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GHAR PARAU

1971 Speleological Reconnaissance Expedition to Iran

1972 Expedition to Ghar Parau Iran

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THE DISCOVERY AND EXPLORATION OF GHAR PARAU, IRAN

David M. Judson

The 1971 Expedition

The 1971 Speleological Reconnaissance Expedition to Iran selected a large area, roughly four mountains in a line N.W. to S.E. forming a portion of the central spine of the Zagros Mountain Range, in the northwest of Iran. Our area of interest corresponded with the outcrop of the Cretaceous limestone and extended from near Paweh (a few kilometres from the Iraqi border), in the northwest, through Kermanshah to Harsin in the southeast. It took in the mountains of Kuh-e-Shahu (3366m.), Kuh-e-Naraman (2980m.), Kuh-e-Parau (3357m.) and Kuh-e-Shirez (2450m.).

This large area was examined in a very cursory manner in the hope of finding large resurgence caves rising onto the plains to the south of the mountains. The prominent resurgences were examined, but without exception the water either flows under great pressure from narrow fissures well below the water surface, (Paweh, Rawansir town, and Harsin), or into lake resurgences where it is filtering through alluvial material over a wide area.

The massif of Kuh-e-Parau was examined in more detail, especially two large closed depressions or plateaux: – 1) the Kershaqal Plateau at 2600-2750m. situated 6 km. due north of Parau summit, consisting of a string of depressions averaging about 600m. in diameter; and 2) the Parau South Plateau at about 3100m. A number of shafts were descended on Kershaqal Plateau, but all were found to be blocked with mud and boulders at depths of no more than 30 metres. All the shafts were similarly blocked on the Parau South Plateau, although some were found to be a little deeper. The deepest is just over 100m. containing pitches of 30m., 25m. and 10m. We found one major swallet hole, almost in the centre of the Plateau – Ghar Parau. This was explosed on the first visit to the plateau, but not pushed beyond two large collapse chambers. On a later trip a way was found through the block fall, and through a short mud crawl to a large descending passage, Damavand Avenue.

An expedition base camp had been set up adjacent to the large resurgence Kherzeh Zendeh, with the permission, and on the advice, of the Governor General of Kermanshah Province. As the potential of Ghar Parau came to be appreciated parties bivouaced on the Parau South Plateau adjacent to the cave entrance. The last of these temporary camps involved nine of the team, most staying for six nights. Either due to the effects of altitude (3100m.) or to the below-zero night time temperatures, or both, most members of the team were not able to sleep well on the plateau. However, three further caving trips saw the exploration of Ghar Parau and its survey down 25 pitches to a depth of about 740 metres. (A brief report of the 1971 Expedition has already been published – Judson, D.M., 1971, Preliminary Report of the 1971 Speleological Reconnaissance Expedition to the Zagros Mountains, Iran; Trans. Cave Res. Gp., Vol. 13 no. 4, pp.307-311).

The 1972 Expedition to Ghar Parau

The 1972 Expedition was planned from the outset as an attempt to complete exploration, survey and photography of Ghar Parau. It was billed as a world depth record attempt. From the entrance to Ghar Parau to any of its possible resurgence points there is a minimum vertical difference of 1700m. (5600 feet).

Of the sixteen expedition members, four set out two weeks in advance in a Land Rover towing a ½ ton trailer. The rest of the party flew out to Tehran by scheduled airline on Saturday 19th August. Over 15 cwt. of food and rope was sent out four weeks ahead on a regular lorry service – the rest of the supplies and equipment went with the Land Rover. When the Land Rover party arrived in Tehran from Kermanshah to collect the advance supplies they learnt that all three cases had been taken off the lorry and impounded by the Iranian Customs at the border post, Bazargan. It took a week to recover these three cases and transport them to Kermanshah ourselves.

Although a helicopter had been promised to us, to lift all the equipment and supplies on to the plateau, this failed to materialise and we had to resort to donkey power, as we had done in 1971.

With the shortage of food in the first week, a token force of five or six was maintained on the plateau, steadily laddering up the known part of Ghar Parau. On almost all of the first ten pitches Hilti rock bolts were put in – either to achieve a safe belay or to achieve a good take off and a free hang for the rope. This early work proved to be most valuable later on. In most cases the walls were no more than about a metre apart and it was possible to use the "Champion" expanding rock drill. With this excellent tool, a 40mm. x 12mm. hole for a 9mm. bolt took only about seven minutes to drill.

At the end of the first week the food arrived from Bazargan and, still with no helicopter, we initiated a big lift by donkey train. Parties moved up to the plateau on Saturday and Sunday 26/27 August, leaving only Dai Ede down below, who continued working round Kuh-e-Parau sampling the resurgence waters.

The full scale assault on Ghar Parau started on the Sunday, and laddering reached the top of the 23rd pitch that day. At this stage, it was generally agreed that we were becoming overstretched. We were badly in need of a camp site. We had planned on setting up four main camps using hammocks stretched across the passage, but there was nowhere wide enough, except at the food of the larger pitches, and also no separate supply of water.

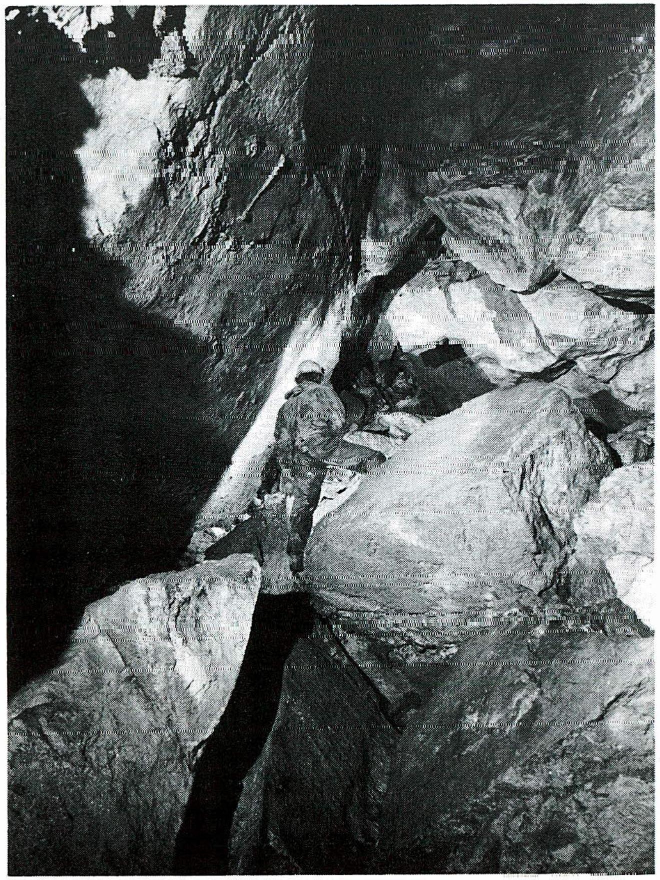

Figure 1. The boulder chaos near the entrance. (J. C. Whalley)

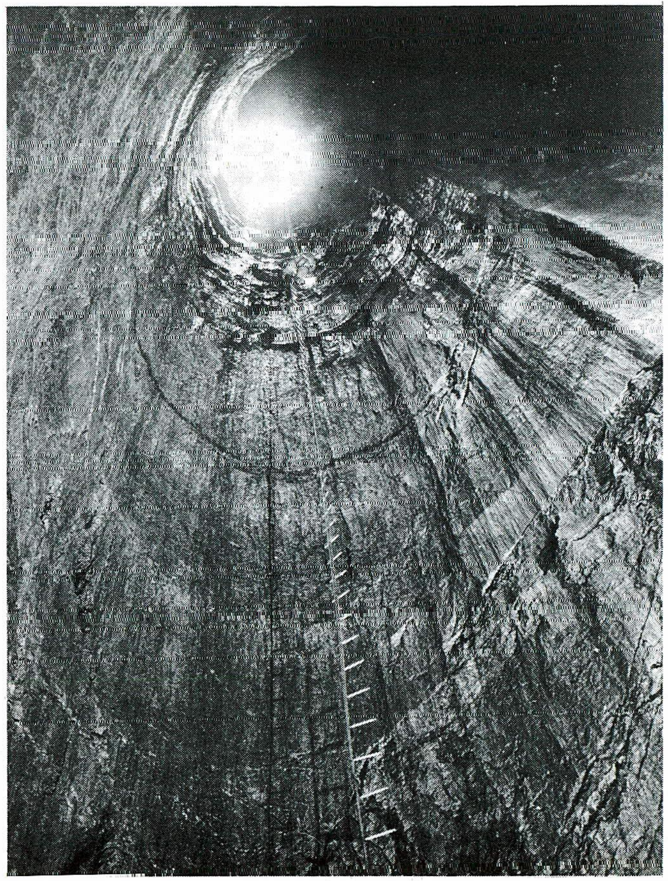

Figure 2. The Eroica pitch. (J. C. Whalley)

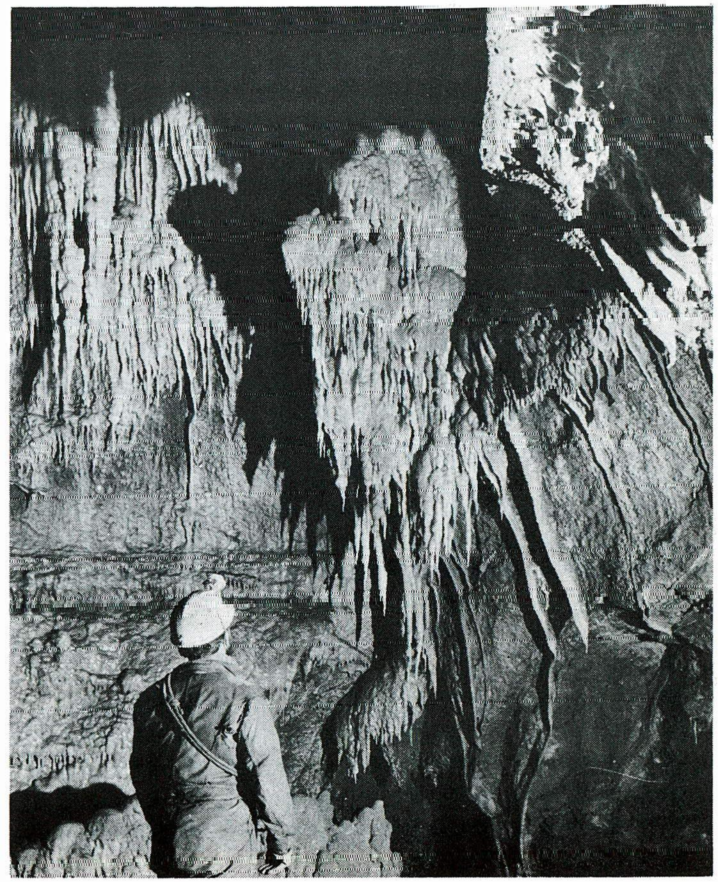

Figure 3. Formations in Masjid Hall. (D. M. Judson)

Fig. 4.

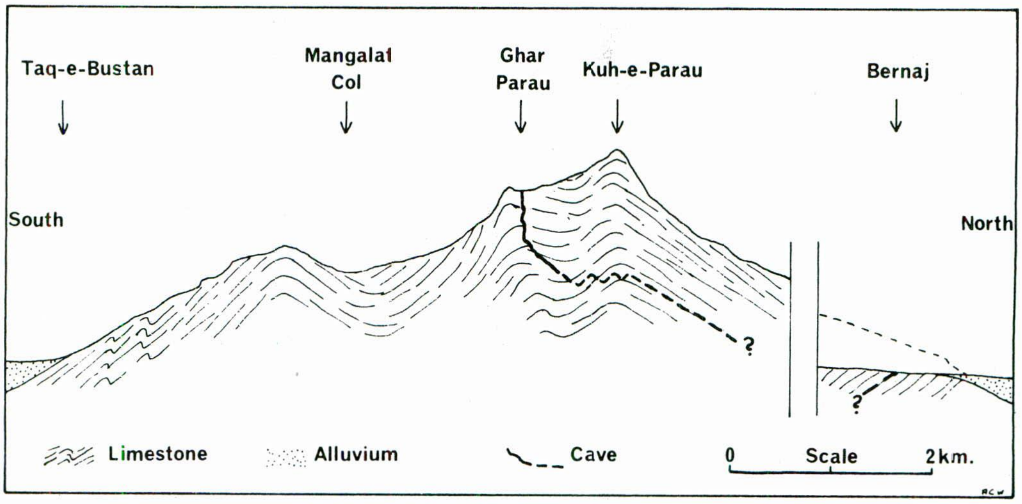

Figure 4. Diagrammatic section through the Kuh-e-Parau massif showing simplified geological structure, the relative position of Ghar Parau and the postulated pattern of the cave beyond the limit of exploration.

