SHORT COMMUNICATIONS

GEOLOGIE EN MIJNBOUW VOLUME 48 (1), p. 67-72 1969

SUBMARINE CANYON AND FAN DEPOSITS IN THE UPPER CRETACEOUS OF THE SOUTH-CENTRAL PYRENEES, SPAIN

B. VAN HOORN[1])

ABSTRACT

This preliminary study shows the existence of a submarine canyon during Upper Cretaceous time in the South-Central Pyrenees.

Deposits filling up this canyon are mainly an alternation of thick limestone breccias and calcareous quartz sandstone layers in the western part of the area, grading into an alternation of limestone breccias, turbidites and blue marls in the east.

A western location of the source area of breccia components is demonstrated by their stratigraphic record and measured current directions.

After a short transport on a relatively steep slope in a submarine canyon, material was deposited in the canyon mouth building up submarine fans.

INTRODUCTION

Mesozoic sedimentation in the South-Central Pyrenees started with deposits in a continental facies during the Lower Triassic, gradually overlain by shallow marine sediments in the Middle and Upper Triassic, Jurassic and Lower Cretaceous (M i s c h, 1934). Marine sedimentation took place in a marginal basin, parallel to the axial zone of the Pyrenees (d e S i t t e r, 1964).

This picture changed during Upper Cretaceous. Slumps, locally thick breccias and mudflows are the lowermost deposits in a sequence consisting mainly of bluish grey marls and sandy limestones which have been interpreted as turbidites (M e y *et al.* 1968). As there is no relation to an orogenic period, we may regard these sediments as a flyschoid formation (d e R a a f, 1968).

Folding of the Mesozoic sediments occurred during the Pyrenean phase in the Tertiary (d e S i t t e r, 1964).

This paper illustrates the first phase of the flyschoid facies by giving a description and interpretation of exposed breccias and related sediments. It is based on a study made in a region along the Esera river, near the village of Campo, province of Huesca, where this particular kind of deposits occurs.

STRATIGRAPHIC RELATIONS AND OCCURRENCE OF THE BRECCIA FORMATION

The breccia formation has been described by M i s c h (1934), and more recently by S o u q u e t (1967), W e n n e k e r s (1968), and M e y *et al.* (1968), as Campo Breccia Formation.

A Santonian age has been determined (M i s c h, 1934; S o u q u e t, 1967).

The boundary with the underlying Aguas Salenz Limestone Formation is rather sharp and sometimes unconformable, the transition into the overlying turbidite formation (Vallcarga Formation) is gradual (M e y *et al.* 1968).

To the northwest of the Esera valley the formation pinches out beneath a thrustplane at the southern flank of the Cotiella structure, to the east it becomes gradually thinner and disappears near the Turbón ridge.

Complete sections occur at many localities, the three most important will be treated here in brief.

In the westernmost part, along the Barranco de

[1]) Geological Institute, Leiden State University, Garenmarkt 1b, Leiden, The Netherlands.

