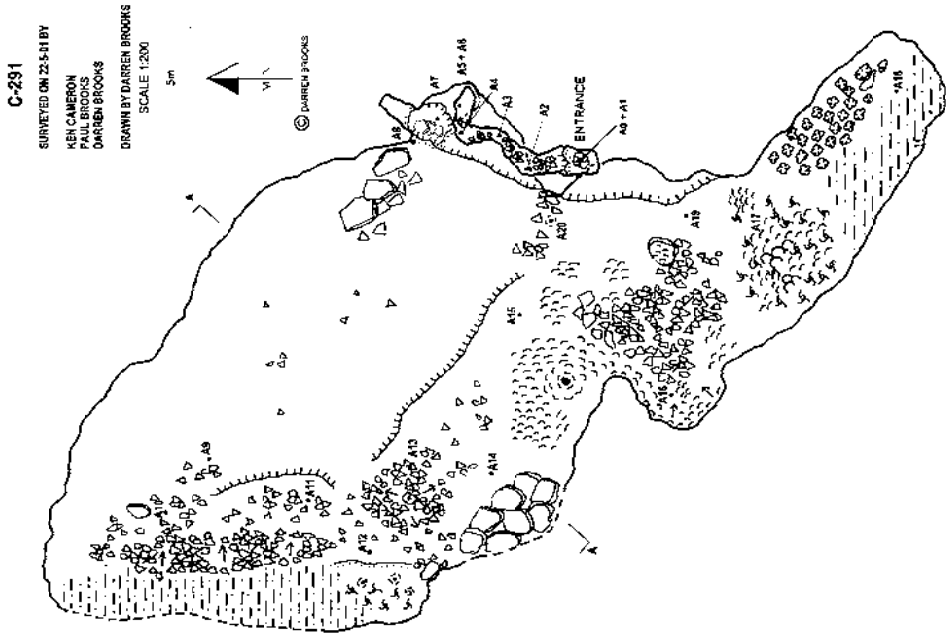
C-254 is a good example of a ridge top entrance to a well developed multi-level cave. The nature of the development is consistent with regular, persistent inflow of water over a long time scale. The only explanation for the location of the entrance is that the surrounding surface was once much higher and the cave drained a much larger area. Surface solutional processes and erosion have resulted in many ridge top entrances in the Cape Range.