Fig.5.

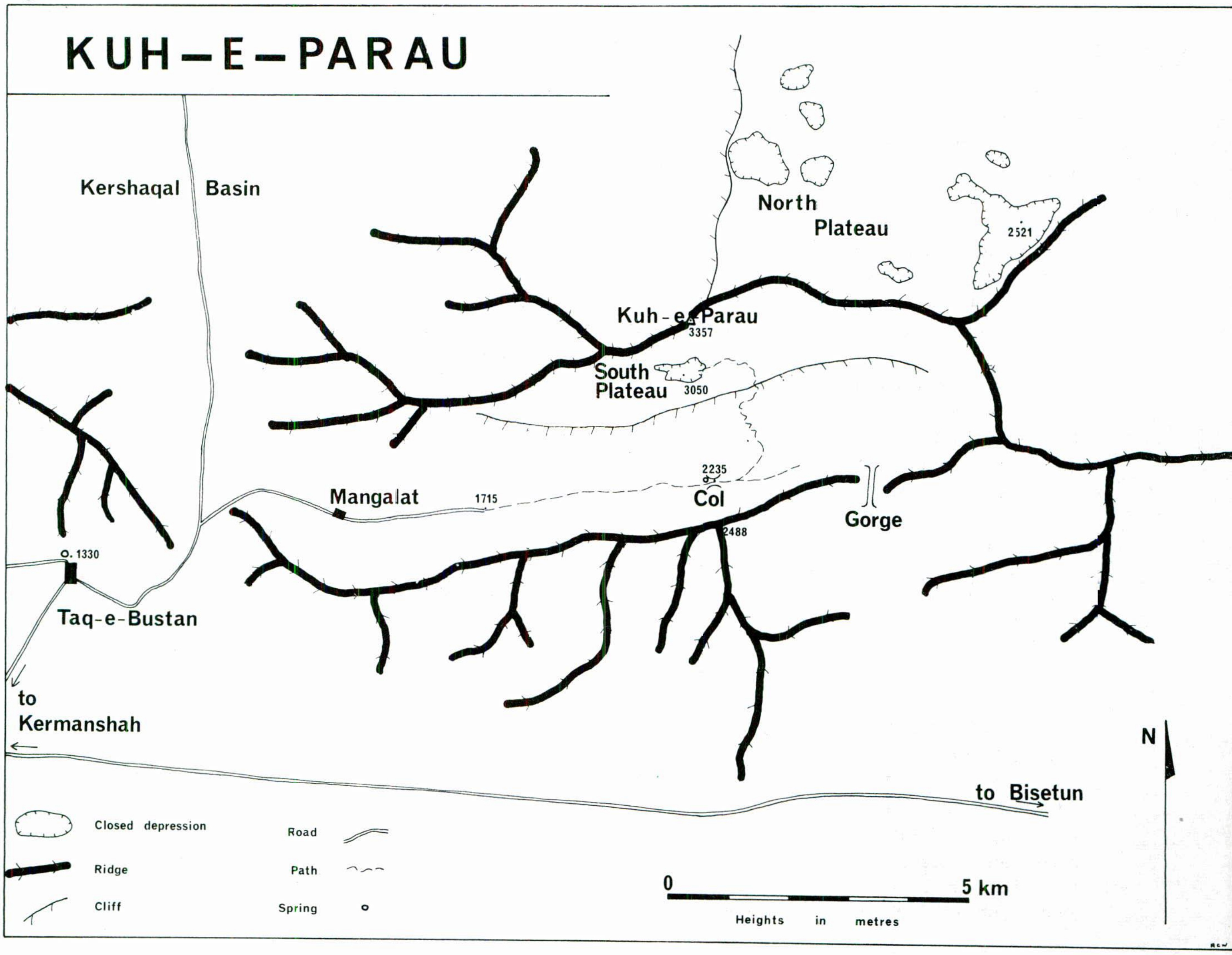

Figure 5. Sketch map of Kuh-e-Parau and the approaches to the South Plateau.

On the Monday, Mike Jenkins and Pete Standing went down with the specific objective of finding a suitable camp site. If necessary this would have to be somewhere in the unknown, below the 26th pitch.

They found a small inlet above the 25th pitch, but no space for a camp. Making the first descent of the 26th pitch they moved on into the unknown. Immediately the passage was 3-4 metres wide – ideal for hammocks – and there was another small inlet. Although at a depth of only 750m. (2460ft.), in a cave so continuously restricted, and therefore strenuous, this is a very considerable depth indeed for a first camp. The two continued along the passage, Ferdowsi Avenue, in search of the next pitch. After only a few metres the walls started to crowd in again and the roof came back into sight. Round a couple of bends and the roof came down more steeply – and then came the inevitable sump. Underwater the shingle floor went down steeply – the roof did likewise.

Two further parties went down and both made serious attempt to by-pass the sump, by traversing high in the roof from the top of the last pitch. Neither were successful and we were compelled to admit that this sump – Sump 3 – constituted the end of our exploration of Ghar Parau – perched, as it is, almost 1000 metres above the general resurgence level of the area.

Brief Description of Ghar Parau

The cave starts out in the bottom of a deep semi-circular, quarry-like crater. From the remains of a snow plug, a steeply descending passage quickly opens into two spacious chambers littered with large fallen blocks. After the Greasy Slabs, and a five metre climb down among boulders, a high chamber is entered, but the roof gradually comes down at about 20 degrees, until a low point is reached in the Muddy Crawl – a flat out squeeze in mud and water about 2 metres long. The passage is soon walking height once more, and the size gradually increases into Damavand Avenue – the largest section of cave to be met with, being up to 10m. high and wide, and a most impressive canyon type passage. A major inlet passage enters from the right, Freshwater Inlet (the source of all of our surface camp water in 1971), and thereafter the section diminishes rapidly to another construction. The Corkscrew is brought about by a calcite barrier which almost blocks the narrow rift passage. This heralds the start of the first highly decorated section of Ghar Parau.

The first two pitches follow – 6 metres and 7 metres – and then comes the much photographed stalagmite boss formation, "Cyrus the Great". Directly from Cyrus' Chamber is the first large pitch, The Eroica (37m.), a superb belled shaft in the Yorkshire tradition, possibly the finest in Parau. The Eroica is a completely free hanging climb and it was generally agreed that this was the hardest climb in Parau – perhaps the altitude had its effect?

Below The Eroica the passage gives its first taste of things to come. Often it is no more than 20cm. to 40cm. wide – a meandering vadose slot, etched out of the floor of a much larger passage.

The fifth pitch is a fine 15 metre wall climb – about a metre in width all the way down. Below is Quality Street – starting out with a well decorated aven-chamber with good stalagmite drip formations on its floor, and continuing as a narrow but well-decorated stream passage. A superbly decorated chamber in the roof of this passage has been called the Masjid Hall.

Following the 21 metre seventh pitch is a tiring succession of small pots. There are seven or eight of these awkward little climbs in the 30 metres of passage leading to the next big pitch, Bootlace Pitch (39m.). Pitches nine and ten (5 and 30m.) follow in close succession before the tiny stream winds its way down into the first sump. The traverse above this sump, The Crunch Bit, was the farthest point reached by a Polish party in July, 1972. The First Traverse is both short and easy, quite different from the Slid Traverse which follows closely after another three short pitches – and is the by-pass to Sump 2. The mud which covers so much of the walls of Ghar Parau, is particularly thick in the lower section of the cave below the 13th pitch; the Slid Traverse is therefore particularly interesting.

The 15th pitch is a climb down from Slid Traverse back into the stream passage. The Shahanshah, at 42m. the largest pitch in Ghar Parau, follows immediately, and about half-way down two windows open rather surprisingly into another parallel shaft. Two more pitches of 7m. and 22m. follow closely and bring this extremely steep section of cave to a close. With the exception of the three-stepped Yek Do Se Pitch all the following pitches (numbers 19 to 26) are short. This is certainly the most cruel passage of all, for between the pitches there is a continuous string of short drops of one, two or three metres, all in a passage – meandering for the most part – which is in effect a topless narrow slot in many places less than 30 centimetres wide. We called this section the Thirty Nine Steps.

All this, to the top of the 26th pitch, had been discovered by the 1971 Expedition. We had planned to use the normal ladder and lifeline techniques down to this level, make a camp, and then press on exploring deep into the unknown, from the camp, using a single rope with abseil and prussik techniques. As it turned out it was really too deep – in a cave so continuously strenuous as Ghar Parau – to have a first camp at - 750m. There was no suitable site below about - 350m. Apart from sufficient space we needed an independent water supply; the stream which we had been following all the way down was quite tiny (about one litre flow in five metres), and of course polluted by our own presence. If the cave had continued for any distance, we would have been faced with a serious tactical problem.

Caving Equipment and Techniques

We took with us 450m. (1500ft.) of conventional flexible wire ladder. 150m. were lent to us by both the South Wales Caving Club and the Craven Pothole Club, and for this we thank them most sincerely. The other 150m. was built by our members, John Harper and Mike Jenkins, the wire being donated by Latch and Batchelor.

Because we were anticipating relying on abseil and prussik techniques for all large pitches below a depth of about 700 metres, we carried out a certain amount of research to establish the most suitable rope for our purpose. We felt that a non-spin rope was desirable, but that the kernmantel rope as used by most rock climbers was both too expensive and, more significantly, was too elastic. British Ropes proved to be most helpful and eventually we purchased a total of 1400m. (4300ft.) of their 1½"inches circumference 8-plait nylon log-line rope on very favourable terms. We had two test lengths of 45m. each and they kindly made the main order up for us in hanks of 10 x 100m. and 2 x 150m. Although prussiking was only carried out on a few of the lowest pitches, for self-lifelining and abseiling we found the rope to be ideal.

Ghar Parau seems to be singularly short of belays. Where there were belays they were either insubstantial (viz. weak stalagmite columns), or were not well sited. Both for abseiling and prussiking it is absolutely essential that the rope should have a completely free hang from its belay. A not exceptionally sharp edge of rock can cause dangerous chafing of the rope after only one or two descents, even when the angle involved is as little as 10°. For these reasons we used Hilti bolts for almost all of the first ten pitches; further down multiple piton belays were used. The Hilti bolts were of the thin sleeve type; holes being drilled with the "Champion Rock Drill" This is a rotary expanding device requiring a wall to push against at 300mm. to 600mm. from the site.

Descendeurs used were either Clog or Fisher types. Clogs were most commonly in use for prussiking and self-lifelining as well as safeguard for lifelining and tackle hauling.

We were supplied with 1" wide red nylon webbing by Brough Nicholson & Hall Ltd. of Leek. This has a breaking strain of just under a ton and came in useful in a great many ways – for ladder belays where pitons were used, for prussik slings and perhaps most of all, for assistance in lieu of ladders or rope on the more awkward of the many short drops in the lower half of the cave.

We made up eight lightweight sheet hammocks from unproofed 5oz. nylon, threaded with a loop of the 1" nylon tape. These were to be used for two small underground camps, together with "Karrimats" and best quality down sleeping bags – unfortunately the camps were never required. A trial run in Notts Pot in July proved the arrangement to be quite practical and also very comfortable.

With regard to our personal clothing for underground use, I think that we were the best dressed team of cavers ever to set out from England. Each man was kitted out with two sets of Damart Thermawear (and a third set for camping), which consisted of long socks, long-johns and long-sleeved vest. On top of these, most members wore Ken Pearce nylon/neoprene dry suits, and, outside, a water proof boiler-suit made to our own design by Ladysmith Busywear Ltd. The boiler suits were found to be so good that for many of the trips the 'Pearce' suits were not required. The boiler suits had elasticated ankles and wrists, inside chest pockets, a hood, and a zip protected by a velcro fastener. The narrow winding abrasive nature of Ghar Parau was a severe test, but they stood up to it extremely well.

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Peter A. Standing
Antony C. Waltham
John C. Whalley.

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The National Enquirer

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The British Petroleum Co. Ltd.
World Expeditionary Association
The Mount Everest Foundation
Randal Coe, Esq.
E. Land, Esq.

Figure 6. A minor fault in the expedition transport.
(A. Champion)

Figure 7.

