The Caves and Karst of Astraka, Greece

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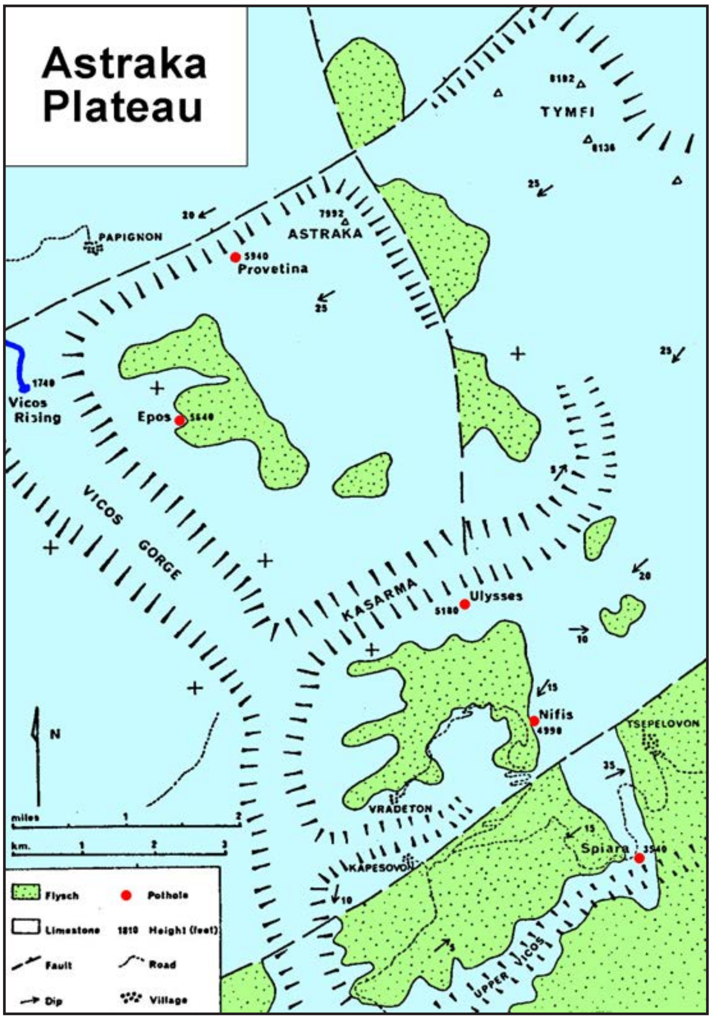
Abstract. The Astraka mountain and plateau, in N.W. Greece, constitute a spectacular and little-visited glaciokarst cut through by the 1000-metre deep Vices Gorge. Deepest of the numerous shafts are Epos Charm, Provetina and Tripa tis Nifis. The morphological details of the gorges, potholes, karren fields and post-glacial patterns present problems that are not yet completely resolved, though their evidence suggests the possibility of recent earth movements and karst development by glacial meltwater.

The mountain of Astraka rises to an elevation of 2436 m in the northwestern corner of Greece, close to the Albanian border and 60 km from the Adriatic coast. It is an uplifted fault block that projects westwards from the main escarpment of the Tymfi Mountains, themselves rising to 2497 m. Below the scarp face, east of Tymfi, lies the River Aoos, and cutting through the western end of Astraka is the Vicos River. These act as base level to the local relief of around 2000 metres, which is entirely in massive, cavernous limestone.

Scenicly, Astraka is magnificent. On its west and south the horizontal limestone forms a plateau cut by the Vicos Gorge, 1000 m deep, with over half that depth down vertical cliffs. To the north there is a massive fault scarp. The eastern side is more complex with the folded limestones rising to Tymfi and dipping down to the villages around Tsepelovon. The rather less hostile cliffs along the southern side allow access to the one village, Vradeton, that is actually on the Astraka block. This side is also the approach used by the handful of shepherds and their sheep who are normally the only occupants of the mountains through the long hot summer. The countryside is wild and untouched, and surprisingly few cavers have ever sampled its delights.

Unfortunately the full depth potential has not yet been realised in the caves of Astraka. But Greece's deepest cave, and one of the world's deepest shafts, are both on this one mountain, in addition to dozens of other potholes that have been looked at or descended. Not every fissure in this splendid karst has been explored or even found; there is still the chance of the big one. For so far none of the known caves has much horizontal extent, and none has entered any sort of master system. The great incentive is the Vicos River. For five months of every year the entire flow of the river sinks upstream of Kipi and passes beneath Astraka to emerge at the spring at the northern end of the gorge. The underground course of the river



Vicos Gorge, looking west.

lies a thousand metres feet below the potholes of the plateau; it is unenterable at both ends and is completely unexplored.

Cave exploration interest in Astraka developed in 1962 when a visiting party of British cavers was directed by the shepherds to the entrance of Provetina, which was clearly a very deep hole. British expeditions visited it in 1966/67/68, and finally bottomed it, claiming a depth of around 400 m; and it was then the deepest known shaft in the world. Wanderings by individual members of these expeditions led to the discovery of the entrances of both Epos Chasm and Tripa tis Nifis. In 1969, an expedition led by Pete Livesey explored Epos, so gaining the Greek depth records which still stands today (Waltham, 1970). They also descended the first pitch of Tripe tis Nifis, then known as the Hole of the Married Woman. A small British expedition in 1970 explored Tsepelovon Spiara and a number of lesser shafts in the same area (Bull, 1970).

In 1973 the Americans arrived. They descended Epos and Provetina on ropes and also prospected most of the shafts on the plateau between Astraka and the Vicos Gorge. Their deepest discovery was a 130-m deep pothole whose entrance was originally found by Livesey in 1968. Two years later, in 1975, an Australian/Bristol mini-expedition used the new road to Vradeton to give easier access to the southern end of the limestone. They explored Ulysses Pot, descended a bit further down Trips tis Nifis, and stirred up interest by finding a hole that “took eight seconds for stones to fall down”. So 1976 saw an even smaller British expedition in the area. Ulysses was surveyed, Tripa tis Nifis was bottomed at 292 m, the “8-second hole” was found to be only 60 m deep (Tripa Kranoula) and an extensive search of the area between Tymfi and Astraka found no more major shafts. Finally, the Americans returned in 1977, led by Wil Howie. They surveyed Provetina, finding it to be 407 m deep, and excavated the fissure at the bottom of Tripa tis Nifis to deepen it a little. In addition, they explored dozens of other lesser shafts, and discovered Tripa Oedipus, 136 m deep, near Vradeton, and a single shaft, Cailotripa, 158 m deep on the western side of the Vicos Gorge near Elefotopas.