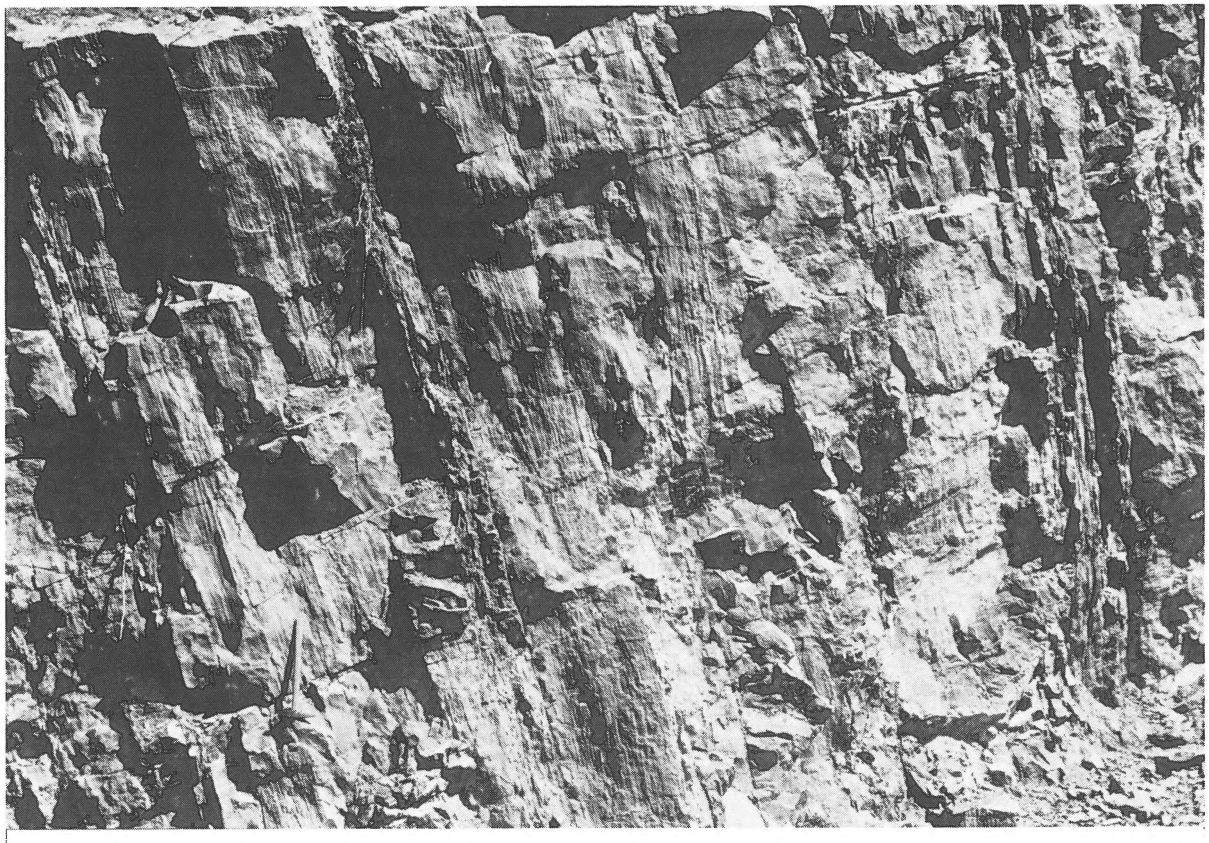


Fig. 1

Massive calcareous sandstone layers inbetween the breccia formation showing parallel lamination. Thickness of sandstone layers is up to 80 cm. Layers are overturned, youngest deposits at left (photo by P.J.C. Nagtegaal).

Yalĭ (near Vĭu), a complete sequence is found unconformably overlying the micritic Aguas Salenz Formation. The total thickness is about 400 m. The Formation consists mainly of well-bedded non-graded limestone breccias, with many scour-and-fills at its base. The thickness of the breccia layers varies between some centimeters and 20 m, the diameter of the fragments of which they are composed between some millimeters and 4 m. The frequency of breccia layers decreases towards the top of the formation, their being replaced by well-bedded, poorly sorted calcareous sandstones containing a relatively high percentage of well-rounded (P e t t i j o h n, 1957) quartz granules. The thickness of the sandstone layers varies between 5 cm and 3 m. A faint parallel lamination is very common (Fig. 1), as are enclosed limestone fragments and mud pebbles. No graded bedding has been encountered, only a few sole marks (mainly groove casts at the base of scour-and-fill structures), as well as assymetric ripple marks at the top of sandstone layers. There is a strong parallelism between current directions indicated by these structures and those determined by groove casts, flutes and channel axes. The features of these layers strongly resemble those which have been described from fluxoturbidites (D z u l y n s k i *et al.* 1959; U n r u g, 1963), sandflows (D z u l y n s k i and W a l t o n, 1965), proximal turbidites (W a l k e r, 1967), or mass-flow sandstones (S t a u f f e r, 1968).