Looking north from the summit of Kuh-e-Parau. (D. M. Judson)

Figure 8. The South Plateau, viewed from the summit of Kuh-e-Parau, with the Ghar Parau entrance in the centre distance.
(J. C. Whalley)

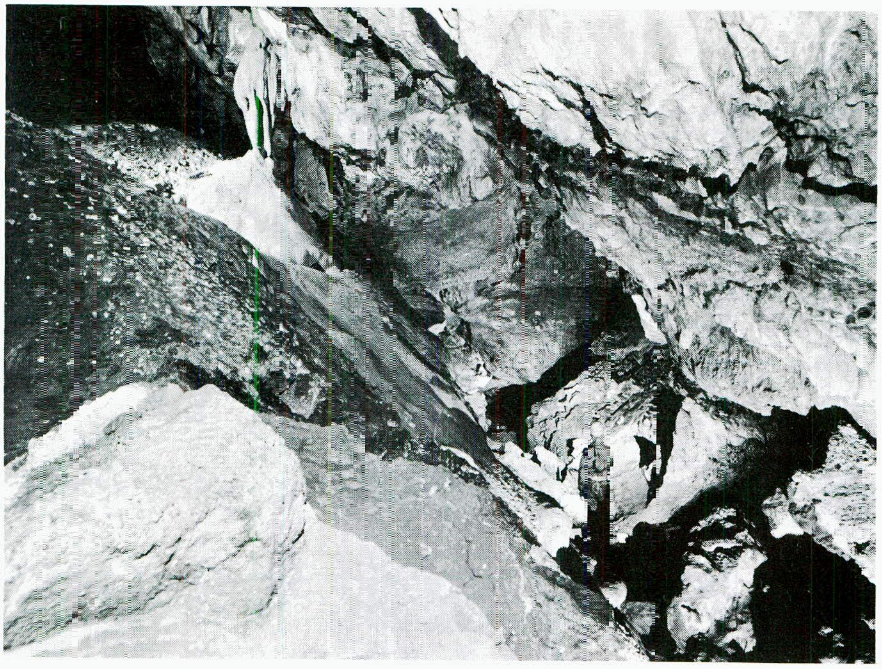

Figure 9.

Damarand Avenue. (J. C. Whalley)

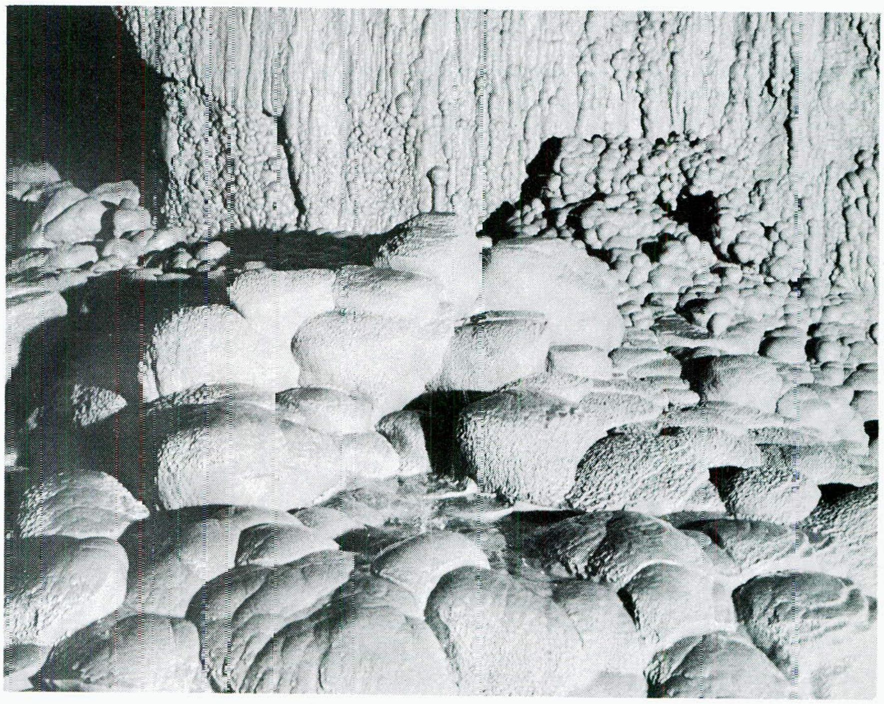

Figure 10

Flowstore in Masjid Hall.
(D. M. Judson)

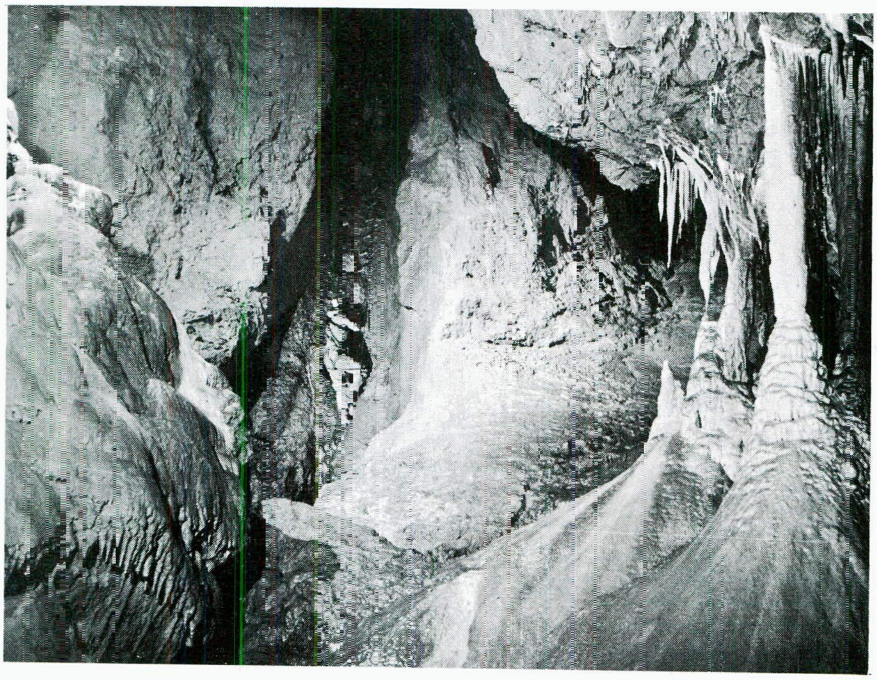

Figure 11. The second pitch and the "Cyrus the Great" stalagmite.
(J.C.Whalley)

The following individuals, firms and organisations, were most helpful with advice, donations of equipment or with the supply of food or equipment at reduced rates and we wish to express our thanks to them also:—

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Thorn Lighting Ltd.
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May & Baker Ltd.
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Parke Davis & Co.
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THE KARST OF KUH-E-PARAU, IRAN

A.C. Waltham and D.P. Ede

The Zagros Mountains stretch along the western and southern sides of Iran, forming a continuous range with numerous peaks of 3000 and 4000 metres. They are structurally young mountains with characteristically spectacular relief, and form part of a larger system which extends from the Alps to the Himalaya. Like so many of the world's great mountain chains, limestones form major elements of their structure.

Particularly well marked in the region just north of the Persian Gulf is the division of the Zagros into two parallel units. Along the southwest is a generally low, but spectacularly dissected, belt of soft sedimentary rocks. These date mainly from the Tertiary, and, in a period of earth movements which is not yet completely finished, they have been buckled into a series of relatively gentle folds. The most prominent unit in this sequence is the oil-bearing Asmari Limestone which forms a number of almost perfect anticlinal mountains where the other softer sediments have been stripped away. Most of the Asmari Limestone is either very porous or rather marly, and, largely for these reasons, it is rarely karstified.

In contrast to these low fold mountains, the northeastern unit of the Zagros consists of contorted and overthrust masses of thick Cretaceous limestones. These form the highest parts of the Zagros, including Zardeh Kuh with its summit at an altitude of 4540 metres. This line of limestone massifs overlooks, to the northeast, the main plateau of Central Iran which averages over 1500 metres in height. Drainage from large areas of the central plateau passes through the Zagros thus contributing to the marked relief of the mountain belt. Eventually the rivers leave the mountains to a second much lower flat region to the southwest – the great sedimentary basins of Mesopotamia and the Persian Gulf.

Kuh-e-Parau – which roughly translates as the mountain of the waters – is the highest peak in the block of the limestone front ranges which lies immediately north of the city of Kermanshah (see figures 1 and 3). The block is elongate northwest – southeast, parallel to the main geological structure and its two ends are truncated by major transverse valleys. Its highest point is at 3357 metres and nearly 500 square kilometres lie at an elevation of over 2400 metres. Practically the whole of the massif is karst. Surrounding it are almost flat broad alluvial plains at around the 1400 metre level. The boundary between the limestone mountains and the alluvial plains is mostly very sharp – particularly along the south and west sides of the massif. Surface gradients on the mountains are very steep; long and high, normally insurmountable cliff lines are common. Furthermore the limestone is dissected by a number of deep dry valleys. All these factors combine to give the Kuh-e-Parau region a terraine which is rugged and spectacular.

The climate of the Zagros is continential and consequently prone to extremes. Climatic information for the mountain regions is almost completely lacking, and inferences must be made from the recorded data for Kermanshah. Annual precipitation on the plains averages just over 40mm. Kermanshah normally records no rainfall in the months June to September, and precipitation is evenly spread over the winter months. This pattern must be repeated on the mountains though the total annual precipitation is probably nearer 80mm. Most of this falls as snow; indeed winter snow cover is great enough almost every year to drive packs of wolves down to the outskirts of the city foraging for food. The combination of low latitude and high elevation in a continental environment gives the Kermanshah region impressive temperature variations. Average daily maximum shade temperature in Kermanshah for the whole of July and August is 37°C, and for five of the summer months the diurnal temperature range exceeds 23°C. From December to March the average daily minimum is below freezing on the level of the plains. High on the mountains temperature ranges can be expected to be even more spectacular. Even at elevations of over 3000m., sunlight temperatures may frequently exceed 50°C during the summer months, and night temperatures below freezing are common right round the Calendar. Diurnal temperature ranges most probably span freezing point for nine months of the year in the high karst regions of Kuh-e-Parau.

Kermanshah is one of Iran's half dozen largest cities, and has a population of over a quarter of a million. It is the commercial centre for the many farming communities spread over the plains. Cultivation of the plains is fairly complete, though usually of very low quality, and is partly dependant on extensive irrigation schemes. The water supply of Kermanshah is from wells in the underlying alluvium, but many of the villages take water from powerful springs on the edge of the limestone mountains (see figure 4) and distribution of these springs had guided many of the village locations. Taq-e-Bustan is one of the oldest village sites and its spring is not only well utilised but is also adorned with an ancient temple and rock carvings.

In contrast to the plains, the mountains are barely populated and utilised. Semi-migrant Kurdish peoples occupy permanent villages round the base of the mountains, and each summer move to live in tent villages at higher elevations. There they graze animals or locally even grow crops on the seemingly barren limestone slopes. Soils are generally very thin and patchy, and the dominant natural vegetation is thistle and some very coarse grasses. The Kurds' summer villages are all sited next to springs; some of these are perennial, while others dry up in the late summer so restricting the village occupation to the spring months.

Regional Geology

The massive limestones which form Kuh-e-Parau lie in the core of a highly distorted orogenic zone which borders the more gently folded geosynclinal zone lying to the southwest. Consequently they are complexly folded, crushed, overthrust and faulted, and slightly metamorphosed. In addition, due to their being on the margin of the geosynclinal zone, their lithology does not correlate stratigraphically with the less deformed sediments of the same age to the southwest. Little is therefore known of the structural detail or succession of the limestones which support the high karst landscapes; the only published report on the regional geology (Falcon et al., 1964) barely mentions them, and the following notes are only based on this and limited reconnaissance fieldwork.

The main unit of karsted limestone is estimated to be well over 1000m. thick; its steep folding gives it the overall relief which is twice this figure. Its age is Middle Cretaceous, probably Cenomanian but probably also ranging into the preceding Albian stage. Though traceable for great distances along the Zagros chain, this lithology cannot be correlated accurately with the dated sequences further to the southwest. Essentially overlying but also probably interbedded with the main limestone is the series known as the Radiolarites. These constitute a 500m. thick sequence of red cherts and thin limestones, and are found in a belt just southwest of the mountainous limestone outcrops. Besides underlying the town of Kermanshah they also form the low foothills just south of Kuh-e-Naraman, but all the major contacts are faulted, so the precise stratigraphic relationship is unknown. Underlying the Middle Cretaceous limestones are further Mesozoic limestones, dolomites and shales which are only exposed in a thrust slice in the south face of Kuh-e-Naraman; it is doubtful if they otherwise rise above base-level even in the core of the anticlinal mountains.