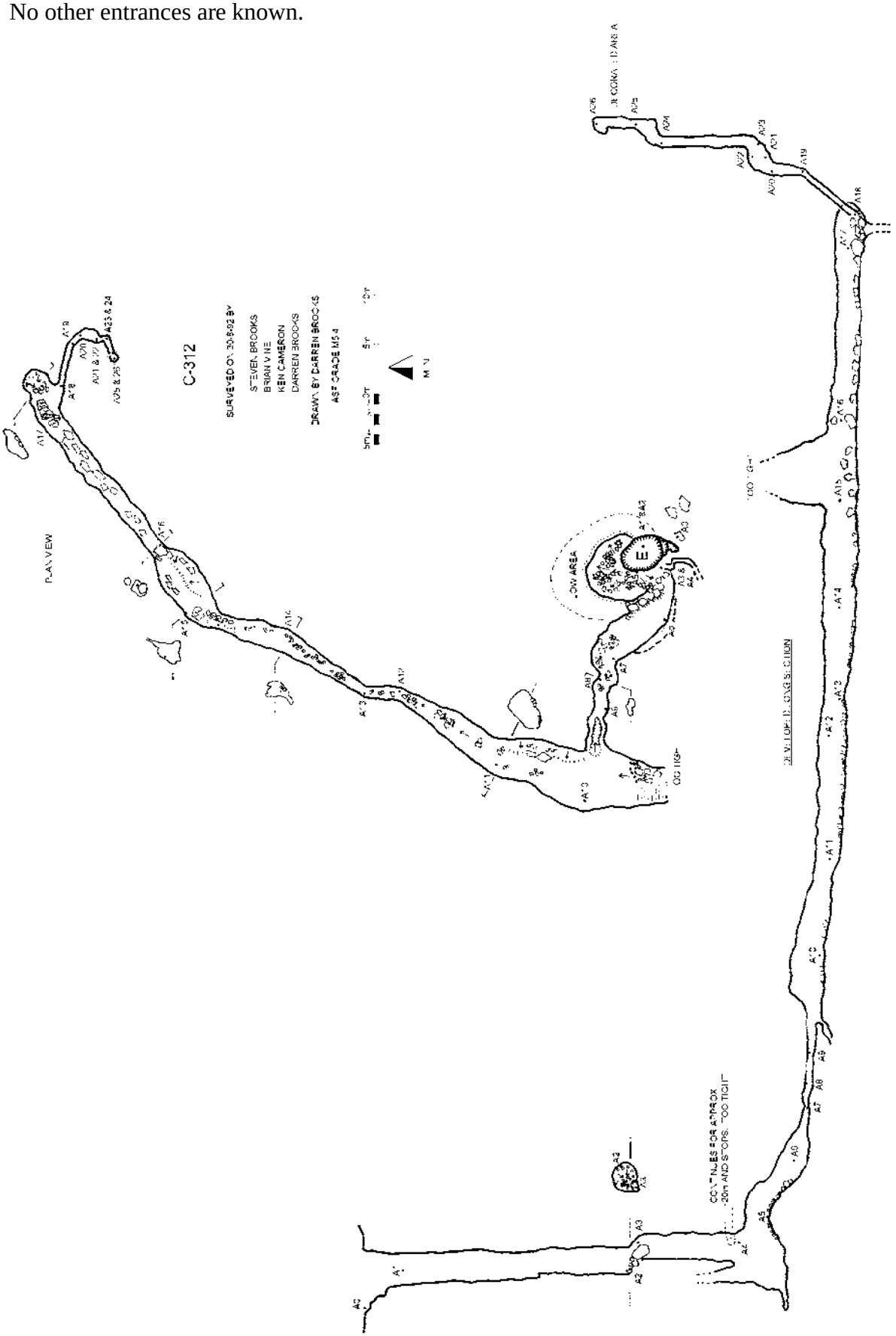
C-254 is a vertical cave with an entrance located on a ridge. It has challenging vertical pitches and is well decorated with ancient decaying speleothems. Its horizontal section contains some ancient bat guano deposits.

C-291 is regarded as a major Cape Range cave by virtue of its accumulated length. A subfossil specimen was collected from here in 1989 when the complete skeleton of a possum was found residing undamaged on a rock ledge deep within the cave. The cave also contains troglofauna.

