SECTION II

Geology, Geomorphology and Caving.

Geology.

The geology of the area is simple in principle, but somewhat complex in effect. Basically only three lithological units are present.

1/. An Impermiable Limestone of Cretacious age, which underlies the area. This may well be the grey limestone which weathers yellow and was mistaken by some for sandstone, when in its weathered state. This was only seen on the 'High Level Route' near the Breche de Roland. To the South it is not exposed again before theOrdessa Valley (i.e. in the area specially examined by the expedition), but it must influence cave development, as at Aven du Marbore and Aven des Cigalois (See Dubois and Dainat).

2/. A grey Massive Limestone(a) of Lower Eocene Age. This rock is very similar to the typical Carboniferous Limestone of Great Britain, except that it contains no coarse fossils (crinoids etc.,). This is said to be 150m thick, and is the chief cave development strata of the area. Typically exposed as clean solution furrowed bare rock. It will support precipitous slopes.

3/. A Brown Thinly Bedded Foraminiferal Limestone,(a) containing abundant Nummulites (and Fusilinids?). Probably also Lower Eocene. This overlies the Massive Limestone strata. Beds are seldom greater than 6" thick, and frequently much less. Characteristically slopes on this rock are covered with flat fragments forming scree, looking from a distancelike slate or shale tips.

The regional strike is East-West, and frequently views from the South give the impression of low dips - this is an erroneous impression, except very near the Ordessa Valley, where the actual cliffs are near horizontal beds. North of the Ordessa Valley folding becomes more intense, till at the 'border divide' (i.e. the higher parts of Taillon, Casque, Marbore etc.), overfolding and/or thrusting of all beds can be seen - see sketch section.

(a) - Hereafter used with capital letters when these two specific beds are meant i.e. Massive Limestone and Thinly Bedded Limestone.

The Massive Limestone folds competantly, in relatively simple folds. The thinly bedded limestone folds incompetantly in complex tight folds and overfolds. This contrast is well seen in slide with the simple folds to the South. Again slide shows the competant and incompetant folding in close contact. The tightly folded, Thinly Bedded Limestone is relatively easily eroded. The llanos are flat broad valleys at right angles to the general N-S drainage direction. These are formed where a deep downfold (possibly accompanied by thrusting) has produced an East-West band of easy denudation, and an East-West series of valleys parallel to the strike have developed. South of the llanos all above height approx 2,500 to 2,600m is in the Thinly Bedded Limestone, typically mountains that are steep and scree covered, but not precipitous. The South face of Pointa Blanca (as traversed on the 'High Level Route') has a part cover of Thinly Bedded Limestone in near vertical beds. This is a semi-precipitous slope, and makes treacherous climbing. North of this are clean, Massive Limestone slopes until the (?Cretaceous) 'yellow weathering' limestone is encountered.

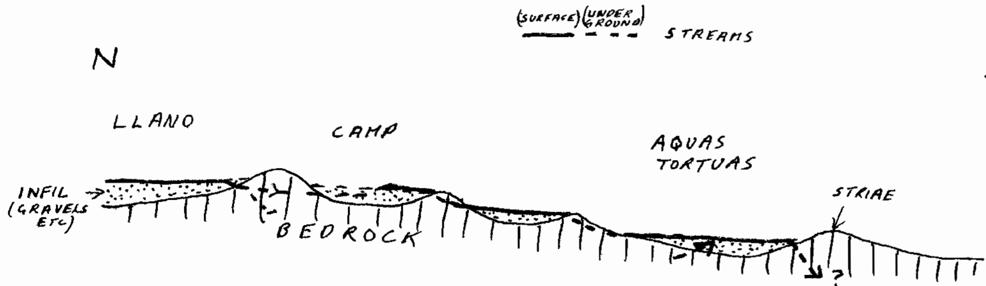
The upfold South of the llanos, and forming the southerly, smaller counterpart of the 'llanos syncline' is of importance from the point of view of caves. The N - S drainage cuts relatively narrow valleys across it, and the expression of the anticline is seen in the valley side rock outcrops marked on Schraders Map. (Either side of 'Aquas Tortuas' in the Salerons Valley and 'Sumidero' in the Cotatiaro valley. Both give an impression of an anticline much larger than it appears on the ground).