Above the limestones are basic Eocene extrusive rocks which only occur on the northeast slopes of Kuh-e-Kamarkoh where they are followed by mixed Miocene sediments. Elsewhere the limestone is directly overlain by the Pleistocene and Recent clastic alluvium which floors the plains and valleys surrounding the karst mountains.

Most of the karsted limestones are very massive and relatively featureless except for containing a dense network of small joints forming no particular patterns. Parts of the limestone are thin-bedded, but over most of the outcrops it is extremely difficult to discern the bedding at all. Shale beds, or any other form of non-carbonate horizons, are not generally present. Some of the limestones are claimed to be of reef origin, but bioherms with their characteristic erosional forms were not observed. In general the carbonate rocks are slightly dolomitic. A single, typical, sample was analysed to reveal 5% $MgCO_3$, representing a calcite-dolomite ratio of 10 : 1; the insoluble content was less than 0.1%. The texture of the rock is a crystalline mosaic with grain size ranging 0.05–0.3mm., giving it a compact appearance and a high crushing strength. The coarser grains occur in veinlets and in irregular patches, and the grain size patterns bear no relationship to the dolomite – calcite distribution. Much of the finer material has an oolitic structure, with thinly distributed ooliths no more than 0.1mm. in diameter, and locally a pellet texture is present. Well preserved foraminiferan shells are abundant, but no macrofossils or fragments have been recognised. Insoluble, non-carbonate, grains were not observed.

The general structure of the limestones north of Kermanshah is one of steep, moderately tight, high amplitude folds, broken and complicated by steeply inclined thrust faults. Both the fold axes and the main faults are oriented NW–SE, parallel to the Zagros chain, except where they swing to nearly east–west immediately around Kuh-e-Parau itself. Without prolonged fieldwork over the whole region, which was not carried out, it is difficult to explain the individual structural details; but at present it suffices to say that most of the morphology is loosely stratimorphic. For example, the south west flanks of Kuh-e-Kamarkoh are essentially dip slopes, and the huge cliff line north of Kershaqal has been picked out due to the underlying thrust fault.

The Kuh-e-Parau ridge is essentially formed along the crest of an anticline, as are the two ridges west of Bisetun and the ridge south of Mangalat. These anticlines form an en echelon pattern and the Nagibaran and Mangalat valleys lie along two of the intervening synclines. In detail the structures are complicated by many parasitic folds, in particular along the mountain front above the Kermanshah–Bisetun road where landslipping has also taken place.

Kuh-e-Parau's South Plateau, which contains Ghar Parau, is formed in a synclinal podfold on the south flank of the main anticline. However its structure is not as simple as this because the subsidiary folding of the plateau limestone is oriented obliquely to the main regional folds (see figure 10). The chert breccia limestone exposed in the western half of the plateau, contains about 20% of blocks, up to a metre across, of red chert; it appears to be a lower leaf of the Radioarite Series, probably lenticular in form.

Karst Landscapes

The main features of the mountain ranges are lossely controlled by the structure and stratigraphy of the Cretaceous limestones, except where they are dissected by the major transverse drainage lines. In detail, however, the dominant components of the landscape are karstic. Large fluvial valleys tributary to the main transverse tangs* do occur but are few in number and mostly relate to the major geological structures. Steep, stream-cut, ravines and gullies are present on nearly all the steeper mountain slopes, but are no more abundant than those present on any limestone massif which has been subjected to some phases of mechanical weathering in either periglacial or arid environments. Talus slopes and alluvial cones are conspicuous due to their rarity, really only forming very thin wedges in the steepest gullies and at the bases of the steepest cliffs. Some ancient, cemented, fanglomerates have been revealed by later incision in the Mangalat valley.

* A tang may be defined as a deep, steep-sided, gorge, active or inactive, which shows complete disregard for geological structure.

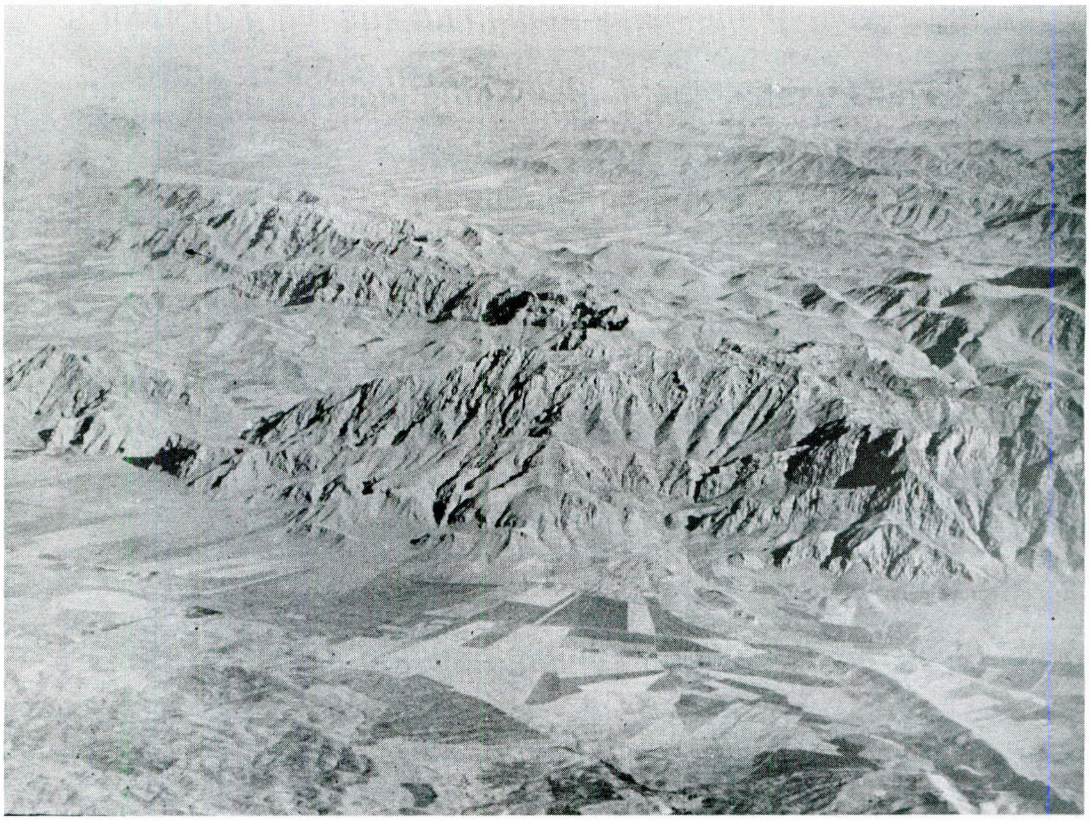


Figure 1. Kuh-e-Parau and the Kermanshah limestone ranges, looking north from an aeroplane. (A. C. Waltham)

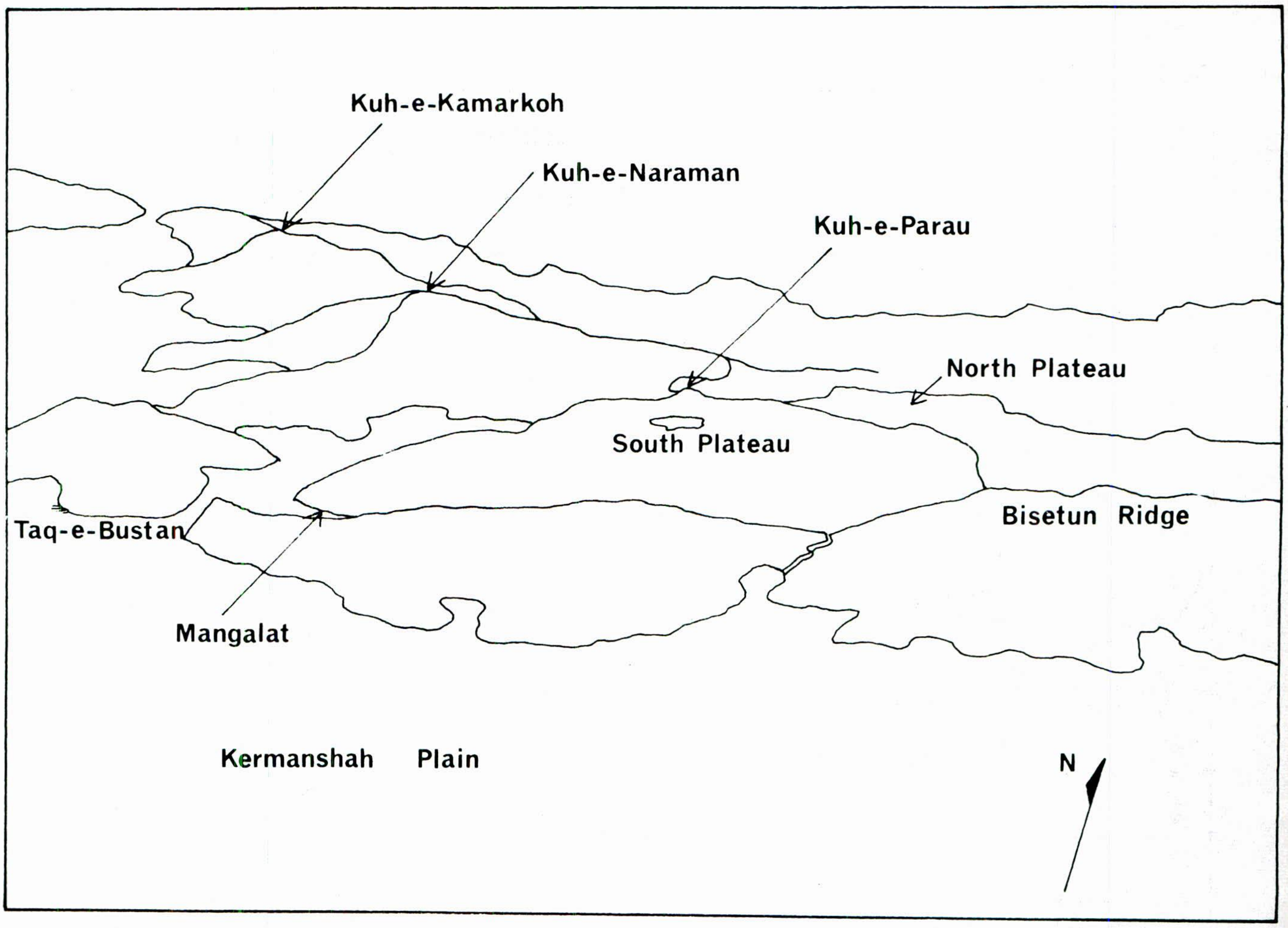


Figure 2. Key to Figure 1.

Fig. 3.