The central section, along the Esera valley, is exposed over about 385 m, consisting mainly of limestone breccias which are sometimes graded (Fig. 2). The unconformity plane is clearly visible here (Fig. 3). Thick sandstone strata do not occur, only silty laminated material at the top of breccia layers. Bedding thickness can be as much as 35 m; the largest diameter of fragments only exceptionally

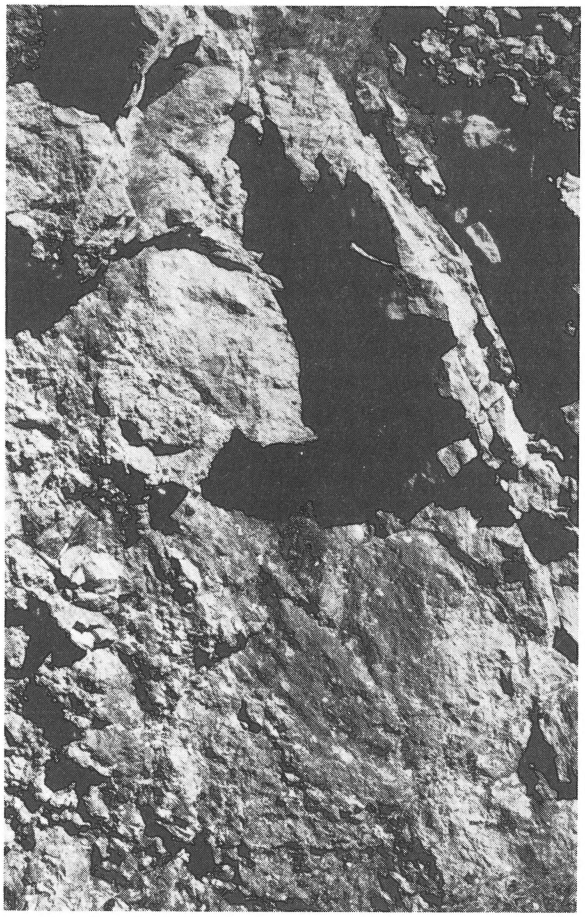


Fig. 2

Graded limestone breccia layer. Largest boulders, at left, are about 35 cm in diameter. Top is microbreccia and laminated calcarenite.

reaches 5 m (mostly at the base of the formation). Basal surfaces of breccias are commonly erosion-grooved, true scour-and-fill structures are almost absent.

In the easternmost part of the area, along the Barranco de Llert, the formation is only 50 m thick. Well-bedded layers up to 2 m thick, alternate with yellowish-brown weathered turbidites and autochthonous blue marls. The diameter of the rock fragments does not exceed 70 cm and is mostly about 20 cm. The formation is gradually transitional to turbidites with a non-graded a-interval (B o u m a, 1962), consisting of microbreccia material analogous to that in the breccia layers. Sometimes, a poorly developed cross-stratification can be seen in this microbreccia.

ORIGIN OF THE CAMPO BRECCIA FORMATION

Some significant aspects relating to the origin of deposits forming the Campo Breccia Formation will be described: the source area, the direction of transport, and the mode of transport and deposition.

With respect to the source of the deposits, an attempt has been made to determine the age of different rock fragments encountered in the breccia layers. The largest amount (about 95%) of the material comes from Upper Cretaceous formations, with Albian conglomerates, Permotriassic sandstones and Paleozoic phyllites as accessorial components. A relatively large quantity of ophites is also present, probably of Upper Triassic age (M i s c h, 1934; M e y, 1968). Upper Cretaceous rock fragments occur through the entire sequence, contrary to Triassic and Paleozoic material which appears halfway the formation, whereas, in the western part of the area, Triassic rocks are found in increasingly older layers.

A striking point is the absence of fragments of Jurassic and Lower Cretaceous age. Hence, it is tempting to look for a source area where these formations are missing or thinning out, and where the older formations (of Triassic and Paleozoic age) are available. This area can be found to the west and northwest of our region, where Upper Cretaceous rests unconformably on increasingly older strata (M i s c h, 1934), contrary to the northern, eastern and southern directions, where a complete Mesozoic sequence can be encountered. The Esera river is an approximate facies boundary between a western area in which Jurassic and Lower Cretaceous are lacking and a fully developed Mesozoic in the east.

The distance between source area and site of deposition has not been large, as demonstrated by the angularity of sandstone boulders. Even fragments of Permotriassic age having retained their original sand/mud stratification have been found in the breccia layers.

A littoral environment must have been quite near, to provide well-rounded quartz granules for the thick sandstone layers intercalated between the breccias.