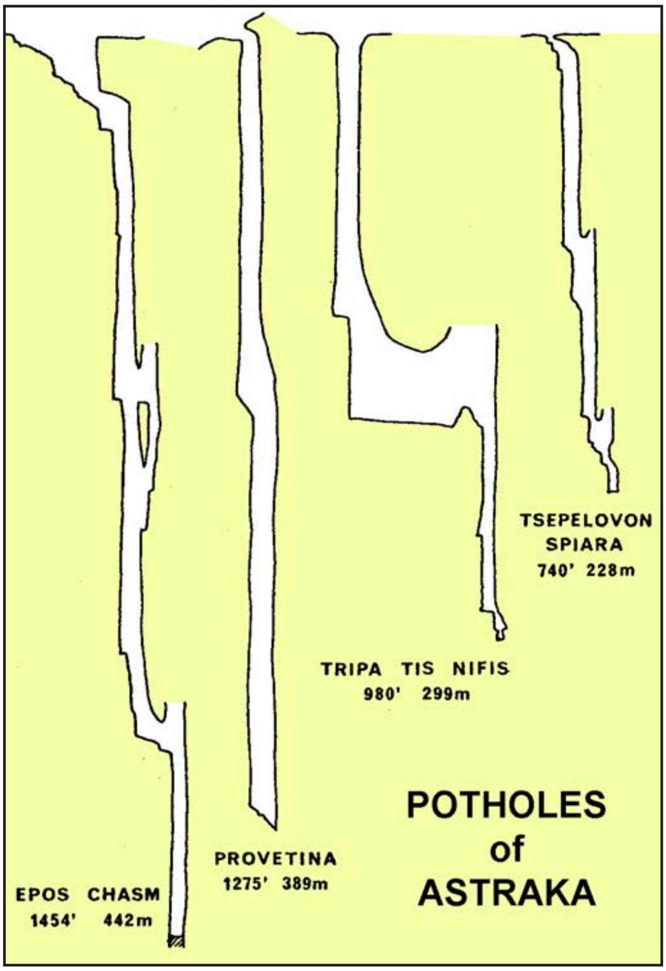
Besides the expeditions noted above, there have been other visits by British, French, Greek and Czechoslovakian cavern, which have however only resulted in minor discoveries. The situation on Astraka at present is therefore that it contains four out of the seven deepest caves in Greece. All these have been explored by the British, but the dozens of other, smaller but still very fine, potholes have nearly all been explored by the Americans who have put much more time into prospecting the limestone. Any future expedition will therefore require a little luck to make a major discovery; but it is a big karst, the potential is there and, if all else fails, the scenery is fabulous.

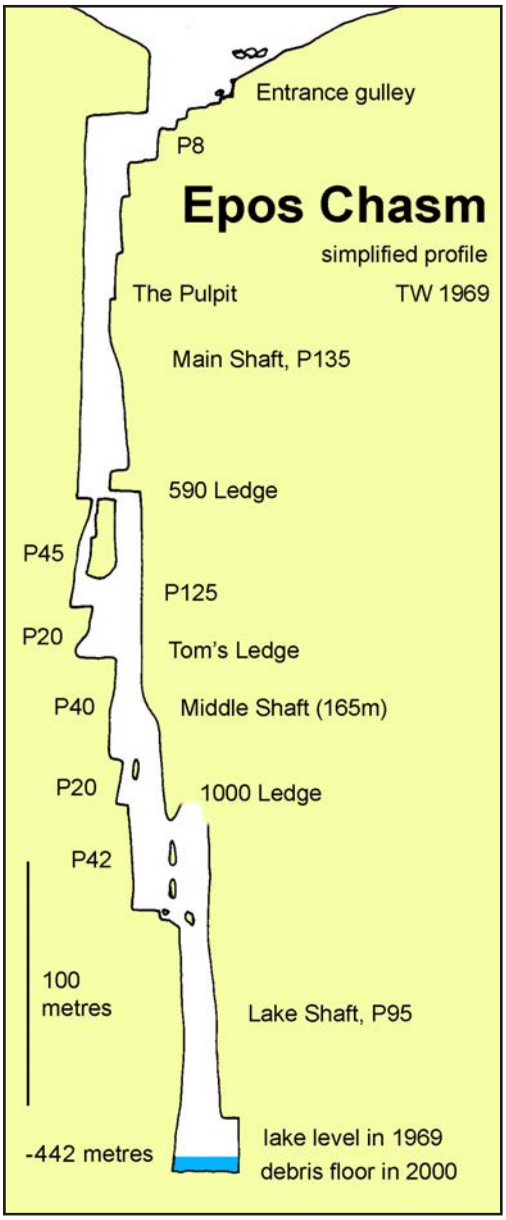
The potholes

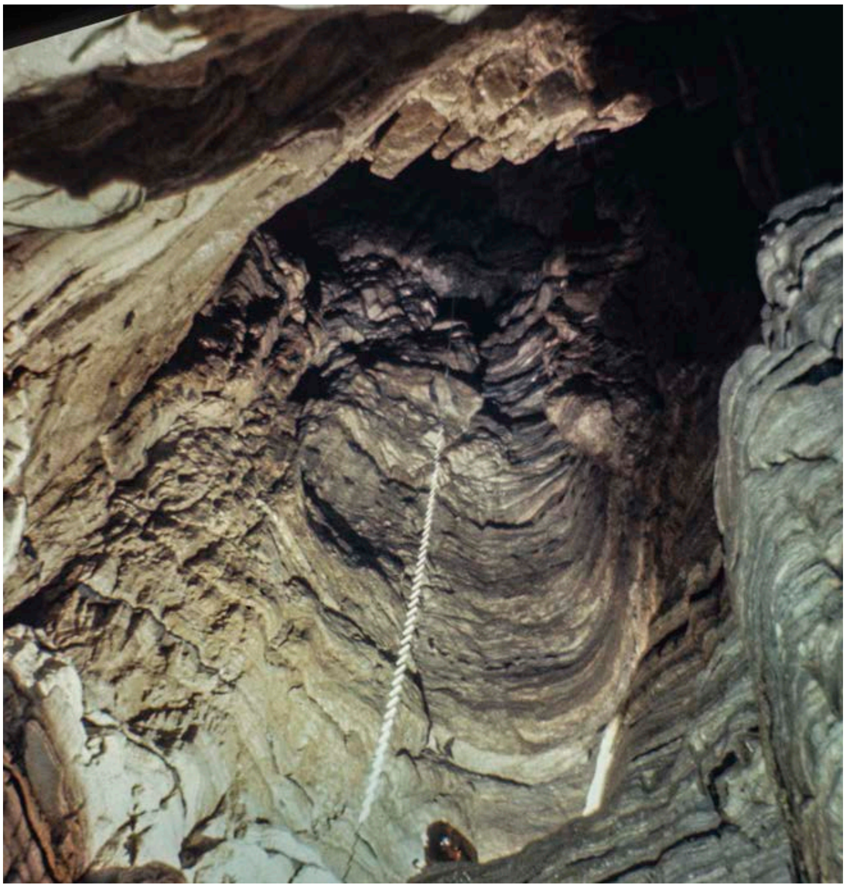
Epos Chasm was discovered and partly descended in 1968 by Pete Livesey, and then fully explored and surveyed by his expedition in 1969. Its entrance lies at the confluence of five gulleys feeding down shale slopes into a shallow closed basin floored by the limestone. It is a splendid situation, at the inner edge of the limestone pavements that extend to the lip of the Vicos Gorge almost directly above the resurgence, more than 1000 m below. Epos is a simple series of vadose shafts formed at the almost perpendicular intersection of two major sets of