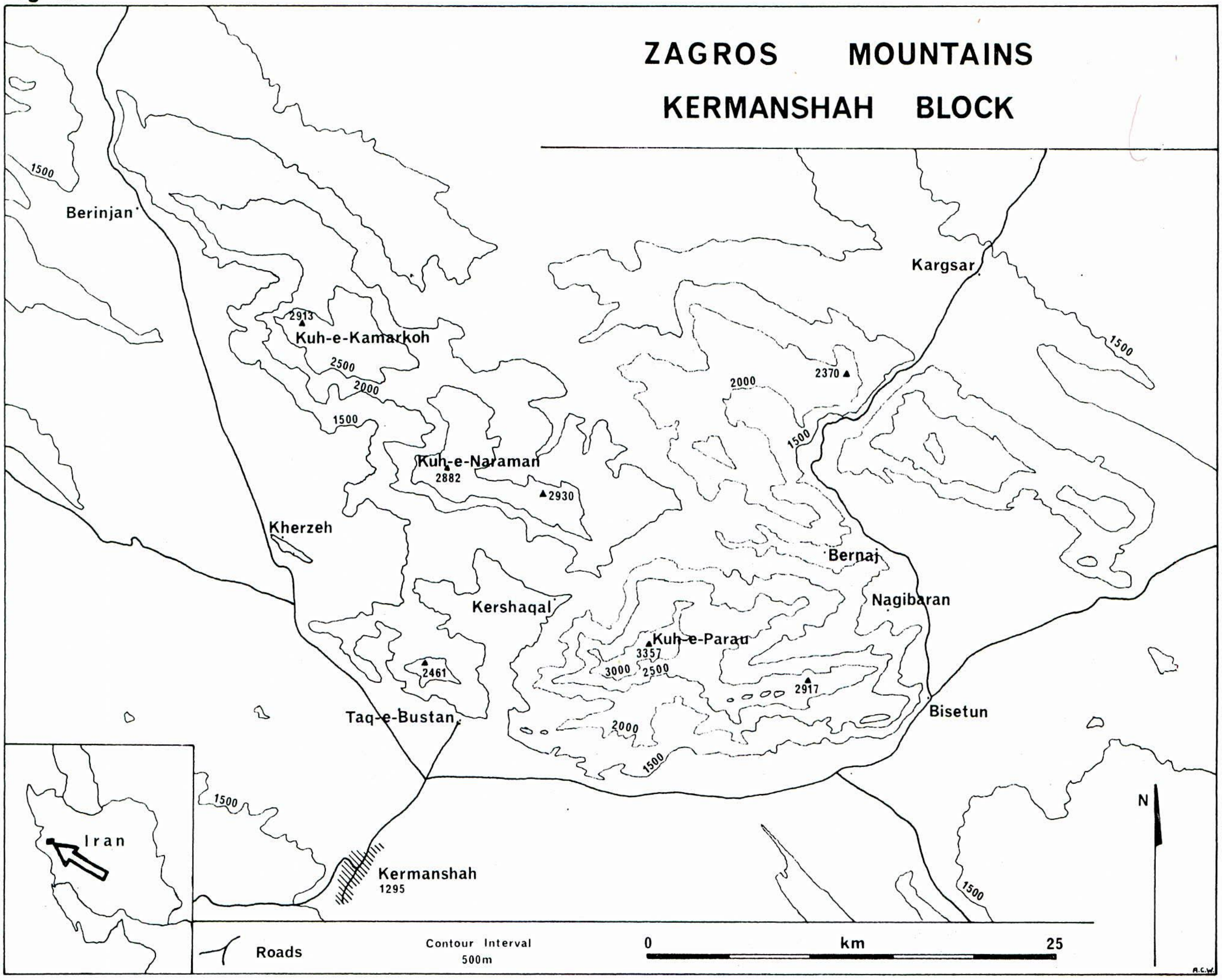
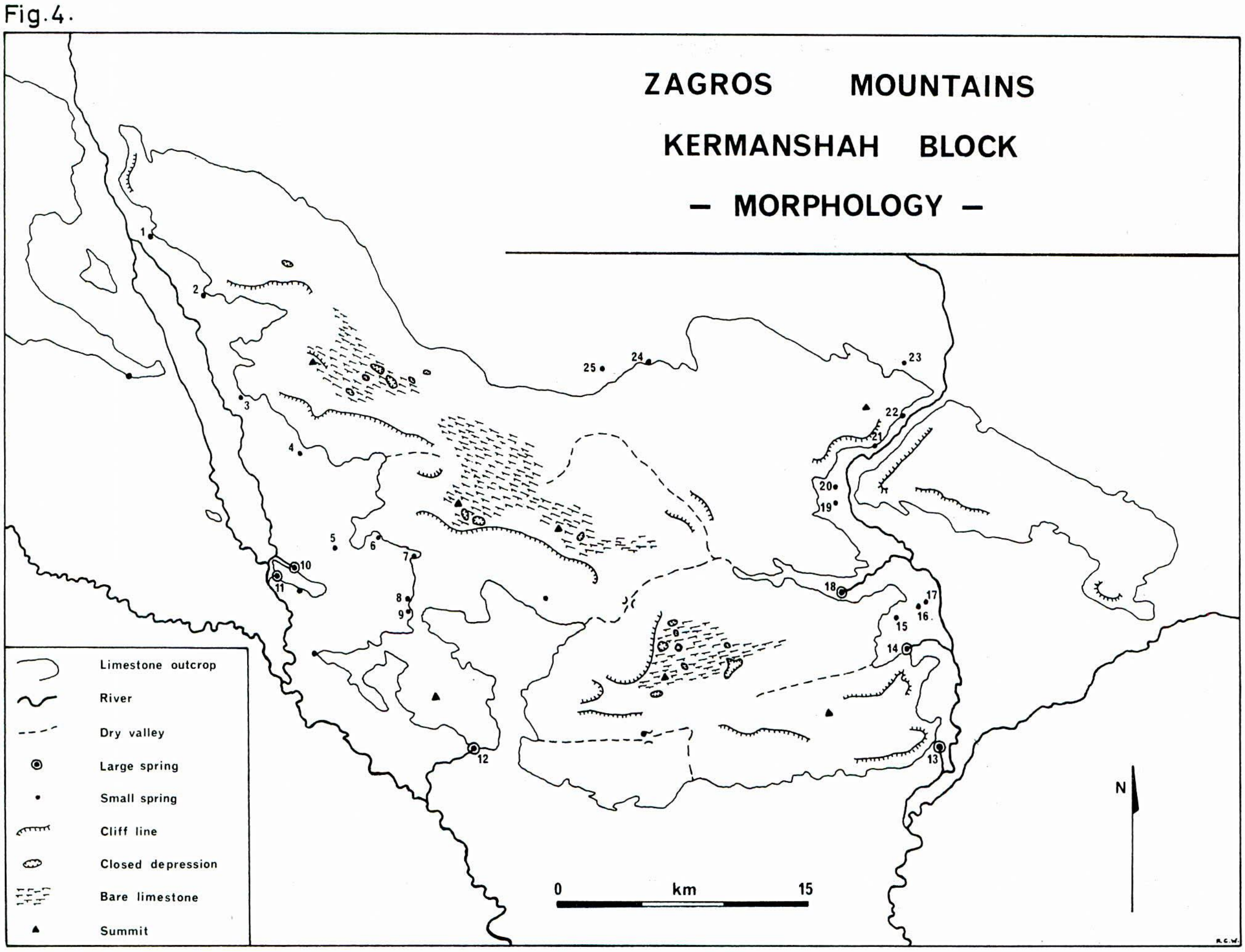

ZAGROS MOUNTAINS
KERMANSHAH BLOCK
Berinjan
Kargsar
Kuh-e-Kamarkoh
2913
2500
2000
1500
Kuh-e-Naraman
2882
2930
2370
Kherzeh
Bernaj
Nagibaran
Kershaqal
Kuh-e-Parau
3357
3000
2461
2917
Taq-e-Bustan
Bisetun
Iran
Kermanshah
1295
N
Roads
Contour Interval
500m
0
km
25

Fig. 4.


ZAGROS MOUNTAINS
KERMANSHAH BLOCK
– MORPHOLOGY –
Limestone outcrop
River
Dry valley
Large spring
Small spring
Cliff line
Closed depression
Bare limestone
Summit
0
km
15
N

As in so many karst regions, the most distinctive features of the surface morphology are the closed depressions. They vary across a considerable size range. Where reasonably bare limestone occurs on fairly gentle surface gradients, solutions dolines 1 to 50 metres in diameter are common, and, except on the main mountain ridge crests, are closely packed so that there is little undisturbed surface between the adjacent dolines. However, such bare limestone outcrops only form a small percentage of the landscape. Most of the gentler slopes on the mountain blocks are covered by thin veneers of broken limestone debris mixed with terra rosa. Solution dolines may be buried beneath this layer but subsidence dolines, or shakeholes, are not present in it, due to the inactivity of water erosion in the present conditions. Similarly blind valleys are uncommon except as minor features within the very large depressions.

It is the large depressions with diameters of hundreds or even thousands of metres, which are so spectacular in the Kuh-e-Parau karst. Isolated depressions of this size range occur right across the limestone outcrops, the South Plateau, which contains Ghar Parau, is just one example, which as it is only very shallow and on the side of a major mountain slope appears rather like a plateau (see below). Elsewhere they occur in small groups; there is for example a descending line of depressions down the Kershaqal ridge of Kuh-e-Naraman. The locations of most of the depressions appear to be structurally controlled, as are most of the large scale morphological features. They either lie in structural basins, as does the Kuh-e-Parau South Plateau, or occur as dips in the thalwegs of the dry valleys, such as the one just south of the summit of Kuh-e-Kamarkoh. Figure 4 marks only the largest depressions but it is notable that most of them occur on the higher, more gently sloping, parts of the massif.

Exceptional to the rule of structural control are the two great groups of depressions occurring on the North Plateau of Kuh-e-Parau (see figure 5) and on the eatern plateau of Kuh-e-Kamarkoh. In these two areas the depressions are so closely packed that there is no intervening flat land – they form large scale doline fields – and there is no apparent geological control of their patterns. The largest single depression, in the Parau field, is 2000m. across and, except at one narrow col, the rim stands over 150m. above the floor of the depression. In these doline fields it is quite distinctive that the floors of the dolines are much more rounded than the interdoline ridges. It appears that when they were formed the solutional lowering of the doline floors was far more rapid than the solutional and mechanical weathering of the higher surfaces the sharpness of the interdoline ridges is due to their being essentially residual features. Even the greater mechanical weathering and restricted solutional erosion within the modern climatic conditions has not eliminated all trace of this earlier differential erosion.

The smaller depressions have almost conical floors of bare solid rock and shattered limestone debris. The present arid climate means that the dolines' modern drainage is mostly an underfit, and the central sinkholes are nearly all choked by shattered limestone, inwashed terra rosa or, in some cases, snow. The karst depressions are nearly all fossil landforms. Some of the larger dolines have flatter floors of terra rosa (e.g. Parau South Plateau – see below) and more than one sinkhole, but again these are mainly choked. However, the very large closed depressions, particularly those on the North Plateau of Kuh-e-Parau, are complex forms in that their floors consist of a network of smaller dolines each in the order of 50 to 100m. across.

Much of the exposed limestone is scored by karren grooves. They are nearly all of the rundkarren type and are particularly common on surfaces sloping at 30–60°. They may be many metres in length, are mostly 10–30cm. wide and are characteristicly very deep (see figure 7) – in some cases the deeper sections of the grooves have expanded and coalesced, leaving only arches where there were once ridges. Some of the steep and deep forms may be better described as rinnenkarren, but there is no evidence to show the widened floors of the grooves as being due to peat concentration (i.e. hohlkarren), because of their steep gradients.

The most important feature of the karren is the fact that they are now almost totally inactive. The surfaces of both ridges and grooves are broken and irregular – the result of mechanical weathering in the modern climate (figure 8). Smooth rounded solutional forms are only present on partially buried slabs where recent wind erosion has removed a protective layer of terra rosa to reveal the fossil solution features (figure 9). Higher up the same blocks there is a steady increase in the degree of surface shattering due to the progressively longer time for which the rock has been exposed to modern weathering. The surface fracture traces are themselves etched out very slightly – probably the result of solution beneath the modern seasonal snow cover. But youthful rillenkarren are absent and there was only one example observed where a minute modern solution channel had developed down the floor of an unusually long, shattered large karren groove. The overall distribution of karren does not appear to be related to any form of altitude zones.

Karren fields only cover a small proportion of the limestone massifs. The dominant surface detail is irregular, broken and stoney. Thin soil layers contain very large proportions of limestone blocks – there rarely being enough soil exposed at the surface, between the blocks, to permit any cultivation. Karren on the loose limestone blocks indicate by their orientations that in many cases they pre-date the establishment of the blocks in their present situations. Though most of the steep slopes are devoid of any regolith, some solifluction terraces on a valley side on Kuh-e-Kamarkoh do indicate the activity of mass movement – these probably date from modern spring thaw processes. However, most of the block and soil covered slopes have too gentle gradient to permit such movement – like most of the landscape elements, they appear to be fossil.

Scattered across all the Kermanshah limestone outcrops is a number of shafts and cave remnants. Nearly all are choked at very shallow depths – indeed the only known caves which pass beyond the limits of daylight are those of the Parau South Plateau. The important feature about them is that they are all inactive at present. Furthermore many of them are isolated in positions with no catchment area – clearly they have been truncated and must date from a period previous to a phase of, relatively minor, trimming of the surface landscape; their inactivity is not purely a feature of the modern lack of rainfall. Most of the shafts and caves are now choked with rock debris and inwashed sediment. In addition one shaft observed on Kuh-e-Karmankoh contains the remains of a thick fill of flowstone cemented blocks – further evidence of its considerable antiquity.

Karst Waters of the Kermanshah Block

The Kermanshah block was defined partially on the basis of practicality for water sampling and partially on grounds of convenience. At the western end there is a distinct structural break which also defines a limit to the general karst hydrology of the block. At the eastern end the limit was taken as the surface drainage through the tang, time not permitting a more detailed analysis to determine the exact ground water limit With this limitation in mind many of the springs around the Kermanshah Block were sampled to determine their calcium hardness, total hardness and water temperature. Estimates of discharge were also made using techniques ranging from current meter readings to floats and cross sectional velocity measurements. The purpose of these measurements was to determine:–

1 Absolute levels of spring hardness.
2 Absolute levels of spring temperature.
3. Variation of both parameters within the area defined above.
4 To determine whether any division of spring types, as found in other karst areas, could be made.