Current directions measured in these sandstones by flute casts indicate an orientation from southwest to northeast, which in the easternmost part of the area changes from west to east, as determined

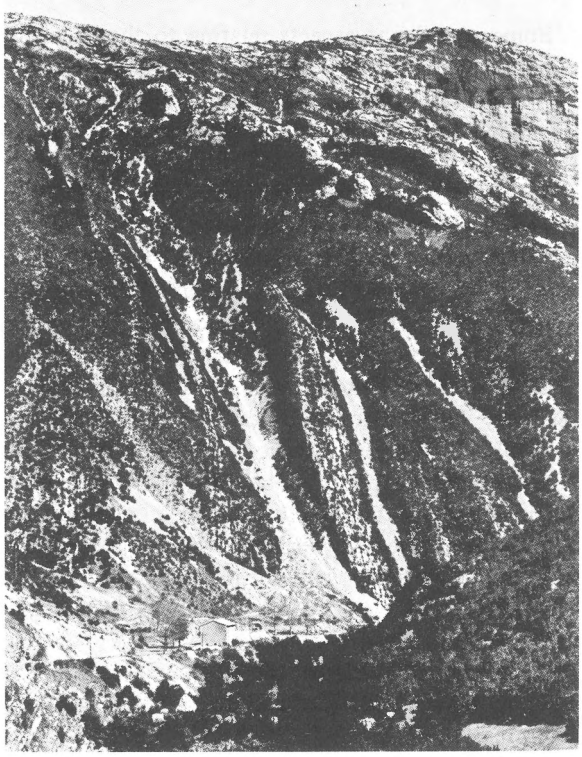


Fig. 3

Unconformity between the Campo Breccia Formation (at right) dipping to the south and the underlying Aguas Salenz Formation, almost vertical. Exposure along the Esera valley (photo by P.J.C. Nagtegaal).

by cross-stratification in microbreccias and flute casts at the base of intercalated turbidites. Channel axes of breccia layers closely follow this trend. These facts appear to be in agreement with a westerly provenance of breccia material, as has been tentatively indicated before.

Transport probably started in areas where a rapid accumulation of eroded débris and sand on a gently falling slope caused overloading. Hereby, shearing stress, caused by continuous and rapid sedimentation, must have exceeded the critical shearing resistance of the loosely packed non-consolidated sediment. If the deposition plane was not horizontal, a lateral displacement of material would have occurred, leading to a slide (M o o r e, 1961).

The most likely places where these conditions can be expected are in submarine canyon heads, where intercepting of bypassing material from bottom currents is frequent (S h e p a r d and D i l l, 1966; S t a n l e y, 1968). Currents carrying sand and other material (gravel, shell fragments) can be generated through tropical storms, as has been demonstrated recently (H a y e s, 1967).

Movement of material probably occurred along the axis of a submarine canyon, on a relatively steep slope, as a kind of subaqueous rockfall (D o t t, 1964) or traction carpet, gravity being the most important acting force.

Scour structures and mud pebbles indicate that submarine erosion took place.

A certain distance of transport will lead to a separation of material according to size, the largest boulders being moved faster under influence of gravity than gravel and sand. In such a case, a graded breccia deposit will be formed after a sudden decrease of the slope gradient. The finest material of the traction carpet, mainly sand and silt, builds up the top part of a breccia layer. Components which have been taken up into a turbulent suspension, will move further on as a true turbidity current.

The more proximal deposits are to be expected in the canyon mouth, sedimentation taking place here like a kind of sudden freezing of transported sand or breccia material.

A transition from proximal deposits to relatively distal sediments is apparent from the description of the westernmost section near Yalí to the eastermost sequence near Llert. Distality of sediments in this area can be concluded from the better grading, the deposition of true turbidites and the reduction of boulder size and bed thickness.