Entrance to Epos, with flysch slopes beyond.

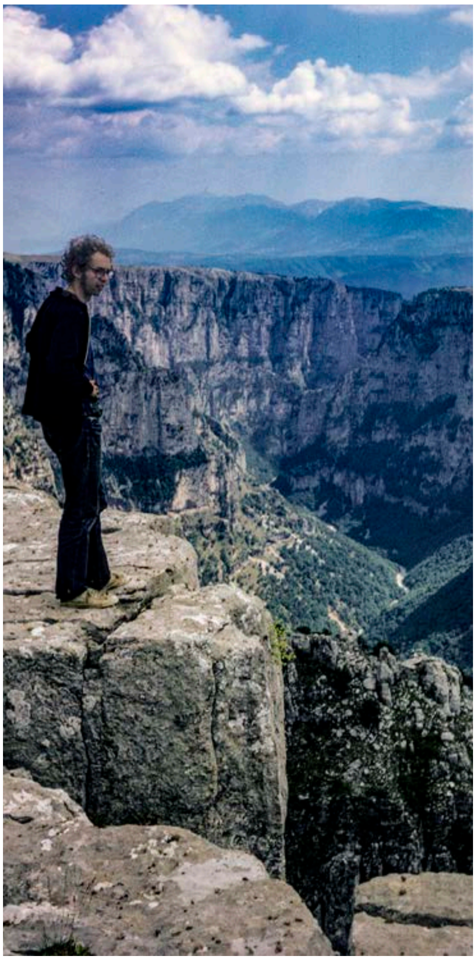
fractures. The first 30 m of descent is a steep gulley down one of these fractures until, just beyond daylight, the first large pitch is met. This is 135 m deep, down the wall to the Pulpit ledge and then 80 m free to the floor. A few netres away lies the next shaft, which is 165 m deep. The obvious way down is a 120 m drop to a ledge, but a small adjacent hole offers a route down four pitches via a series of ledges to the same point. From the foot of the shaft a few metres of steep canyon in clean white limestone offers great prospects, but only lead to the lip of the final 93-m pitch. This ends in the middle of a deep, unplumbed lake with the sides of the shaft dropping vertically into it. It is a spectacular finish to what is currently the deepest cave in Greece at -442 m.



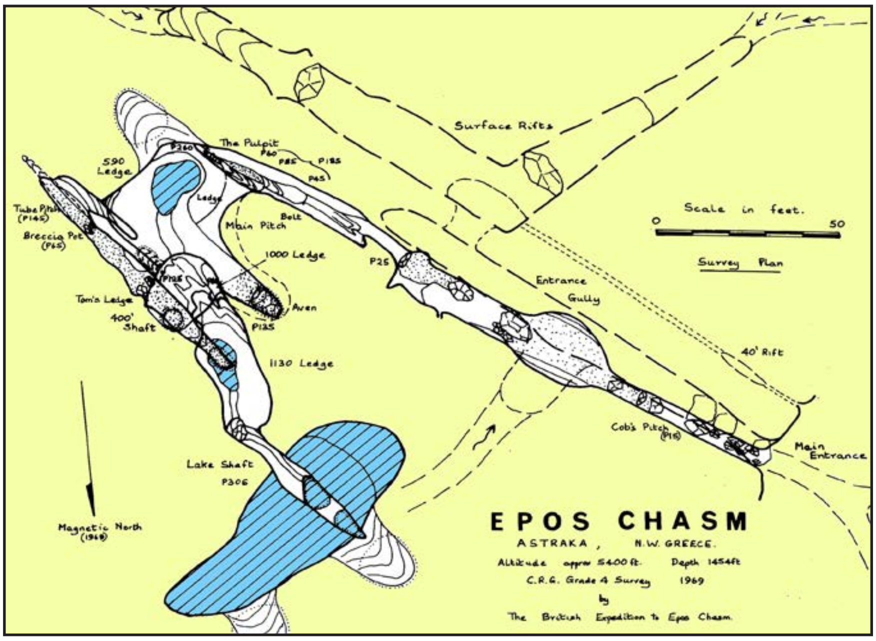




Main shaft of Epos (photo: John Russom).