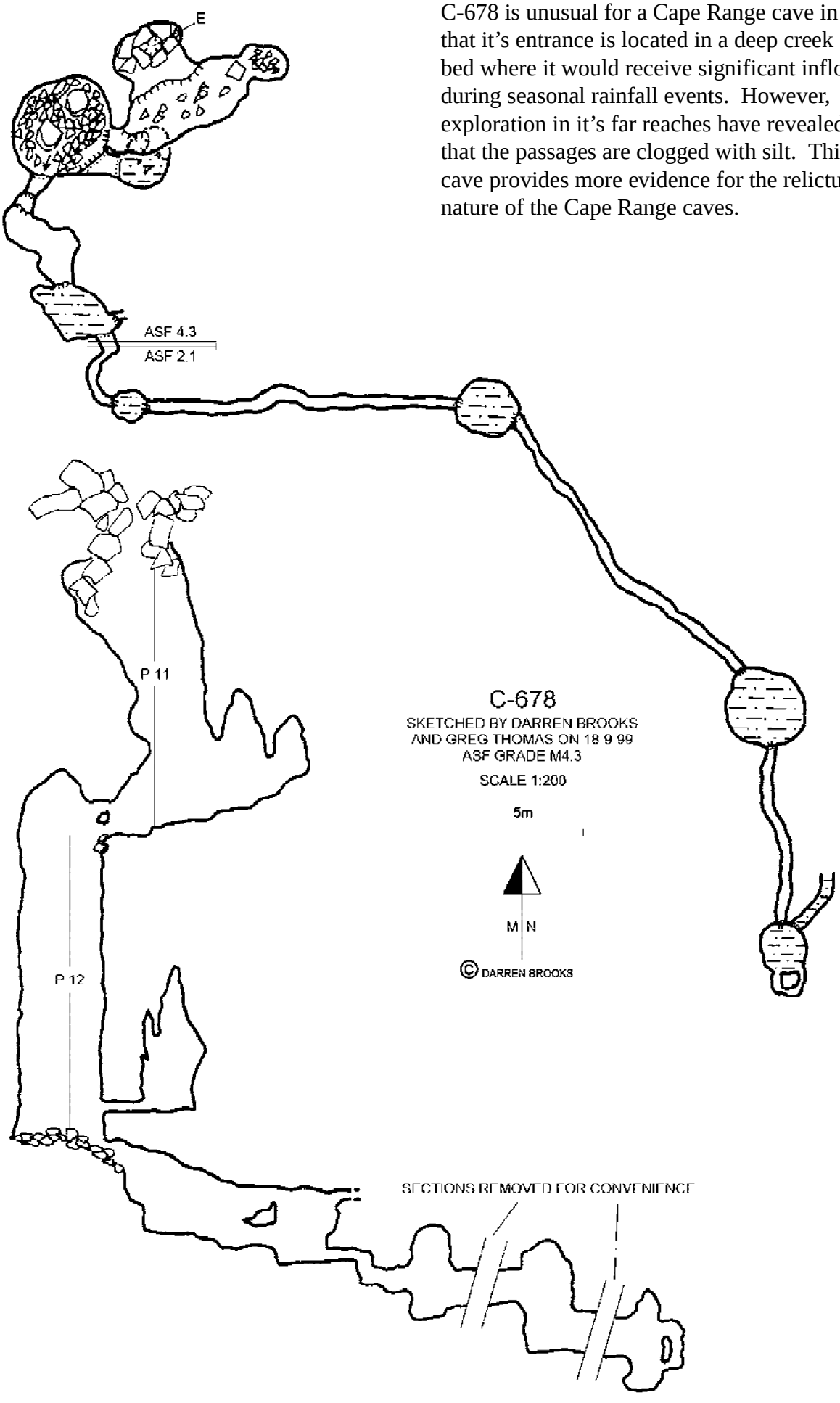




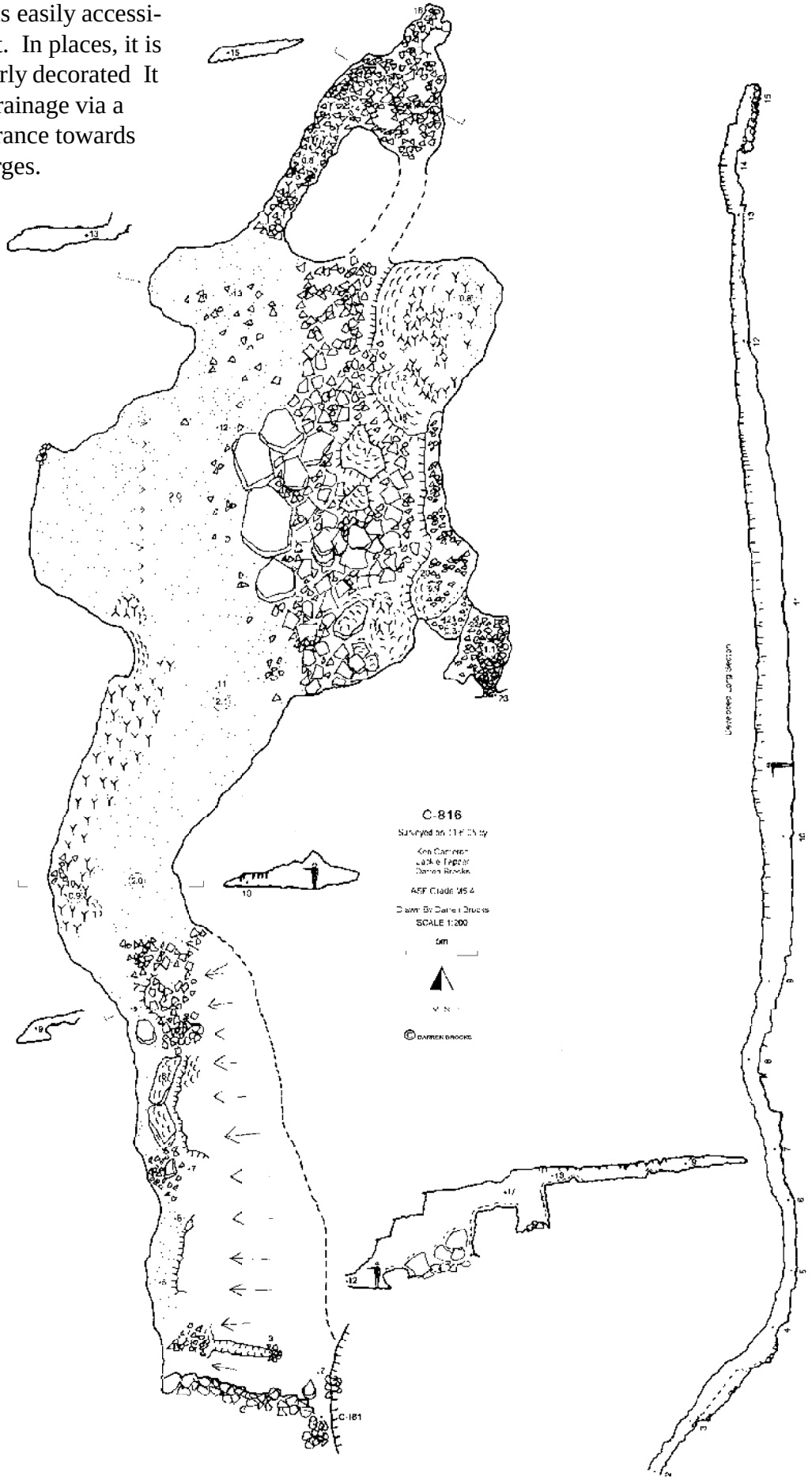
C-312 contains some interesting fossil bat guano that has partially lithified. The current entrance seems an unlikely access point for bats. No other entrances are known.