Geomorphology.

Geomorpholgically, the area displays the work of 4 agencies. Glacial Erosion (almost certainly modifying a pre-existing surface stream pattern) has carved the striking Cirque du Gavarnie, and the less well formed cirques South of the Breche de Roland, and immediately West of Pta Blanca. The classic 'U' shape of the Salerons Valley (see slide) and its step and rock basin form are also obvious glacial features. The Breche de Roland is really a very short arête (in the strict sense), formed by the impingement of the 'Refuge Cirque' (a 'sub-cirque' of the Cirque du Gavarnie) on a cirque to the South of the Breche. The lesser glacial development of the South Faces of the Pyrenees, relative to the Vorth faces is obviously a function of aspect (i.e. differential solar radiation effects). Surface solution has destroyed all glacial striae except on the 'lips' of the Cotatuero llano and Aquas Tortuas (The latter case indicates that very quickly after the glacier retreated Aquas Tortuas was drained by an underground route - see idealised section below). There are many permanent snowfields in the area - see various slides.

Stream Action is most strikingly represented in relatively low angle, coarse debris fans, which largely infil the basins of the two llanos, and the Sumideroof the Cotatuero Valley. The infilling of the basins of the Salerons Valley is probably similar, with no larger admixture of rock fall material. However in no case is a basin completely filled, andthe rock lips form ridges across the valleys. The water escapes from the basins by underground courses, in many cases only to re-appear down valley of the rock lip or step. (See also the comments on Grotte Casteret in Sub aerial denudation).

FIG 1 PAGE 8.



IDEALISED SECTION THROUGH THE SALERONS VALLEY

Frost and Solution modify the landscape, acting together they produce impressive screes, especially on the Thinly Bedded Limestone. Deep solution runnels can be seen on otherwise unmodified glacially rounded surfaces. Slide shows how striping of an anticline, bed by bed, is being accompanied by the potent combined action of solution and frost. No patterned ground was seen, but it is reported by Troll (1941) at height 8,000 feet plus, in this area. Work on water sample analysis is recorded in the appendix to this section (originally written as appendix to the Solution paper for Proc. Vol. 10(1)).

Caves of the Area.

1/. Valley Sides of the Salerons Valley.

There are numbers of rock shelters a short way up on the sides of the Salerons Valley, typically at the break of slope, at the foot of rock faces. These may well be features developed at the top of permanent snowfields as shown in the diagram below (see next page), (S - Probable position of permanent snowfield, with typical 'crack' at the head, allowing and encouraging solution and frost action).

Fig. 9.

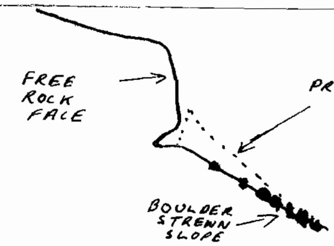


Fig ii Semi Permanent Snowfield, with typical crack at head, allowing & encourageing solution and frost action at this point.

(An interesting line of thought is to compare these and rock shelters in the combes and gorges of Mendip, which have also suffered a 'periglacial' climate in the past.).

Some rift like caves up to 20 feet long are also present in the valley sides, these are thought to be formed by recent stream action. There is frequently a rising at the foot of the cliff corresponding to these (see diagram in appendix). The rock shelters mentioned above might have been originally similar, later modified as suggested.

2/. Sinks and other Holes in the Floors of the Llanos and the Salerons Valley.

There are many sinks in the floor of the Salerons Llano. None of these have much accessible cave passage. The longest on is only 75 to 100 feet. None of these are, in any case, likely to give access to much cave passage as some of the water flows to the Salerons Valley, as shown above, and any deeper passages are probably water filled. Dye testing may be useful.