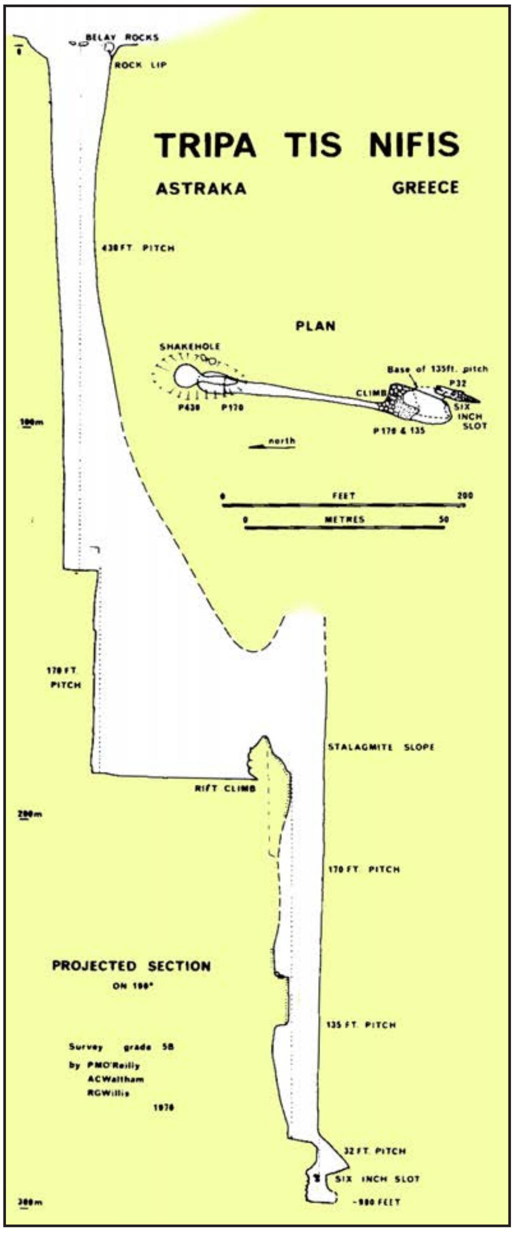


Pete Livesey on the rim of the Vicos Gorge.



A thin bed of black chert forms the floor of the Main Shaft in Epos Chasm, and is broken by the next shaft, 165 metres deep, in front of the seated person (photo: John Russom).

Provetina opens as a gaping hole in a gulley wall near the top of the enormous cliff line that overlooks Papignon at the northern end of Astraka. It was partially explored by Jim Eyre and others in 1966/7 and was bottomed by a British army expedition in 1968. It is formed on the intersection of two joints and appears to be an isolated, but very large shaft intersected by the surface gulley in its top corner; there is still a roof over part of the entrance. It is not certain that it ever took a large stream, for it may have been formed entirely underground by drip and film water before being exposed by the gulley. The first pitch is 165 m, down a superb cylindrical shaft, to the sloping snow ledge of the Spider. From there a drop of 215 m is free to a sloping floor of gravel and boulders with no hope of a continuation. At 407 m, Provetina is no longer the deepest shaft in the world, and it is arguable that it is in fact two shafts; but it still provides one of the world's greatest vertical trips.



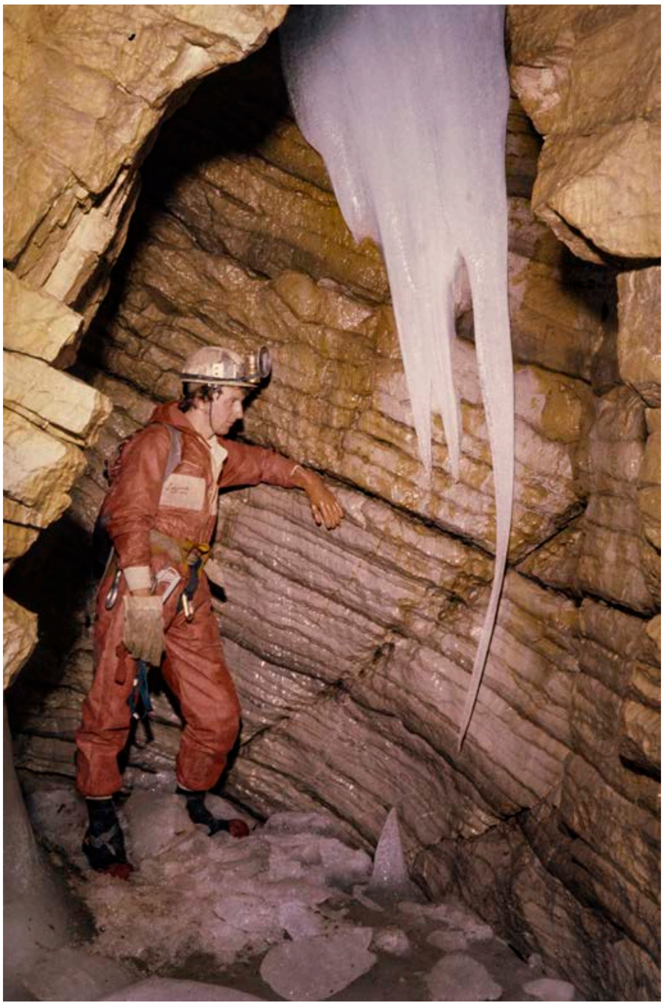
Tripa tis Nifis had its name loosely translated to "Hole of the Married Woman" when Jim Eyre was directed to it by the shepherds in 1967 and told of the bride who had fallen down it 'a thousand years ago'. He descended the first pitch in 1969 but then, incredibly, the cave was unvisited for six years. The Australians gained a pitch in 1975 but ran out of rope only a little way down the next large shaft. This was descended by the Astraka '76 expedition the following year, but they were stopped at a narrow fissure, which was bypassed by the Americans in 1977 but led only to another even more hopeless crack. The whole cave is formed on a pair of parallel faults as a pair of vadose shafts, though the massive stalagmite on the second one suggests it is much older than the entrance shaft; there may be an old inlet high in the roof. The entrance shaft is 183 m deep, free down the centre of a perfect cylinder for 131 m to a large ledge and then down the end of a massive rift. Following the dip of 10°, this rift leads to a climb over a stalagmite blockage to another large shaft, leading in turn to a floor of cobbles and a single narrow fissure. This leads to a small chamber and an even narrower dug fissure to a smaller rock floored chamber which is the end, 299 m down.

Tsepelovon Spiara was found only a few metres from the road leading to the village of the same name, by the Westminster Speleological Group in 1970. The rather uninspiring, tree-shrouded, entrance yields a few metres of passage leading to the first pitch of 101 m. The pothole is essentially a single vadose shaft nearly 200 m deep, and the first pitch ends on a nasty, scree-covered ledge, from where three shorter pitches lead down between more broken ledges. From the foot of the main shaft, two short pitches lead to a clean washed boulder choke at a depth of 226 m.

The narrow fissure through to the last short drop in Tripa tis Nifis.