SITE OF DEPOSITION OF THE CAMPO BRECCIA FORMATION

Evidence of a deposition in a submarine canyon is supplied by the dips of the unconformity plane after rotating the underlying Aguas Salenz Formation to an original horizontal position. Rotation has been performed using the tectonic strike of this formation as axis, not taking into account the regional plunge. Therefore, at different points strike and dip of the Aguas Salenz Formation and the Campo Breccia Formation have been indicated on the map (Fig. 4). An original horizontal position of the Aguas Salenz Limestones is proved by a perfect conformity between this formation and turbidite

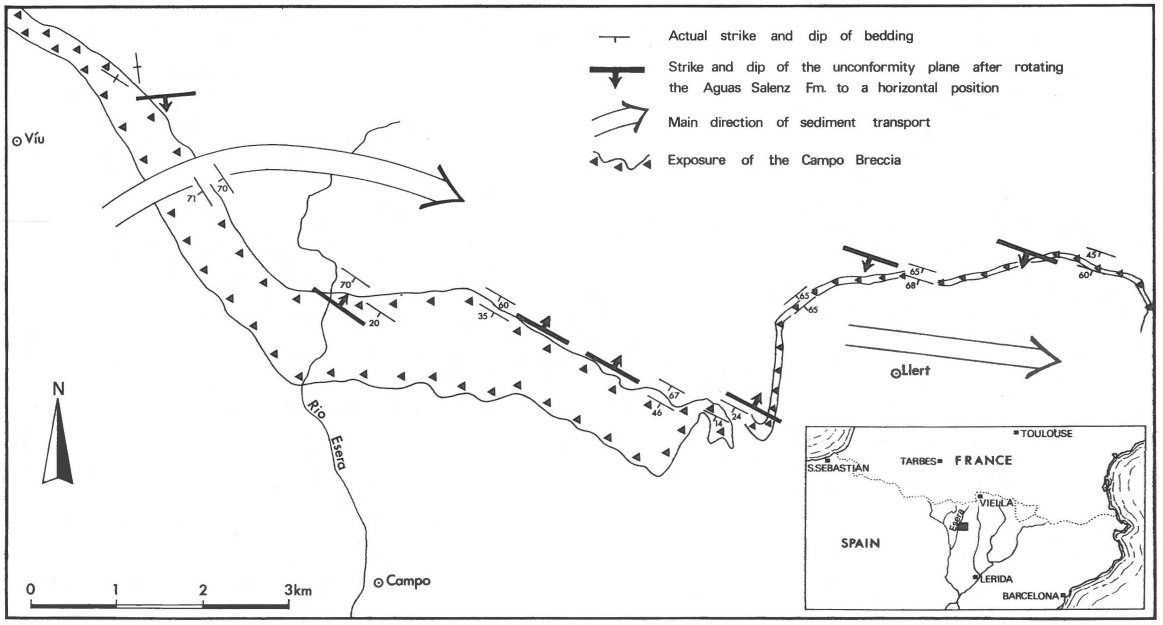


Fig. 4

Transport direction of material building up the Campo Breccia Formation in the submarine canyon.

layers of the sequence following the Campo Breccia Formation.

The rotated unconformity plane dips in a southern direction in the northern part of the area, contrary to a northern direction of the paleoslope in the south. Inbetween nonangular unconformity contacts were found.

CONCLUSIONS

The Campo Breccia Formation and related sediments were deposited in a submarine canyon, cut into Upper Cretaceous limestones. The existence of this canyon is shown by:

a) the original paleoslopes of the unconformity plane showing, the existence of a submarine canyon, oriented in the western part of the region from southwest to northeast and changing in the east to a west-east direction (Fig. 4). This submarine canyon must have been quite narrow and steep in the southwest (as proved by a greater unconformity angle), gradually becoming wider and less steep to the east;

b) current directions which closely follow the pattern distinguished in a);

c) the lateral change of the sediments filling up the submarine canyon. A transition has been noted from non-graded thick-bedded calcareous sandstones and breccias in the west to graded breccia layers along the Esera valley and finally into relatively thin-bedded breccias and turbidites with a microbreccia a-interval.

Probably the westernmost deposits have been laid down in a submarine canyon mouth, where an abrupt change in slope gradient occurred. A gradual transition into sediments building up submarine fans at the base of the slopes is reflected by exposures in the east (Llert region).

ACKNOWLEDGEMENTS

Many thanks are due to Prof. A.J. Pannekoek, Dr. J.D. de Jong and Mr. P.J.C. Nagtegaal for their critical reading of the manuscript and helpful suggestions.

REFERENCES

Bouma, A.H. (1962) – Sedimentology of some Flysch deposits. Elsevier, Amsterdam, 168 pp.

Dott, R.H., Jr. (1963) – Dynamics of subaqueous gravity depositional processes. Am. Assoc. Petrol. Geol. Bull., 47, p. 104-128.