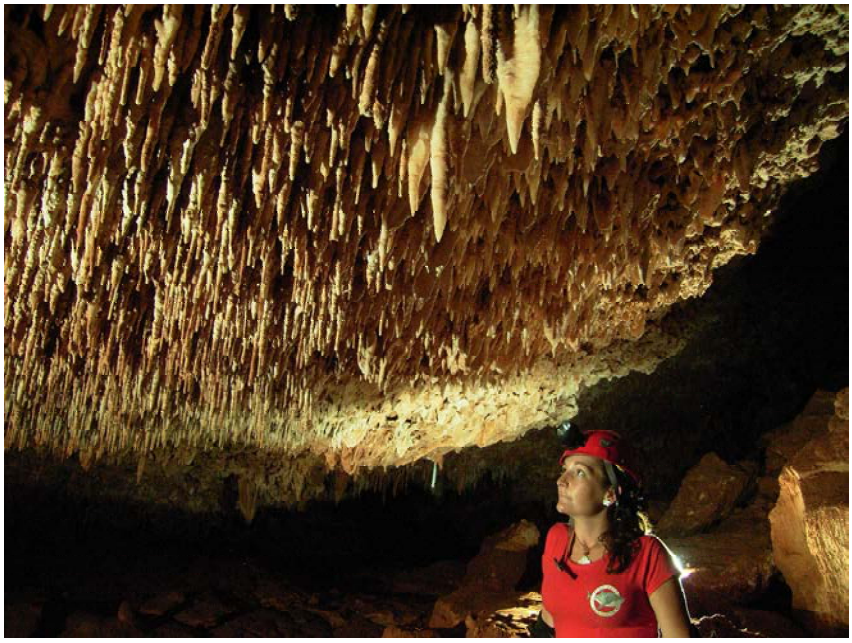
C-678 is unusual for a Cape Range cave in that it's entrance is located in a deep creek bed where it would receive significant inflow during seasonal rainfall events. However, exploration in it's far reaches have revealed that the passages are clogged with silt. This cave provides more evidence for the relictual nature of the Cape Range caves.



C-816 is located close to a track and is easily accessible by foot. In places, it is spectacularly decorated It displays drainage via a doline entrance towards nearby gorges.



Passage infill in C-816.



C-816 also contains some spectacular decoration and offers photographic opportunities.

Speleothems in C-816.

The well decorated main chamber of C-816.