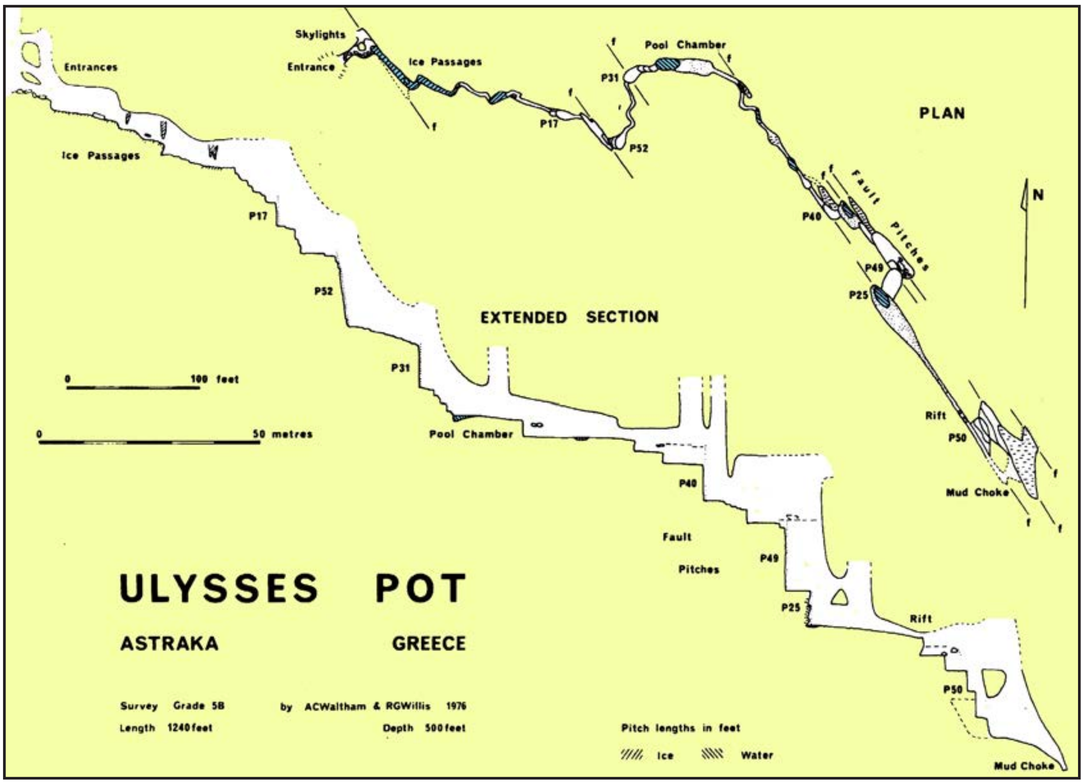
The first shaft of Tripa tis Nifis, looking upwards at night.

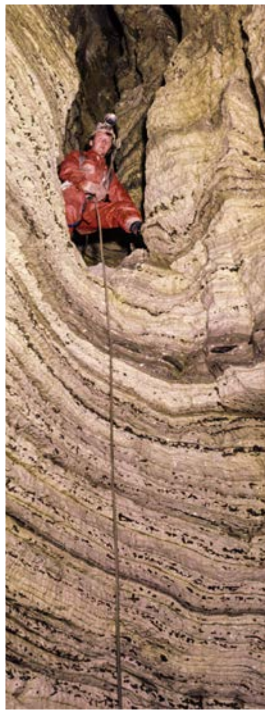
Ice decorations in Ulysses Pot.



Ulysses Pot is the only cave currently known on Astraka with any significant horizontal development. Found by the Australians in 1976, it occupies an obvious site draining a closed depression on the south flank of the Kasarma gorge. It is 380 m long with seven short pitches, taking it to a depth of 152 m. There are no traces of early phreatic development, as it is just a simple vadose canyon devoid of inlets except down a few avens. In classic sense it meanders in an overall down-dip direction with a pitch on each of a series of minor faults, until it reaches a major fault that it follows along and down to the terminal chamber and mud choke. Ice cascades and stalactites adorn the first section of passage, and add even more variety to what is anyhow a very pleasant little cave; it is unfortunate that the mud choke prematurely terminates a very promisingly situated cave.

These five cave systems are only the major ones of Astraka explored or surveyed by the various groups of British cavers. The numerous other shafts and potholes, mostly explored by the Americans and, with the exception of Gailotripa, not as deep as Ulysses, are not described here (amd the planned American report never appeared in print). In summer none of the potholes takes any stream. After a heavy thunderstorm Epos may have a little spray on the pitches, and the bottom pitch in Provetina is sometimes damp due to meltwater from the Spider. Tripa tis Nifis is totally dry, and Ulysses only has its one permanent deep pool. The caves have not yet been visited other than in summer, so little is known about their active hydrology. However, Astraka normally bears a mantle of two metres or more of snow right down to village level through the winter, and there must be a significant spring melt period. Epos, Nifis and Ulysses at least must then carry





Thinly banded limestone in Ulysses Pot.

streams, as they offer the immediate drainage to sizeable areas of shale cover. Most of the smaller potholes high on Astraka and Tymfi and remote from the shale boundaries are blocked by snow plugs right through the summer.

Geology

Astraka lies in a region of Mesozoic and Tertiary sedimentary rocks that were heavily involved in the Alpine orogenesis, from the point of view of both the sedimentary facies and the subsequent folding and faulting.

The main limestone is Upper Cretaceous to Upper Eocene in age and is about 600 m thick. It is a massive or bedded sub-lithographic calcilutite, containing chert bands and units of autobreccia some of which are on a spectacular scale. Fossils are rare. Beneath this another 800 m of limestone are of Upper Jurassic and Cretaceous age, and their base is not seen at Astraka. This is more thinly bedded than the upper unit, and contains some dolomite, though the proportion is only significant east of Astraka. Above the limestone, the flysch dates from Upper Eocene into the Miocene. These thinly bedded marls, shales, siltstones and sandstones total over 1000 m in thickness but only the lower units are exposed around Astraka.

The major structural features are the two ENE-WSW faults that divide the area into three blocks, of which the middle one is structurally and topographically the highest. Due to the contrasting fold structures in each block the throws vary along the length of the faults, but in round figures that of the southern fault is 600 m or more. The northern, Papignon, block consists of two westward dipping escarpments of the limestone separated by a large north-south fault. This fault continues into the central block, which contains Astraka, and forms the impressive east wall thereof, before dying out to the south just near Kasarma. Both Astraka and Tymfi are therefore escarpments in the west-dipping limestone terminated eastwards by faults, that of Tymfi lying in the Aoos valley. Southeast of Kasarma, the dip is locally to the south, and west of Astraka the limestone levels off to form the great horizontally bedded plateaux on either side of the Vicos Gorge. Thin outliers of flysch lie in the structural depressions and cap some of the hills on the Astraka block. The southern, Tsepelovon, block has mainly flysch at the surface. However the underlying limestone is exposed along the floor of the Vicos valley and on an anticline west of Tsepelovon village.

Superficial deposits in the area are sparse. There are scattered pockets of residual clays, screes, coarse alluvium in the main valley floors, and some isolated moraines on the higher slopes.