Most of the springs passing from the limestone massif occur at the level of the base of the mountain front. Those issuing on high level cols form only a minor part of the groundwater drainage of the limestone. The main observational work was, therefore, carried out during a series of water sampling runs around the massif at a level of about 1350 metres.

Considerable variation was noted in the specific location of spring sites. These variations together with the index number of the springs of each type (see figure 4) are listed below:–

Mountain front rocksites (M/Fr) 1, 2, 3, 12, 13, 21, 22.
Valley related rocksites (V/T) 14, 18.
Basin spring rocksites (B/r) 6, 7, 8, 9.
Detached Block spring rocksites (DB/r) 10,11.
Mountain front alluvial sites (M/Fa) 4, 5, 19, 20, 24, 25.
Basin spring alluvial sites (B/a) 15, 16, 17.
Wells 23.

This variation in specific location may be an arbitary areal distinction. It does, however, serve to initially categorise the sites sampled without any reference to chemical characteristics; the validity of this differentiation can then be examined in the light of the results obtained from the water analysis.

Certain of the categories are self evident, but it may be useful to describe them in more detail. The first group (M/Fr) includes sites where water issues directly from the rock at the mountain front. This group includes the large perennial springs of Taq-e-Bustan and Bisetun. Valley sites (V/r) are those at which springs occur in or just below dry valley systems. Map evidence suggests that these valleys may be active under high groundwater conditions, and the springs may therefore represent baseflow conditions in the regime of these sub-surface catchments. The basin type (B/r) includes springs where water emerges directly from the rock but the actual spring location is within a broad basin. The detached block springs (DB/r) have water issuing in considerable quantities from a small hill isolated from the main mountain front. These two sites are once again distinct rock springs. At the mountain front alluvial sites (M/Fa) the springs are directly beneath the mountain front, but the water issues from alluvium at varying distances from the edge of the rock wall or steeper debris slope. Comparable are the basin alluvial sites (B/a) except that these springs are in broad basins. A single well on the north side of the massif was sampled; water is being pumped from depth at a distance of about 200m. from the foot of the mountain slope.

At this stage it is useful to make brief mention of the evidence relating to the limestone aquifer provided by observation of the landforms and regional climatic conditions.

Precipitation in the region is extremely seasonal, the main source of groundwater to the limestone resulting from snow melt. Owing to the sparsity of soil cover, and the dissected nature of the upper mountain plateaux, much of this melt passes directly into the groundwater system, and, despite the presence of numerous large basin drainage systems, it does not seem to be channeled to form distinct sinking stream components. The lack of water, and drainage inactivity, of the Ghar Parau cave system itself suggests that much of the melt water percolates into the limestone mass before it is integrated at the surface into stream systems. Once in the limestone mass, percolation movement appears to be rapid, the water passing to considerable depths below the input point. At these depths the main control over the actual path of water movement must be structural; the specific locations of the alluvial spring sites, and particularly sites 10 and 11, suggests that the surface drainage on the surrounding plains has little or no control on the actual location of emergence. Higher level valley head springs do occur, but these are few in number and have small discharges (less than 3 litres/second or 0.1 cusecs).

Though some of the springs must act as resurgences for the small flows which occur within the Ghar Parau cave and no doubt within other systems in the area, they seem to be mainly fed by what has been termed "percolation water." This applies particularly in the summer months, and is suggested by the relatively large number of active small springs present despite the dry climate.

Figure 5. The North Plateau as seen from the summit ridge of Kuh-e-Parau. (D. M. Judson)

Figure. 6. The Nagibaran spring. (A. C. Waltham)

If the results of water sampling and analyses are now considered the validity of the initial spring categories can be examined. On table 1 there is no clear overall pattern immediately visible. Though the data has not been tested statistically there seems to be little significant difference between sites within different categories. If all rock springs (mean Ca hardness 138) are taken together, however, this water is softer than that from alluvial sites (mean Ca hardness 158).

Table 1. Analyses of spring water of Kuh-e-Parau massif.

Sample Location (Keyed to Fig 4)	*Spring Type (Keyed to text)*	*$CaCO_3$ content ppm*	*Total hardness ppm $CaCO_3$*	*Temperature °C*	*Discharge 1/sec*
1	M/Fr	160	186	15.4	20
2	M/Fr	133	178	19.1	n.d.
3	M/Fr	148	174	18.8	15
12 (Taq-e-Bustan)	M/Fr	123	135	12.7	400
13 (Bisetun)	M/Fr	149	166	16.5	150
21	M/Fr	154	213	16.5	5
22	M/Fr	152	210	17.0	n.d.
14 (Nagibaran)	V/r	111	127	11.1	80
18 (Bernaj)	V/r	125	144	11.5	250
6	B/r	134	155	n.d.	n.d.
7	B/r	136	180	9.2	n.d.
8	B/r	162	190	18.0	n.d.
9	B/r	127	152	17.2	n.d.
10 (Kerzeh N.)	DB/r	134	177	18.9	200
11 (Kerzeh S.)	DB/r	132	173	17.8	175
4	M/Fa	166	194	n.d.	n.d.
5	M/Fa	140	156	13.2	n.d.
19	M/Fa	150	195	15.8	5
20	M/Fa	162	189	15.0	30
24	M/Fa	187	262	n.d.	n.d.
25	M/Fa	114	161	17.3	5
15	B/a	167	200	n.d.	5
16	B/a	172	200	n.d.	5
17	B/a	160	195	18.0	5
23	Well	171	235	n.d.	n.d.

Perhaps the most interesting conclusion that can be made from these results is that the larger springs (sites 10, 11, 12 13, 14, 18) have, apart from site 13 (Bisetun), significantly lower calcium contents than the smaller springs. As a group the highest contents are represented by the basin spring alluvial sites possibly because these have small flows which have been in contact with the limestone for the longest time.

The water temperatures again show considerable variability, but this is accentuated because many of the springs discharge into natural or artificially created pools. Thus, in many cases, it was impossible to take the water temperatures at the actual spring openings. The relatively low values at sites 12, 14, 18, 7, 5 suggests deep seated movement to these sites with little flow close to the heated rock surface.

The absolute level of the hardness recorded in the area are lower than hardnesses recorded in many parts of Britain during the summer months. Calcium and total hardnesses of Mendip springs are often recorded at 200–250ppm, $CaCO_3$, while in Gower 200ppm $CaCO_3$ is often exceeded. This suggests that, despite the deep seated flow which must take place to maintain the springs of the area, the solutional capacity of water entering the limestone is not as high as that entering typical British limestone aquifers. This must be the case as the limestone aquifer itself is 2000 metres thick even if only the thickness above the springs, up to plateau surfaces, is considered. This represents a much greater potential for solution than exists in any British limestone area. It may well be that in the Zagros, as in many British areas, the soil cover is a major controlling factor over the absolute levels of hardness reached. The soil cover on the high plateau and mountain surfaces is extremely sparce. This sparsity, and hence low potential for enhancement of solutional capacity, is accentuated by the seasonability of the precipitation. Much of the melt water derived from winter snow tends to have passed into the limestone before the biological processes associated with the soil and vegetation cover become active. (Though there is a certain amount of evidence that CO_2 content increases beneath a snow cover, this has not been confirmed and the indicated CO_2 levels which have been suggested do not approach those found within a well developed soil profile).

The lower hardness values of the large springs suggests that water feeding these springs has integrated into a number of distinct routes. Feed from cave streams in the area seems limited (at least on present evidence) but there is no reason to suppose that preferential percolation routes have not developed allowing a relatively rapid passage of water to the larger spring sites. Discharges from these larger springs were recorded at 0.1–0.4 cumecs (3–12 cusecs) but, following winter melt, figures of 4–6 cumecs (140–210 cusecs) are relatively common. These flow peaks pass very rapidly, and further emphasis the dimensions of the feeder systems and their ability to transmit large amounts of water in a short space of time.

Figure 7. Very deep karren grooves on an inclined slab of South Plateau. (A. C. Waltham)

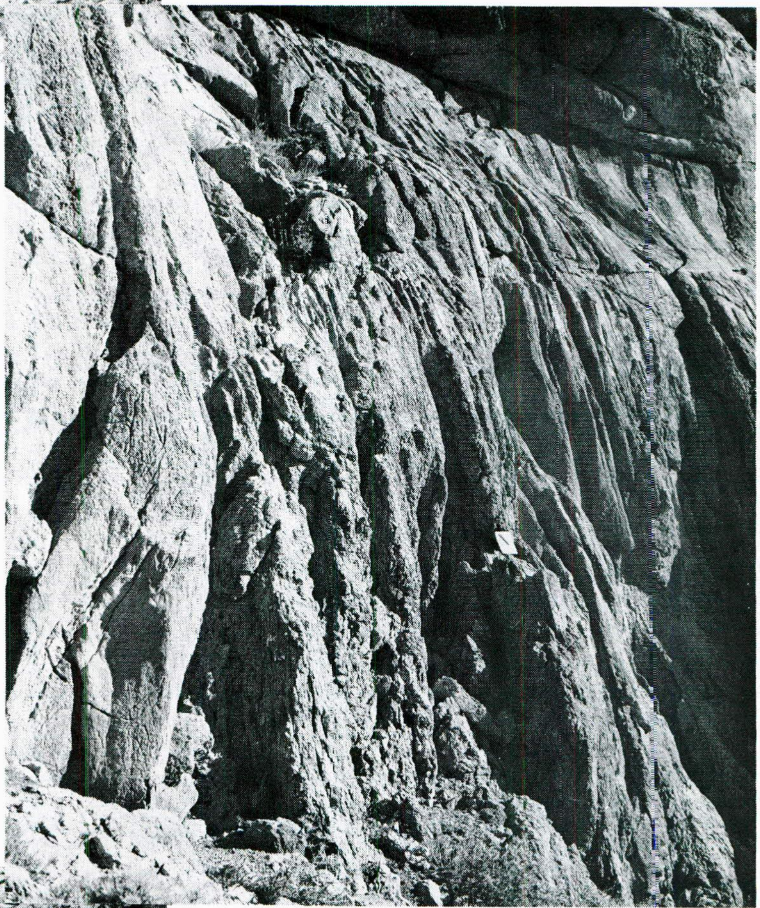


Figure 8. Karren grooves on a steep wall, with all surfaces heavily fractured by mechanical weathering. Notebook gives scale. South Plateau. (D. M. Judson)

Figure 9. Limestone block on South Plateau. Upper half deeply fractured by modern weathering. Lower half has remnant solutional smoothness which has been protected by soil only recently removed. Roll of climbing tape gives scale. (A. C. Waltham)

While in the area, an attempt was made to trace the small amount of flow found in the Ghar Parau cave. Despite the use of fluorescein and charcoal detectors this was not successful. In view of the dip to the north of Kuh-e-Parau summit and the orientation of the dry valleys in the area it is suggested that the most likely resurgences are either sites 14 (Nagibaran) or site 18 (Bernaj). Both lie at the eastern end of structurally oriented dry valley systems and their extreme peak values of flow suggest that there may be large feeder systems into which water from caves like Ghar Parau passes.

Kuh-e-Parau South Plateau

The principal claim to fame of the Parau South Plateau is the fact that it contains the only known open caves in the area, including of course, Ghar Parau itself. Morphologically the Parau South Plateau is just one of the many closed depressions in the area, but, though not the largest, it is distinctive because it has an unusually large, nearly flat, sediment-covered floor. It is this feature, together with its high perched situation which has led it to become known, rather colloquially, as a Plateau.

The nearly flat floor of the plateau is just about a kilometre long but rarely wider than 300m. (see fig. 10). On its north side the slopes steepen into the cliffs which rise to the summit of Kuh-e-Parau, 300m. above. On the south side there is only a low discontinuous ridge rarely more than 25m. high separating the plateau from the cliffs dropping down to the Mangalat col; one dry stream bed breaches this ridge so that only the eastern end of the plateau is truly closed. A spur marks the western end of the plateau but its eastern end is less distinct where it merges into the rugged slopes of the main mountain.