There is only one sink in the Cotatuero Llano. This is only about 30 feet from the lip, having a pothole about 15ft., deep, and the water at the bottom flows into an impassable bedding plane following the dip, i.e. flowing North, back under the Llano. The llano has also a surface water outlet, through a small, narrow gorge through the lip, which naturally flows into the Sumidero, where it sinks into the coarse gravel valley floor. Where the water of the sink in the llano flows to is indefinate. French literature refers to water of this general area flowing North to France, but this probably applies more to greater heights than the llano.

In the Salerons Valley, each 'step and flat' has a minor rising and a sink, as shown in the **diagram** above. None of these are large enough to enter (<u>if</u> one wanted to). The sink in Aquas Tortuas is larger, but becomes impassable after only 20 - 30 feet of sharp rock maze.

On the lip below Aguas Tortuas, somewhat to the right of the valley floor, and some 100 feet up valley from the highest point of the lip, is a pothole shown in slides . This has an 80 ft., daylight entrance pitch, followed immediately by a further 65 ft., pitch into a rift chamber some 15 ft., by 25 ft., and about 60 ft., high, tapering upwards. The bottom is boulder covered, and offers no promise.

3/. <u>'Lapiaz' of the the Collado de Salerons</u>.

This ridge is situated on the crest of an anticline as shown in the sketch section of the area. The Thinly Bedded Limestone has been almost completely stripped off the crest, and on the South Slope, where the 'Lapiaz' is developed in steps, there is no trace of it. The 'Lapiaz' is really a large scale 'clint and grike' or 'limestone pavement' feature. The 'clints' or cracks are up to 80 or 100 ft., deep, and spaced about 20 to 50 ft. apart. The form is not the fantastic chaos of potholes that is more normally called lapiaz, though there is little doubt that further development would result in a 'true' lapiaz. (lapiaz, like arete, is a marginally scientific word anyway).

The anticline on which the 'Lapiaz' is developed is not in fact as simple, at this point, as it is shown on the sketch map. It has at least two crests, and possibly there is some faulting/thrusting ~~antiklinorium~~. The 'Lapiaz' area in fact occurs as a series of platforms down to the Cotatuero Valley. The main exploration was carried out on the highest platform which is by far the most extensive. It is about 50m below the crest. About a dozen or so 80 to 100 feet pitches were descended, each pothole ('clint') was blocked by boulders at the bottom. (N.B. No evidence of 'foreign' boulders* was noted).

However, one that was 89 ft., deep, when a few boulders were moved at the bottom, gave access to a cave. This is steeply descending, some 405 ft., deep and 550 ft., long. Most of the passage is 10 to 15 ft., high and 3-4 ft., wide. A small flow of water is encountered not far from the foot of the first pitch, and gradually increases down the cave, but never becomes more than a 'small stream' (say 5 to 10 'full tap' volumes). There are 5 more pitches, almost all of which involve getting wet. The rock, after the first pitch, is apparently very steeply bedded, apparently thinly bedded, and slippery. The 'thin bedding' may be due to high angle, closely spaced joints, as suggested by some nearby surface exposures. However it is possible that this is <u>the</u> Thinly Bedded Limestone. This is possible if the thrust plane(s) suspected in the crest of the upfold, have caused a mass of Thinly Bedded Limestone to be included. Accurate geological mapping is the only way to solve this problem, coupled with underground rock examination. The end of the cave is in a deep sump, above which is a narrow crack through which a strong draught blows. This draught is felt throughout the cave, except near the entrance pitch. (It always blows towards the entrance). This was very cold draught and caused varying discomfort to the explorers. Certainly for surveyors gloves would be useful (seealso Section III).

Ladder needed for pitches :-

Entrance 90ft.	4th. Pitch. 36ft.
2nd. Pitch33ft.	5th. Pitch. 35ft.(for 10ft. followed by 18ft.)
3rd.Pitch 15ft.	6th. Pitch. 110ft.(for 85ft. followed by 15ft.).