The limestone gorges

The largest single feature of the topography of the area is the Vicos Gorge, cut through the horizontal limestone plateau west of Astraka (Fig. 6). It is 11 km long, between one and two klometres wide at its rim and around a kilometre deep. For much of its length the upper half of its walls are vertical, cut through the massive upper limestones. Its lower, scrub-covered sides slope down through the more thinly bedded limestone in a V-shaped profile. It has two major tributaries on its right bank. The short Kapesovon gorge is close to the southern boundary fault fed by gullies from the shale cap behind Vradeton. Much larger is Kasarma. It starts as an open V-shaped valley between Astraka, and Tymfi, but gains massive proportions with spectacular vertical cliffs as it swings south then west into the Vicos. All three gorges are dry for about six months of every year. Then, through the summer, the Kasarma and Kapesovon catchments are dry, but the Vicos receives

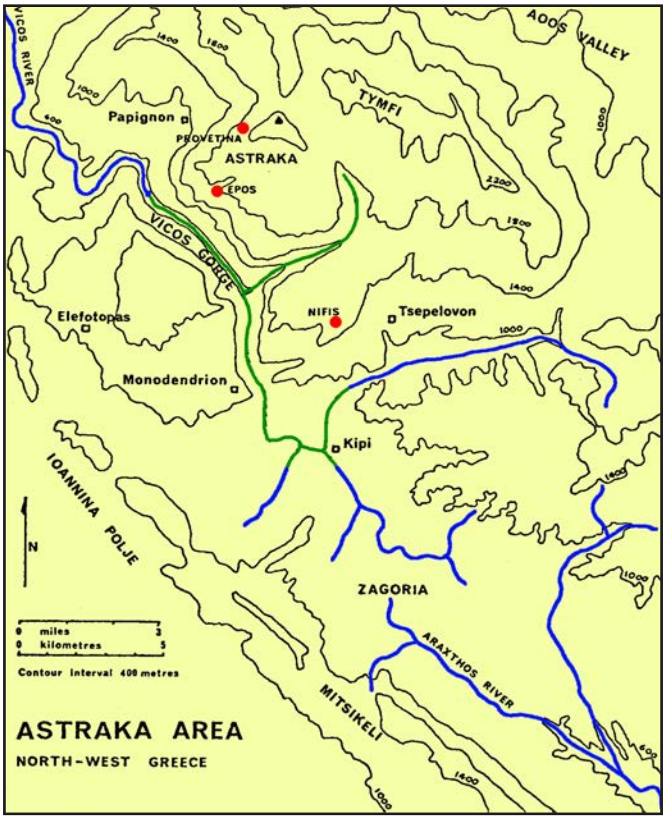
The magnificent limestone canyon known as Kasarma, viewed downstream towards its confluence with the Vicos Gorge.

perennial drainage from the flysch of the Zagoria valleys to the south. All this water sinks upstream of Kipi and no significant caves are known at the various sites. The powerful permanent resurgence at the lower end of the Vicos Gorge is at floor level but emerges from boulders with no hope of access to the cave feeder. The underground route covers 11 km in a straight line, with a drop of around 300 metres.

The Kasarma and Kapesovon gorges are graded tributaries to the Vicos but, while the Vicos itself is also roughly graded, it cuts straight through the Astraka block and thereby presents something of an anomaly. There are no signs of glaciation in the gorges; they are of fluvial origin; yet the Vicos River originates in the low hills of the Zagoria before entering the confines of the gorge. This could be explained by the Vicos River predating the lowering of the flysch surface in the Zagoria, but such extreme differential erosion rates seem unlikely as a flysch cap is still preserved on the Vradeton ridge. similarly the Vicos could be an antecedent river initiated before uplift of the Astraka fault block, but this invokes a rather difficult time scale of earth movements in relation to erosion.

It seems more feasible that the Vicos (and Kasarma) originally flowed south off Astraka, on to the Zagoria and became a tributary of the Araxthos River, which still flows south off Zagoria. The reversal of the upper Vicos may then have been due to tilting of the Astraka block, or even glacial diversion. This would then have allowed at least some excavation of the gorges under locally periglacial conditions during the cold stages of the Pleistocene.

The remaining valleys of Astraka are on a much smaller scale than the three gorges. A glacial trough on the southwestern flank of Astraka itself, feeding just north of Epos is the most conspicuous result of the glaciations. There are intricate dendritic valley systems on the flysch outliers and some of these feed into steep gulleys on the limestone; these may be impressive, such as those below Provetina, but they show signs of only carrying water in the spring melt season. Most of the gently graded valleys on the limestone are permanently dry, and must be relics of the Pleistocene cold phases; many are now dissected into chains or mosaics of dolines.

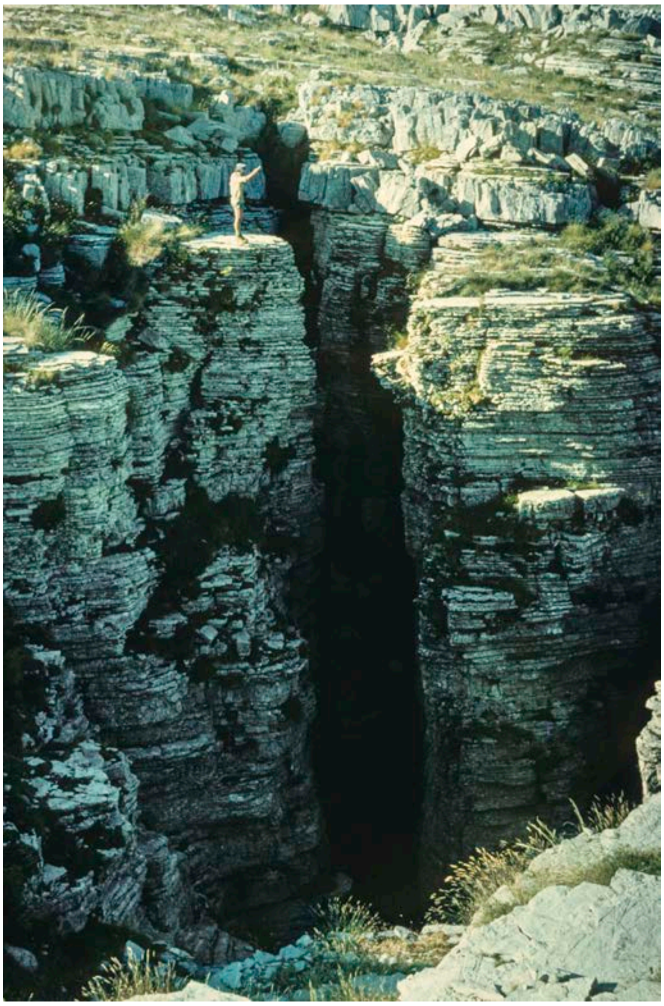


The limestone karst

The dry valleys are a fossil feature of the Astraka karst, but integral with them are the dolines and potholes, many of which are still active.