Dzulynski, S., Ksiazkiewicz, M. and Kuenen, Ph.H. (1959) – Turbidites in flysch of the Polish Carpathians. Geol. Soc. Am. Bull., 70, p. 1089-1118.

Dzulynski, S. and Walton, E.K. (1965) – Sedimentary features of Flysch and Greywackes. Elsevier, Amsterdam, 274 pp.

Hayes, M.O. (1967) – Hurricanes as geological agents: case studies of Hurricanes Carla, 1961, and Cindy, 1963. Univ. Texas, Report of Investigations, No. 61, 56 pp.

Mey, P.H.W. (1968) – Geology of the Upper Ribagorzana and Tor valleys, Central Pyrenees, Spain. Leidse Geol. Med., 41, p. 229-292.

Mey, P.H.W., Nagtegaal, P.J.C., Roberti, K.J. and Hartevelt, J.J.A. (1968) – Lithostratigraphic subdivision of post-Hercynian deposits in the South-Central Pyrenees, Spain. Leidse Geol. Med., 41, p. 221-228.

Misch, P. (1934) – Der Bau der mittleren Südpyrenäen. Abh. der Ges. Wiss. Göttingen, III Folge, H. 12, p. 1-168.

Moore, D.G. (1961) – Submarine slumps. J. Sed. Petrol., 31, p. 343-357.

Pettijohn, F.J. (1957) – Sedimentary rocks 2nd. ed. Harper and Brothers, New York, 718 pp.

Raaf, J.F.M. de (1968) – Turbidites et associations sedimentaires apparantées, I, II. Proc. Kn. Ned. Akad. Wetensch., Series B, 71, p. 313-335.

Shepard, F.P. and Dill, R.F. (1966) – Submarine canyons and other sea valleys. Rand Mcnally & Co. Chicago. 381 pp.

Sitter, L.U. de (1964) – Structural Geology 2nd. ed., McGraw Hill, London-New York. 551 pp.

Souquet, P. (1967) – Le Crétacé supérieur sud-pyrénéen en Catalogne, Aragon et Navarre. Thèse de Doctorat d'Etat, Sciences Naturelles, Fac. Sc., Toulouse, Avril 1967, 529 pp.

Stanley, D.J. (1967) – Comparing patterns of sedimentation in some modern and ancient submarine canyons. Earth and Planetary Science Letters, 3, p. 371-380.

Stauffer, P.H. (1968) – Studies in the Crocker Formation, Sabah. Borneo Region, Malaysia Geol. Survey Bull. 8, p. 1-13.

Unrug, R. (1963) – Istebna Beds-a fluxoturbidite formation in the Carpathian Flysch. Ann. Soc. Géol. Pologne, 33, p. 49-92.

Walker, R.G. (1967) – Turbidite sedimentary structures and their relationship to proximal and distal depositional environments. J. Sed. Petrol., 37, p. 25-43.

Wennekers, J.H.N. (1968) – The geology of the Esera valley and the Lys-Caillauas Massif, Central Pyrenees, Spain, France. Thesis, Leiden State University.

GEOLOGIE EN MIJNBOUW VOLUME 48 (1), p. 72-74 1969

REMARKS ON THE AGE OF EMPLACEMENT OF THE BETIC OF MÁLAGA IN THE SIERRA ESPUÑA, SPAIN

J.J. HERMES[1]) and B. KUHRY[1])

SUMMARY

Observations in the Sierra Espuña region disprove Paquet's assumption (1966a, 1966b, 1967, 1968) of the transgressive character of his "Auversian conglomerates" and thus of the emplacement of the upper tectonic units of the Betic of Málaga before the Auversian and after the Lutetian.

[1]) Laboratory for Stratigraphy, Geological Institute, Nieuwe Prinsengracht 130, Amsterdam, The Netherlands.

INTRODUCTION

According to Paquet (1966a, 1966b, 1967, 1968) the Betic of Málaga of the northern Sierra Espuña consists of a number of tectonic units, – the Morron de Totana unit, the Prat Major unit and the Perona unit – which were emplaced after the deposition of the upper Lutetian and before the transgression of the Auversian. The main argument for this highly important conclusion is the assumed