Fairly long wire tethers are needed for most pitches. A cairn was built at the head of the 'Pot de Collado de Salerons' as this pothole was named.

Some 50m North-West of this, at the foot of a small face, a hole lead to a small chamber, and a 200 ft., plus Pitch. (See slide). Some 180 ft., of ladder was lowered, and a climber went down some 80 ft., when it was seen that the ladder being used was still some 20 to 40 ft., off the bottom of the shaft. A planned later exploration was foiled by rain (and 'altitude enervation'?). This pot is well worth further investigation. Its bottom must be some 50 to 75 ft., below the bottom of the entrance pitch of the Pot de Collado de Salerons. The shaft is similar to the Poll Omega pitches, but more nearly cylindrical, there is a broad ledge about 20 ft., down, and after this the pitch is about 12 ft., diameter, deeply fluted, a nd apparently merging with another similar shaft some 60 -70 ft., down. The pitch is 'free' after the 1st. 35 - 40 ft.

There are still some tens of holes to be explored in 'The Lapiaz'. Some of these will most likely yield more stretches of similar pothole to the Pot de Collado de Salerons. Possibly access to a 'master' system may be gained, or possibly they all sump. (Is the 'sump' at about the same level of the Cotatuero Llano?). Study of the geological structure should help. Possibly the available literature may yield some clues.

4/. The Cotatuero Valley.

This valley is not as well defined as the Salerons Valley, and is not so obviously glaciated. The area considered here is bounded by the cliffs of the Ordessa Valley, the Collado de Salerons and the Sumidero. This area was apparently investigated by Gordon Warwick . This area is one of fairly bare Massive Limestone, with some patches of infil. The sinks that take active, apparently permanent, streams are poorly defined, being in infil areas. The area is dotted with depresions, (See slide) in a more irregular manner than the Salerons 'Lapiaz'. Some holes were seen that are more pothole like, up to 30 ft., deep, but all are impassable. Extensive exploration may well yield some cave, probably similar to that in 'The Lapiaz'. A 'master system' here might be more promising than one in 'The Lapiaz'. However, the holes examined suggested the area is nowhere near as likely to yield explorable cave as the 'The Lapiaz'.

5/. Grotte Casteret.

A number of visits were made to this cave, but aside from admiration of the ice formations this cave did not match up to the picture conjured by N. Casterets' account. The entrance is high up the valley side (as seen in slide) and the end is under a lapiaz field, with which it commicates by many shafts. No signs of recent erosion were seen in the cave. Dubois and Dainat comment that risings in the area are generally well above the floors of the valleys, as a result of 'subaerial erosion being faster than subterranean erosion'. The linkage to a lapiaz field may explain its origin even under present landscape conditions, however this is not easy to envisage. At present the ice formations seem to be dominantly melting.

The cave is now visited by many of the fitter tourists, and it is not unusual to meet several parties of up to 20 people at or near the cave.

Appendix to Smith and Nicholson Proc Vol 10 No 2.

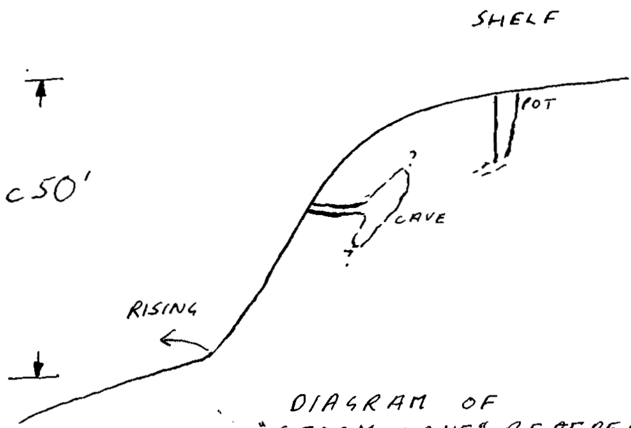


DIAGRAM OF "STORM CAVE" REREREO TO IN SOLUTION PAPER APPENDIX.