The bedrock geology of the plateau appears to be complex. The massive limestones are commonly structureless and the observable dips, marked on figure 10, do not conform to a simple pattern. The broad topography of the plateau does have some structural origin, but instead of there being a simple syncline there are a series of synclinal podfolds arranged en echelon with their axes slightly oblique to the large scale structural elements of Kuh-e-Parau. There seem to be at least three such synclines of varying tightness. Small faults are indistinguishable from the many almost randomly oriented joints, but there are at least two significantly large faults. The entrance to Ghar Parau is on a low angle fault and the same, or parallel, fractures are present in the breakdown-prone entrance series; exceptionally fine slickensides are present on the Greasy Slab and just below it are a group of large calcite scalenohedron crystals which clearly grew in a cavity on the fault plane. Terra rosa obscures the northern continuation of this fault zone, but almost certainly it is one element of this zone which appears in the easterly of the two major sinkholes on the opposite side of the plateau. A second main fault truncates the eastern edge of the outcrop of chert breccia near the western end of the plateau (see fig. 10). This breccia contains about 20% of angular red chert fragments of varying size up to a metre across and it appears to resemble the overlying Radiolarites in lithology. Its absence to the east, either in the exposed cliffs or in Ghar Parau, suggests it is only lenticular in form.

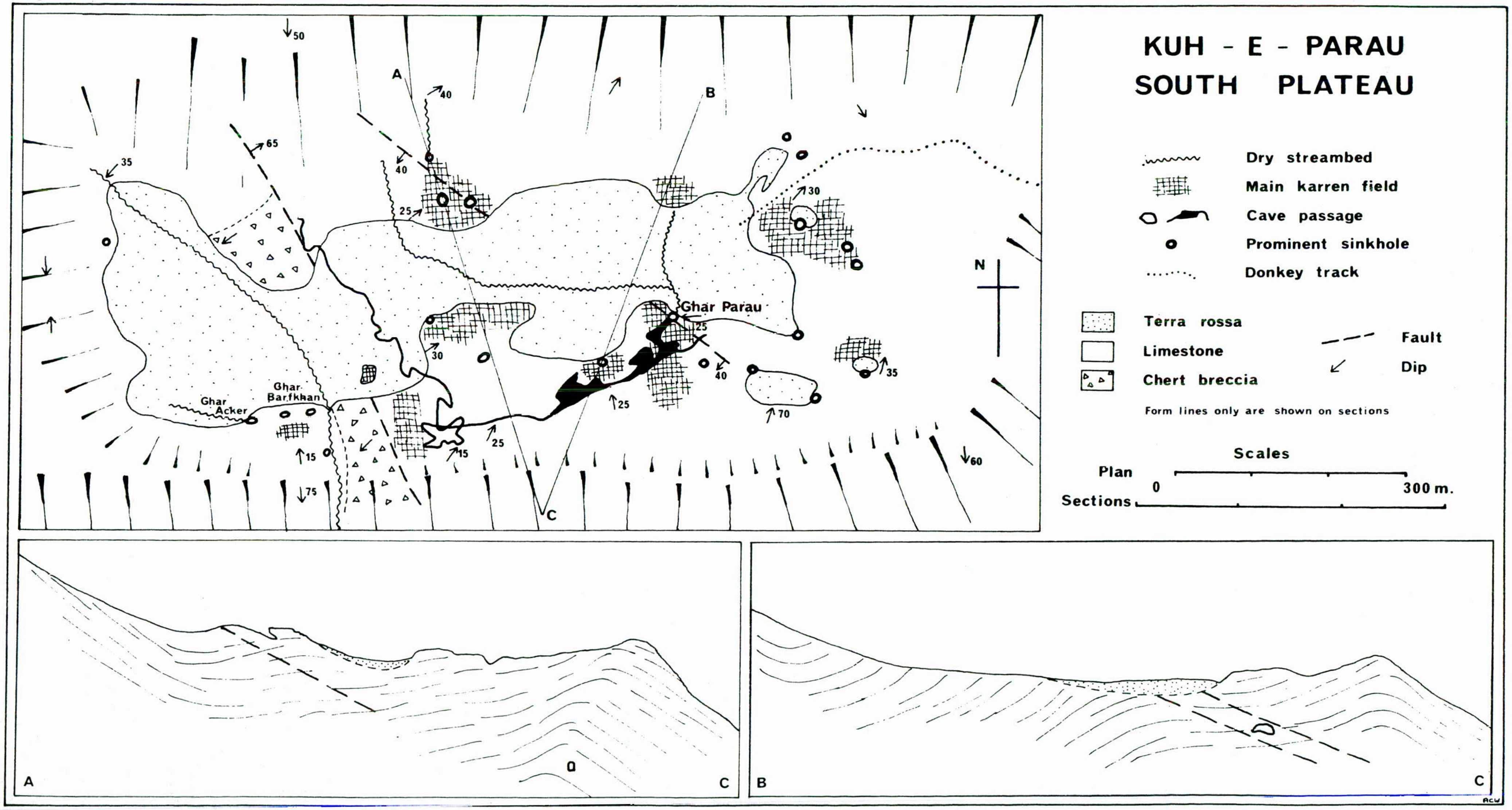
Most of the plateau is covered by a layer of terra rosa. Dry valleys incised into it show it is at least 7m. thick in parts, though its maximum thickness remains unknown. It is basically a fine red silt but it does contain many angular blocks of red chert. Some of these are up to 3m. in diameter and have clearly arrived at their present locations by solutional removal of considerable thickness of limestone. Most of the chert must have originated from the Radiolarites which were in the order of 100m. or more above the present surface and the bulk of the terra rosa must have come from the same source — the intervening limestones being very pure, and there can never have been any significant catchment area producing allogenic detritus. The valleys in this sediment are fossil features. Grain storage bins cut by the Kurds in one of the thalwegs suggest that they do not even carry water during the spring melt season. The two main systems of very shallow valleys converge on Ghar Parau (see below) and the exit gap at the western end of the plateau.

Fossil karren are well developed on many of the bare limestone exposures on the plateau; they show no special pattern of distribution. Nearly all are heavily shattered except where terra rosa removal has revealed preserved solutional forms; this has happened only on sporadic outcrops and the maximum thickness of sediment removal has been less than a metre.

There is a conspicuous absence of cliff-foot notches, short horizontal caves or any other evidence of vorfluter solution. Furthermore, the surface of the terra rosa is by no means horizontal even when ignoring the relatively small incised valley; most of the surface is clearly sloping with a total relief in the order of 10 metres. Both of these two features provide evidence against any theory that the South Plateau closed depression is a true polje. Horizontal planation of the limestone is perhaps the most critical feature of a polje and there is no evidence for this on the South Plateau. Similarly, the various other large depressions that have been observed on the Kermanshah limestone mountains are better described as dolines, or uvalas maybe, but not poljes.

The special feature of the South Plateau is the large number of shafts and caves, and remnants of the same, which it contains (see fig. 10). One of these, at the apex of the centripetal valley system on the eastern half of the plateau is Ghar Parau (see below). But perhaps the two most conspicuous entrances are on the bluff which projects into the northern side of the plateau. The westerly of the pair consists of a 7 metre diameter tunnel descending steadily to a depth of about 20 metres where it is choked with boulders and mud — there is no modern stream to keep the entrance open. The elevation of this entrance, over 30m. above the plateau floor, indicates its antiquity, and its size indicates how important it must have once been. A few metres to the east is another similarly choked sinkhole where fine sediment fills most of the spaces between large limestone blocks so that digging a way into the cave would be most difficult.

Fig.10


KUH - E - PARAU
SOUTH PLATEAU
Dry streambed
Main karren field
Cave passage
Prominent sinkhole
Donkey track
Terra rossa
Limestone
Chert breccia
Fault
Dip
Form lines only are shown on sections
Scales
Plan
Sections
0
300 m.
N
Ghar Parau
Ghar Barfkhan
Ghar Acker
A
B
C

Almost certainly these two sinkholes connect at depth. At the western end of the plateau lie two other open and explored potholes. Ghar Acker consists of a great rift passage running eastwards but descending steeply to a sediment choke at a depth of around 100 metres. Just to the east, Ghar Barfkhan is a steeply descending vadose canyon trending in the same direction. It is very narrow except for the shafts and has been explored to a depth of about 80m. from where it continues but is too tight. It would be surprising if the continuations of these potholes do not lead into the lower reaches of Ghar Parau (see fig. 10). A number of shafts occur at the eastern end of the plateau. They range up to about 30 metres in depth and are all choked by blockfall and inwashed sediment or snow. None has any significant modern catchment area, some are even left truncated on steep slopes and ridges. Like nearly all the other karst on the plateau, they are fossil features.

Ghar Parau

The influent cave system of Ghar Parau has been explored over a length of 1350m. to a depth of 750m., where a sump bars further progress (see fold-out survey, in paper by D.M. Judson in this volume). It consists almost entirely of a single passage carrying a very small stream; there are remarkably few significant inlets or side passages.

The entrance is at the bottom of a 20m. high cliff on one side of a collapse depression, and the first hundred metres of passage are large, but made complex by very extensive breakdown. Solutional roof features are subordinate to clean broken fracture surfaces. This zone of breakdown is by far the most extensive in the known cave and appears to be due to both thermal rock shattering emphasised by the surface temperature variations and also perhaps unloading fractures opening in the structurally complex limestone. At a depth of about 50m. the passage changes from a large collapsed form to a high narrow rift and at the Muddy Crawl the solid rock roof is within 30 cm. of the floor. This however is due to a considerable accumulation of sediment, unknown in depth, along this length of passage. At the end of the crawl, the roof rises and the mud floor drops gently away.

Nearly all the cave passage enlargement in Ghar Parau has been vadose. The only parts where the roof is visible are in the entrance series, and some of these reveal irregular and discontinuous phreatic tubes, nowhere more than 50 cm. in diameter. Some of the tubes are on the sections of cave roof with reverse gradients, such as from the Muddy Crawl up into Damavand Avenue. However these phreatic forms are very minor; they merely represent the very early stages of development before an efficient integrated drainage route had matured in the limestone. As they are so limited, the cave is best regarded as an entirely vadose system, at least as far as Ferdowsi Avenue (see below).

Damavand Avenue is a very large section of passage, modified by a short inlet on the north and extensive breakdown, and partly filled by large deposits of both clastic sediments and calcite. At its downstream end the passage narrows to a canyon which also contains thick clastic sediments themselves incised by a smaller, dry, stream trench. The Corkscrew is merely a constriction formed by banks of flowstone.

Just beyond the Corkscrew, the passage floor drops 5 metres into an even narrower trench. This is the upstream limit, the nick point, of a vadose canyon incised in the floor of the larger, older, cave passage which leads in from the entrance. From here to Ferdowsi Avenue the cave passage is nearly all of the one morphological type – a narrow vadose slot cut in the floor of a larger tunnel. Successive layers of stalagmites and clastic sediments, mostly re-eroded, add to the complexity of the geomorphological detail. The larger, high-level, sections of the passage are accessible in a few places, such as Masjid Hall, but the roof is rarely visible. Some idea of the passage shape can be gained from the tops of the big shafts, where near-vertical walls recede into the gloom. There is, however, no evidence that the upper section of the passage is a phreatic tube – it appears to be just a much larger vadose canyon, descending uniformly and steeply.

The chamber at the top of the Eroica pitch contains a massive stalagmite boss, Cyrus the Great, and a thick layer of sediments which mask any incised floor slot. However, the Eroica pitch is typical of so many in the pothole, being a clean-washed, slightly bell-shaped shaft with finely fluted walls. It is nearly 10m. in diameter; nearly all the following shafts are substantially wider than the interconnecting passages. Immediately beyond it the stream runs into a very narrow tightly meandering canyon and the caver is forced to traverse along the foot of the larger high levels, here no more than 5m. above the stream. But the traverse is only short, and beyond it is, nearly everywhere, only possible to pass along the narrow floor slot, which in parts is no more than 25cm. wide.

Masjid Hall is just a larger part of the upper passage which is unusually well decorated with stalactites, very massive stalagmites and banks of flowstone. But immediately beyond, the streamway – Quality Street – is much lower than elsewhere; it is also wider than normal, well decorated with stalactites and contains a large amount of fill relicts on the walls. It appears that the young, narrow stream slot, almost continuous from the Corkscrew to Ferdowsi Avenue, only developed in the sediment fill in Quality Street; it eventually removed nearly all this fill but barely cut into the limestone floor at all.

From the sixth to eleventh pitches the passage is a classic descending vadose canyon with an entirely stepped profile. The six largest steps are the pitches, but in between them the passage is a whole series of water filled potholes connected by drops of one to two metres. The potholes are rarely more than a metre deep and contain considerable quantities of clastic sediment.

Sump 1 is a youthful feature where the main part of the passage continues round to bypass it. Following a whim of the geological structure, the water abandoned its main canyon to follow a short phreatic loop, and ever since has been progressively draining the phreatic section by cutting the narrow vadose slot which is now visible on the downstream side in the floor of the Twelfth Pitch Chamber. In contrast, the Second Sump and its bypass are both in the same passage. The open part of the vadose trench is no more than 5cm. wide, partly at least due to heavy stalagmite wall deposits, while the water runs through an impassably small section at the base of the trench. The caver has to resort to the Slid Traverse – an extremely muddy series of ledges in the upper part of the canyon. Where the ledges give way, the fifteenth pitch drops back to the stream level where the trench is wide enough for sideways walking.