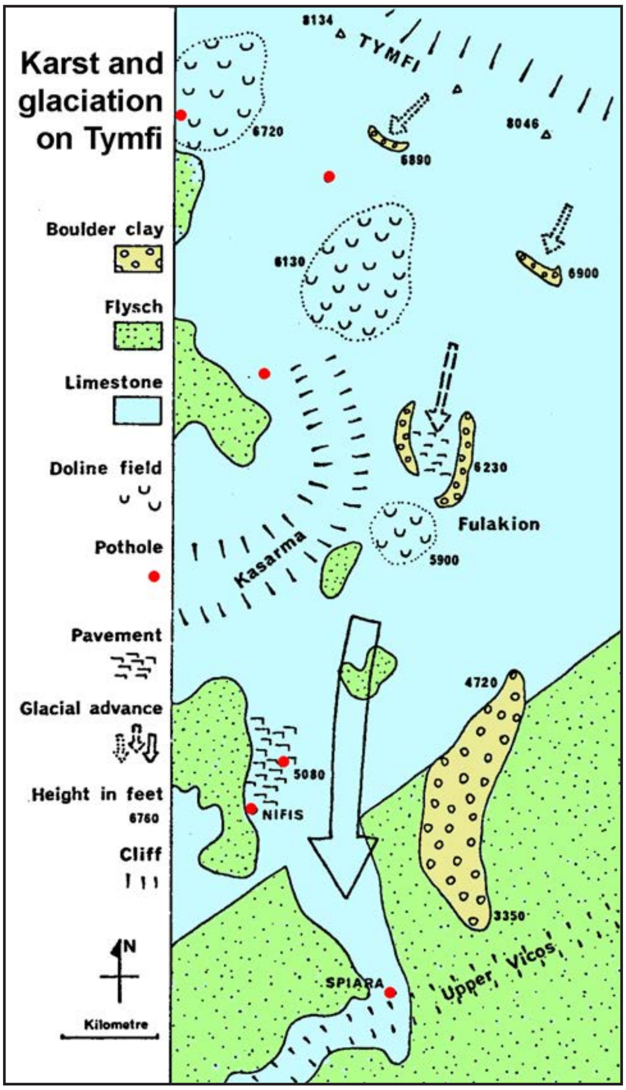
Large areas of the limestone show no signs of carrying integrated surface drainage at any time of the year; the limestone is adequately permeable. There are three important doline fields on the flanks of Tymfi, but elsewhere dolines are not a major component of the landscape. More than 100 dolines were checked on Tymfi. Most are 30–100 m in diameter and 10–20 m deep with sloping debris-covered sides, though many contain rock outcrops. They are mostly floored with nettle patches growing on a soil of sand, clay and broken limestone debris. Some have open shafts against limestone walls and a few drain into horizontal caves; all cave passages are choked within 15 m of the entrance.

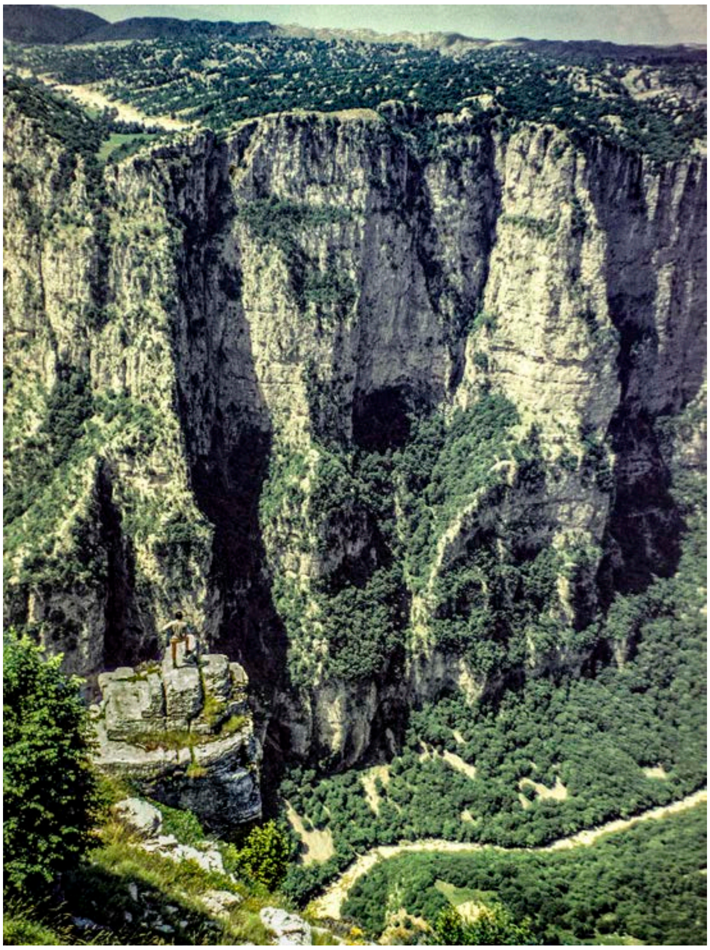
Far more widespread than dolines are potholes, of which hundreds are known all over Tymfi and Astraka. Nearly all are on major joints or faults, and their essential geological control means that only a small proportion lie in dolines. Most are choked with snow or limestone debris at the foot of the daylight rifts; the product of winter frost-shattering is more than can be removed by flowing water as they carry hardly any of the modern drainage. Most precipitation on the limestone sinks straight into the ground. The exceptions are the few potholes close to the boundaries of the flysch out where streams off the flysch ensure both the larger dimensions of the potholes and clearance of choking debris. Epos, Nifis, Tsepelovon Spiara, Ulysses and Oedipus are all located close to the flysch boundaries; Provetina is away from the flysch but is morphologically distinct from the other potholes in that it is a fossil, joint-controlled shaft more comparable with the many small choked examples all over the area. The age of the cave systems is debatable. All are purely vadose and therefore post-date at least much of the downcutting of the



One of the many choked shafts scattered across the slopes of Tymfi and Astraka (photo: Dick Willis).