APPENDIX

In August, 1963, a reconnaissance expedition organized by this Society visited the Central Pyrenees. The base camp was situated some 8 km. to the west of Mte. Perdido (Mont Perdu) at a height of 2,450 m. in the valley of the Salerons which drains south to the Ordessa Valley. The immediate area of the camp was composed entirely of limestone; however, the streams in the valleys only flowed underground intermittently. There were a number of semipermanent snowfields in the vicinity of the camp, many of these fed small streams. Glacially eroded landforms, slightly modified by recent frost action, were abundant. Vegetation was absent over much of the area and was only continuous on the most favourable sites, of which those in the valleys were the most conspicuous. The overall impression was of a landscape in which solutional karstic forms were fast evolving, although at present the area could reasonably be said to exhibit the early youthful phase of the karstic cycle. In this respect the limestone features could be contrasted to the Grotte Casteret and its associated more fully developed karstic features which occurred some 3 km. to the east and at a height approximately 300 m. greater than the base camp elevation. These features are not thought to be genetically related to the present landscape.

Analysis of water samples for their calcium content was undertaken in the field using comparable methods to those described earlier. The precipitation in the summer of 1963 for this area was abnormally high and the cloud cover correspondingly above average. However, the run-off was rapid and, except during periods of heavy rain, the dominant water supply was from snow melt. Water issuing from snow banks showed a negligible calcium content and *p*H's of 5·0–5·5 were recorded.*

Analyses of surface streams showed values of 40–55 p.p.m. $CaCO_3$. These streams were composed dominantly of snow-melt water from the snow banks. Their length was rarely in excess of half a kilometre. They were normally sampled at small stream sinks.

In the Salerons valley there were a number of small risings fed by streams whose underground course was of limited length. The calcium values of these risings varied between 45 and 70 p.p.m. $CaCO_3$; the majority of values were between 60 and 65 p.p.m. $CaCO_3$. One rising (used as the water supply for the camp) was observed to fluctuate in volume daily, the maximum discharge at sunset (approximately 20.00 hr.) was at least five times greater than the minimum discharge at sunrise. The calcium content was also found to fluctuate:

August 10th	10.00 hr.	90 p.p.m. $CaCO_3$
	13.00	85
	15.45	47
	19.00	50

The water temperatures can be taken as constant throughout the day.

The fluctuations in flow were clearly related to diurnal variations in snow melt. The corresponding changes in calcium content may be due to variations in velocity of stream flow giving differing time for solution to take place, or due to the varying proportions of "percolation" water from the flat comparatively well-vegetated area up valley in relation to the water originating as snow melt.

Additional samples were obtained during an intensive rain storm when a completely dry rift-like cave became extremely wet. The catchment area was small and the vertical distance to the surface did not exceed 7 m. The water reappeared at a small permanent rising some 10 m. below the cave.

1. Strong flow from cave roof, 5 minutes after rain began—23 p.p.m. $CaCO_3$.
1. Flow slackening, 15 minutes after rain began—43 p.p.m. $CaCO_3$.
2. Permanent cliff foot rising before rain—60 p.p.m. $CaCO_3$.
3. Permanent cliff foot rising 20 minutes after rain—50 p.p.m. $CaCO_3$.

Measurements in temporary pools on open bare limestone collected on two separate occasions gave the following readings:

1. Immediately rain stopped—15 p.p.m. $CaCO_3$.
   Half an hour after rain stopped—19 p.p.m. $CaCO_3$.
2. Half an hour after rain stopped—12·5 p.p.m. $CaCO_3$.
   One hour after rain stopped—15 p.p.m. $CaCO_3$.

It is suggested that the above results are indicative of rapid limestone solution. Additionally the relatively low calcium content of the water of this limestone area is thought to be related to the low soil carbon dioxide values which are in turn due to the sparse development of vegetation.