The Shahanshah is a large and spectacular vadose shaft with windows connecting it to a parallel shaft. Below it the passage reverts to a continuous series of muddy potholes and cascades in a narrow meandering canyon. Below the Yek Do Se pitch the gradient levels out, and heavier deposits of stalactite almost block the passage in a number of places.

Ferdowsi Avenue, however, is completely different. The passage is much wider and the floor is clastic sediment of unknown thickness, deposited here due to ponding behind the Third Sump. The modern stream has cut a small trench into the sediment. At the sump, the roof comes down at a sharp angle and continues so below the water. The roof profile is slightly rounded and shows evidence of phreatic origins, but this feature appears to extend only a very short way back up the cave.

It is extremely difficult to determine any pattern or geological control in the passages of Ghar Parau; this is both because the root is nearly always out of sight, and also because the limestone is so massive and nearly structureless. A number of faults are clearly visible in the breakdown chambers of the entrance series, and have guided the cave, in general terms, down their dip at least as far as the Muddy Crawl. However, it is notable that the best exposed fault, on the Greasy Slab, has not been picked out by solution; instead the initial solutional opening was underneath and the fault has only guided the pattern of collapse. Lower down, in the main part of the cave, the passages and shafts rarely appear to be guided by the bedding or the fractures in the limestone. The survey suggests that Quality Street has some element of joint control, and the eighth pitch may have originated on a gently hading joint. Elsewhere the passage walls are merely etched along myriads of small irregular fractures, just as on the surface above.

Correlation, admittedly rather tenuous, with the surface geology suggests that the lower part of the cave is heading into the trough of a closed syncline. Should the water drain to Bernaj, which seems most likely on the hydrological evidence, it must cross the main Kuh-e-Parau anticline before going down-dip nearly all the rest of the way to the resurgence – where the water emerges up-dip from flooded passages. (Even if the water goes to Taq-e-Bustan or Bisetun the cave would follow a similar pattern). It is probable therefore, that beyond Ferdowsi Avenue the cave forms a mainly phreatic switchback section, by progressively running up-dip and back down joints (see figure 4 in paper by D. M. Judson in this volume). This probably continues for about a kilometre before the passage crosses the anticlinal axis and reverts to a descending down-dip vadose canyon to roughly the resurgence level, another 1000m. below. A small amount of incision in the crests of the cave passage loops has resulted in a slight lowering of the level of this perched phreas – so revealing the sump sediments and short phreatic tube in Ferdowsi Avenue.

Geomorphic History of Ghar Parau

Layers of partly re-eroded sediments, active and dead stalactites and the various floor slots combine to give evidence of a long and complex geomorphic history for Ghar Parau. The following may be regarded as an outline chonology which embraces most of the features in the cave, but which does not attempt to explain all the details. Ghar Parau's history appears divisible into seven stages.

Stage 1 was an erosive period when the large high level sections of the passage were opened over the entire length of the known system. Even at this early stage almost all the known cave was in the vadose zone.

Stage 2 saw the deposition of large amounts of stalactites and clastic sediments in the pre-formed tunnel. These are now best seen in such places as Masjid Hall and Damavand Avenue.

Stage 3 was marked by a return to erosive conditions but with a much reduced stream which only cut the narrow vadose floor slot and opened up the shafts down most of the cave. The trenches below Masjid Hall and the Slid Traverse are typical.

Stage 4 was again depositional where banks of clastic sediment at least partly filled in the stage 3 trench. Fragments of fill adhering to the walls of the fourth pitch must date from this stage. Similarly the sediments just upstream of the Corkscrew are probably of this stage and they show a distinct layering with an upward decrease in fragment size from boulders to fine silt, indicating more complex geomorphic detail. Of similar age is some calcite deposition in the floor trench, notable that forming the constriction of sump 2.

Stage 5 saw the removal of much of the stage 4 fill – resulting for example in the wall fragments left at the fourth pitch and also the trench cut into the sediments upstream of the Corkscrew. This appears to have been the last significant erosive phase.

Stage 6 was only marked by a further considerable reduction in stream power so that the potholes in the canyon, cut during stages 3 and 5, became at least partly filled with sediment.

Stage 7 is the modern phase, characterised by a minute stream with virtually no erosive power – there is a marked lack of incised slots at the tops of the pitches, which would have been formed by an erosive underfit stream. A certain amount of active stalactite growth must belong to this stage, as does a very small degree of young fluting on the shafts. Perhaps most important is the mud on the walls. Ghar Parau is characterised by a thin coating of wet mud on nearly all the passage walls – reaching down to within a few centimetres of the stream level. It is mainly the result of small quantities of seepage water carrying stage 2 mud down from the ledges and wall remnants in the high level stage 1 passage. Consequently though some of this mud-flow does still take place it may also date back as far as stage 3 in some parts of the cave.

The above rather tentative sequence does lend itself to a degree of correlation with the surface features of the karst. Stage 1 must relate to the main erosion of the South Plateau depression, and most of the other dolines on the Kuh-e-Parau block. This doline field landscape and the large stream cave clearly formed under a much wetter climate than the present one. The accumulation of the clastic fill on the plateau, and the stagnation of the doline development, would then relate to stages 2 and/or 4. Incision of the surface valley system correlates with one of the underground erosive stages 3 or 5; the continued existence even of only a shrunken stream during phase 6, due to the existence of this valley system, helped to ensure that the Ghar Parau entrance remained open and was not blocked, like the majority of the other caves and potholes. The almost complete inactivity of the modern surface karst matches closely the underground conditions of stage 7.

Present Karst Processes

The low absolute levels of hardness in the karst waters of Kuh-e-Parau, compared to for example similar water in Britain, indicate the restricted rates of modern limestone solution. The very presence of the large springs and their rapid response to the snow melt show that there is a degree of integration of groundwater routes, probably mainly in old cave systems. However, the almost complete inactivty of the known cave passages in Ghar Parau show how this hydrological network is underused. Furthermore, the perennial flow of many of the springs, which makes them so valuable to the local communities, suggests the presence also of a considerable storage capacity to the aquifer; much of this may be in the form of slow-moving percolation water, but the continuation of the limestone below local base-level may also permit the existence of a complex, large capacity, phreas.

Clearly nearly all the karst features – the mature karren forms, the large closed depressions and the known cave system – are fossil. In the deeper parts of the cave morphological development is almost static, but the surface karst forms are being steadily destroyed in the modern environment. The depressions and potholes are being filled by mechanically weathered debris and the karren forms are being broken up. The only modern surface solution is taking place under the annual snow cover where the fractures on the karren are being etched out to give complex fretted surfaces.

The fossil landforms must date from a period with a much wetter climate than the present day, when a reasonable soil and vegetation cover would have developed. At present it is difficult to date this ancient climatic variation. However it is very tempting to suggest a correlation with a pluvial phase during the late Pliocene or early Pleistocene, for which exists a number of such isolated pieces of evidence from localities scattered throughout Southeast Asia.

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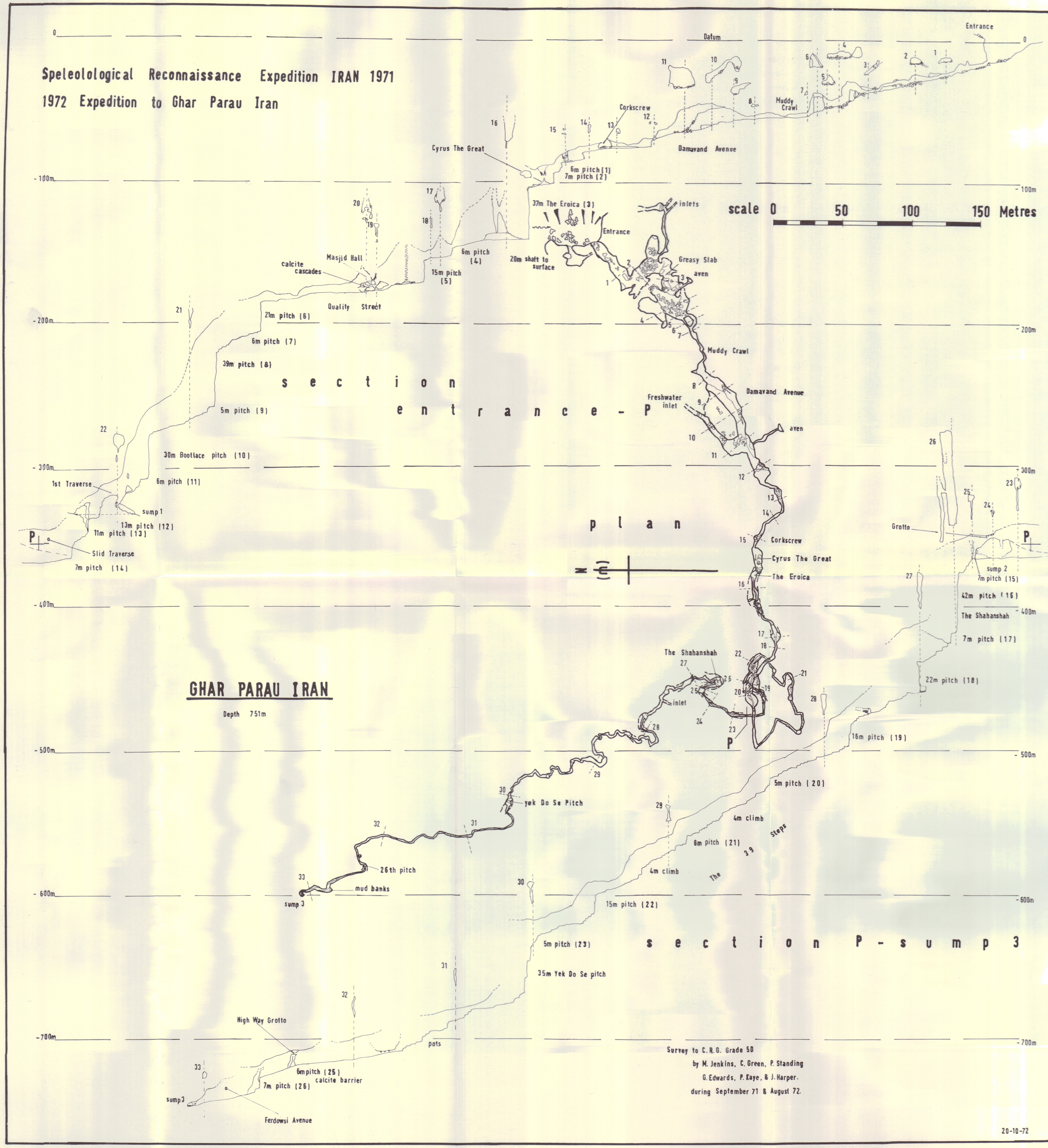

Speleolological Reconnaissance Expedition IRAN 1971
1972 Expedition to Ghar Parau Iran
GHAR PARAU IRAN
Depth 751m
section entrance-P
plan
section P-sump 3
scale 0 50 100 150 Metres
Datum
Entrance
Muddy Crawl
Damavand Avenue
Corkscrew
Cyrus The Great
6m pitch (1)
7m pitch (2)
37m The Eroica (3)
inlets
Greasy Slab
aven
20m shaft to surface
6m pitch (4)
15m pitch (5)
Masjid Hall
calcite cascades
Quality Street
21m pitch (6)
6m pitch (7)
39m pitch (8)
5m pitch (9)
Freshwater inlet
30m Bootlace pitch (10)
6m pitch (11)
1st Traverse
sump 1
13m pitch (12)
11m pitch (13)
Slid Traverse
7m pitch (14)
The Eroica
Grotto
sump 2
7m pitch (15)
42m pitch (16)
The Shahanshah
7m pitch (17)
22m pitch (18)
16m pitch (19)
5m pitch (20)
4m climb
6m pitch (21)
The 39 Steps
4m climb
15m pitch (22)
5m pitch (23)
35m Yek Do Se pitch
yek Do Se Pitch
26th pitch
mud banks
sump 3
High Way Grotto
pots
6m pitch (25)
calcite barrier
7m pitch (26)
Ferdowsi Avenue
sump3
0
-100m
-200m
-300m
-400m
-500m
-600m
-700m
Survey to C.R.G. Grade 5D
by M. Jenkins, C. Green, P. Standing
G. Edwards, P. Kaye, & J. Harper.
during September 71 & August 72.
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