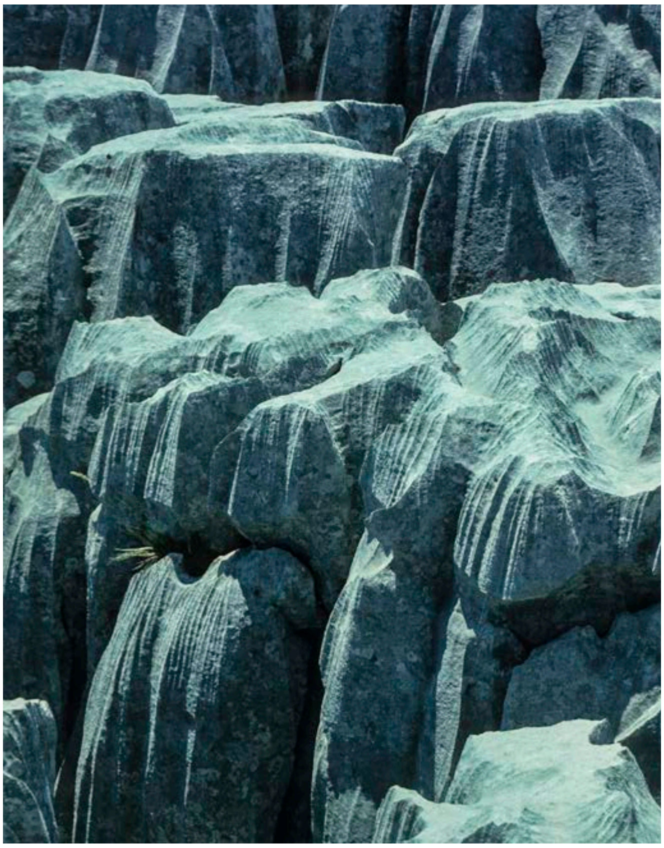
Part of the limestone plateau of Astraka, seen from the lower slopes of Tymfi.





Vicos Gorge, seen from behind Vradeton.

Limestone pavement near the southern edge of Astraka.



Vicos Gorge and the Zagoria. Youthfulness is also indicated by their current acttvity, and clean washed walls, and the fact that they post-date any major retreat of the flysch cap edges. On the other hand, Ulysses and Nifis, and others, contain some massive inactive stalagmite deposits, which probably date to a phase of contrasting climate within the Pleistocene. Until these stalagmites are dated, or the history of the entire area is better understood, further comment on the ages of the caves can only be speculation.

Over most of the limestone area the surface consists of very broken pavements with vegetation, mainly grasses, well established between the limestone blocks. On the higher parts of Tymfi some of the rock is so shattered that the surface is best likened to a felsenmeer. There are also some extensive karrenfields. Those at higher altitudes, and therefore younger, on both Astraka and Tymfi are dissected by deep joints, kluftkarren, and also by extensive rillenkarren. In contrast, the lower and older pavements, especially those around Tripa tis Nifis, are spectacularly dissected by deep rundkarren with superimposed rillenkarren. Fissures between the clints are commonly more than five metres deep, and are scored for their entire depth by rundkarren with troughs around 15 cm wide. Tiny sharp edged rillenkarren are then etched into most of the surfaces. It appears that the rundkarren are relics from a past

A bank of moraine draped over the southern rim of Astraka.

Doline with choked cave, on the slopes of Tymfi.

phase of more moderate pluvial climate, and the rillenkarren are the active erosional forms developed from snow melt that represents the great proportion of the modern precipitation.

Isolated patches of boulder clay occur on both Tymfi and Astraka. Most significant are a series of terminal or retreat moraines at altitudes of approximately 1200, 1800 and 2100 metres, rising from Tsepelovon up the southern slope of Tymfi. It is unknown which stages of the Pleistocene these date from, or even if they are all retreat stages from a single glacial advance in either the Wolstonian or Devensian. Absolute chronology apart, however, they do exhibit distinct spatial relationships with some of the karst features. Upslope from the two lower moraines are extensive areas of pavement compatible with their essentially glacial origins; furthermore the lower pavement, behind the older moraine, is the more mature; that behind the middle moraine bears few karren forms. There is only felsenmeer in the high altitude, presently cold, zone behind the upper moraine.

On Fulakion there is a very spectacular, almost complete, arcuate terminal moraine with the immature pavement inside it. Just outside the moraine, and below it, *is* a major concentration of dolines. Other doline fields lie not far below the high-level moraines on Tymfi: the lowest moraine at Tsepelovon extends off the limestone. This relationship of moraine and dolinc fields suggests a genetic connection and the possibility of meltwater having formed the dolines. This is contrary to current thought, and most available evidence, on glacial and periglacial karst processes. It could be that the situation on Tymfi is due to doline fields dating from the interglacial stages having been removed by glacial erosion stripping the limestone down to the pavements inside the moraines. But dolines are not distributed all over the rest of the karst; there appear to be distinct concentrations below the moraines.

In conclusion, the Astraka area stands as a spectacular glaciokarst. There are dozens of potholes, but the deepest have probably been found already, even though the underground course of the Vi cos is still a mystery. This report has outlined the main elements of the geomorphology but has only touched on some of the problems, notably the implications of doline formation by meltwater and the anomaly of the Vicos Gorge. From the points of view of both karst geomorphology and pure speleology, Astraka still offers potential for worthwhile visits in the future.

Acknowledgements

The author gratefully acknowledges the assistance offered to him by the two expeditions with which he has visited Astraka: the Epos Chasm expedition (led by Pete Livesey) of 1969, and Astraka '76 which took place in summer 1976. The latter expedition was generously supported by a grant towards travel costs from the Sports Council of Great Britain. In particular, the author is grateful to Dick Willis and Paddy O'Reilly, of Astraka '76, for their co-operation in the field, and also to Wil Howie of the American expeditions for valuable discussion.

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This version has been reformatted with the original text (metricated), improved figures and some additional photographs. It is available at www.geophotos.co.uk .

In memory of Pete Livesey, 1943 – 1998.

Postcript

In 1979, another British group visited Astraka, but went into the wrong rift at the entrance of Epos Chasm, and inadvertently discovered an adjacent series of shafts, now known as Epos II. These reached a depth of 419 metres, where the lowest shaft is choked with debris; this also has a window through to the Lake Shaft in Epos I.

Then in 2000 another team visited Epos with the intention of diving the terminal lake. However the lake had drained out, leaving a dry debris floor at a depth of 451 metres below the entrance.