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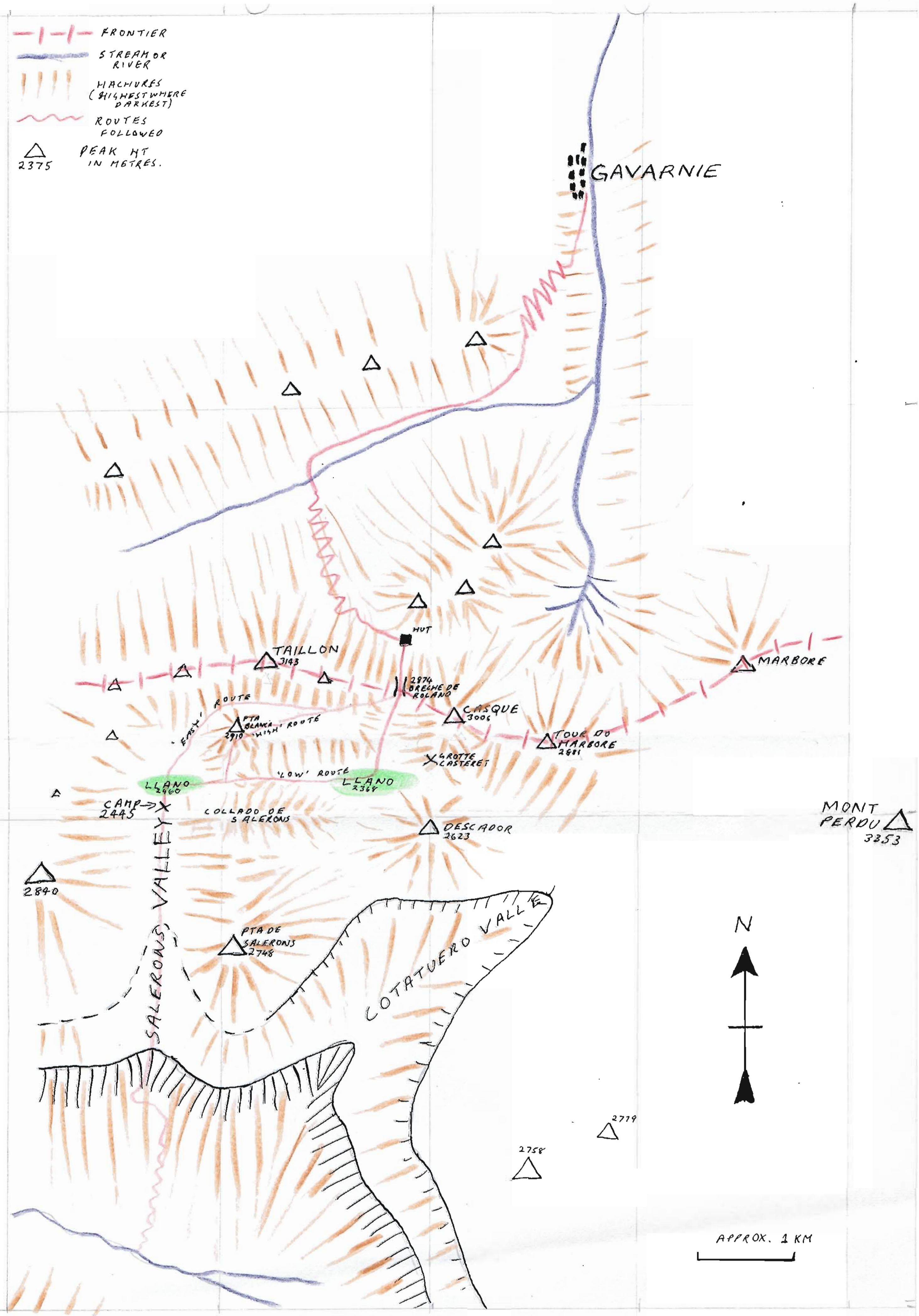
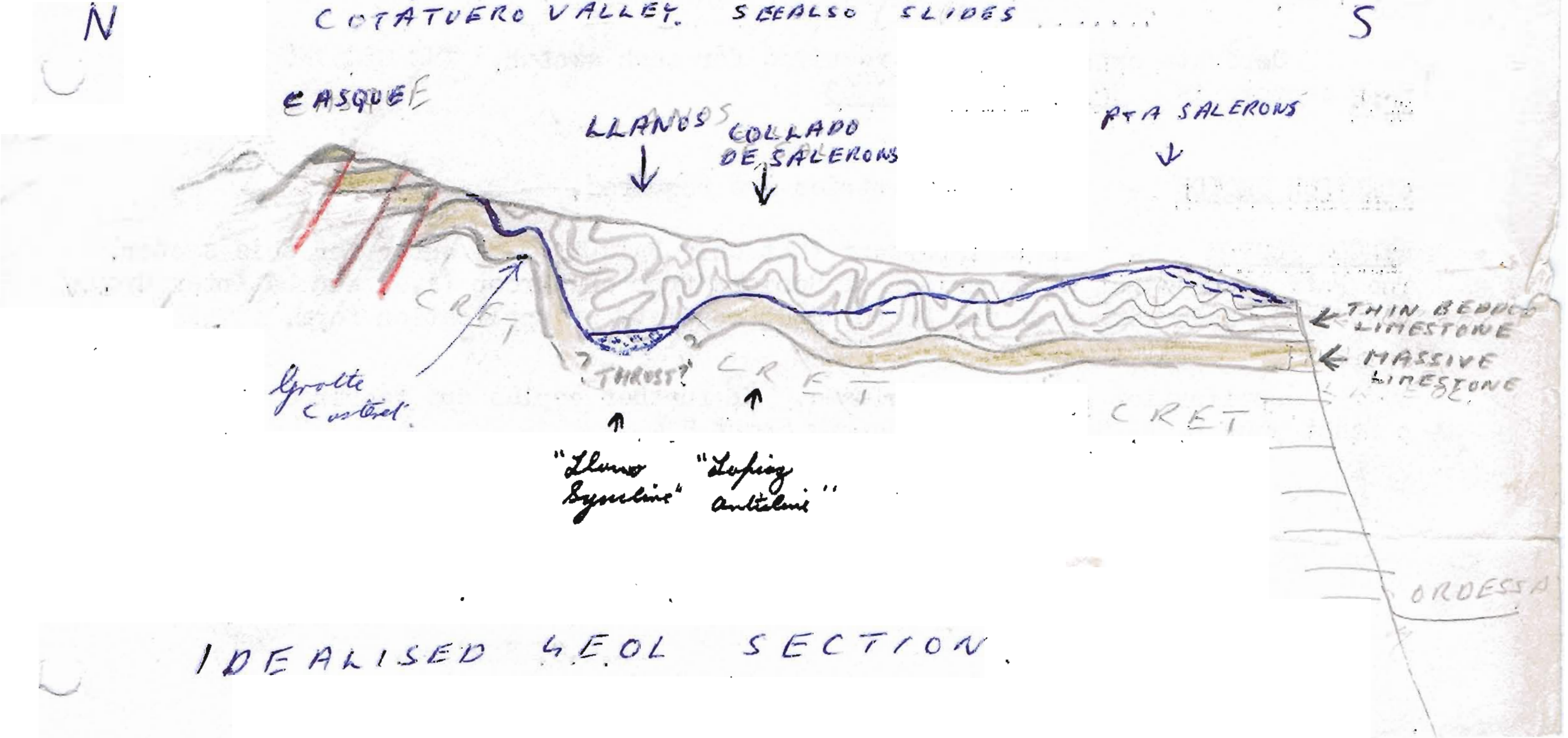
* The *p*H values were obtained by the use of *p*H papers and can therefore be regarded as only a rough indication of the true values.



SKETCH MAP OF U.B.S.S. EXPEDITION 1963

COPY OF BASE FROM SHRADER

SECTION FROM FRENCH FRONTIER TO ORDESSA VALLEY, ALONG LINE CASQUE, PARALLEL JUST E OF COTATUERO VALLEY. SEE ALSO SLIDES ......



IDEALISED GEOL SECTION.