

GEOTECTONIC CROSS SECTIONS THROUGH THE CANTABRIAN MOUNTAINS, NORTHERN SPAIN¹

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ABSTRACT

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The Variscan Orogen in this central part of northern Spain is made up of a practically unmetamorphosed sedimentary succession detached from the underlying crust. The kinematics of the supra-structural elements had an essentially centripetal pattern which, moving separately, formed the Knee of Asturias. It is postulated that gravity powered the formation of these structures in their present general form. The crust is considered to have been most likely cratonised during the whole of the Phanerozoic over most or the whole of the region. This craton must have been fractured into blocks capable of limited relative movements, both vertical and horizontal. Crustal events leading to the deformation were probably much more intense outside the limits of the orogen considered; for example the Hesperian Massif along the western edge of the Iberian Peninsula. The reconstructions made rule out the possibility of a subsurface connection between the Variscan infrastructures of the Hesperian and Pyrenean orogenes.

INTRODUCTION

The cross sections presented here have been prepared in the light of the discussions within the Study Group of the Variscan Orogeny in Europe under the aegis of Working Group 9 of the I.C.G. The account must be read as a conclusion of the study reported to the meeting in 1977 and published in 1979. It will be seen that these sections do not illustrate lower crustal levels. As has been argued previously (SAVAGE, 1979) the evidence available from the surface geology and the very sparse geophysical data do not justify extrapolation of interpretation to any great depth. Nevertheless it is considered that the somewhat negative conclusions do have some relevance to the goals of the Working Group. The most appropriate crustal model for Cantabria is that of a cratonised continental crust established in Precambrian times (SAVAGE, 1979). This hypothesis matches closely the ensialic orogen model proposed for the whole of the Hesperian massif by DEN TEX (this issue) and enlarged on in VAN DER MEER MOHR ET AL. (in press). Lower green-schist facies metamorphism (elevated temperature/low pressure) has been detected in a

number of places in Cantabria (see, for example, RUPKE, 1977). Much may be attributed to depth of burial, but an obscure relationship with igneous activity also seems likely (VAN VEEN, 1965; KOOPMANS, 1962). A similar relationship has been reported in the metamorphics of the Meseta (CAPDEVILA ET AL., 1973) and these fit the slow-warming, conducted heat-loss included in the model proposed.

DESCRIPTIONS AND INTERPRETATIONS

The north-south section of the Cantabrian Mountains presented here is constrained to lie in the unmetamorphosed and very low metamorphic part of the Variscan Orogen in northwest Spain. Along the line of section the orogen is bounded by the Bay of Biscay to the north and the Spanish Meseta to the south. Beyond a narrow 40 to 50 km wide shelf the former is underlain by oceanic crust (BACON ET AL., 1969); while the latter comprises mainly undisturbed Tertiary sediments, probably overlying much older metamorphic rocks. This small segment of the total Variscan belt exposed in the Iberian Peninsula is made up of a tight arcuate series of structures known as the 'Knee of Asturias'. The position of Cantabria in relation to the other parts of the Hercynian

¹ This contribution contains three enclosures.

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orogene in the Iberian Peninsula is shown in the Index Map on enclosure I (after FONTBOTÉ & JULIVERT, 1972).

In line with the low metamorphic grade of the rocks the Cantabrian structures belong to the suprastructure of the orogen, being essentially decollement in character (DE SITTER, 1962; JULIVERT, 1971; SAVAGE, 1979). The condition of complete detachment of the structures denies the possibility of any detailed interpretation to great depths. Even in the cross section drawn (Encl. I) the parts at depths of 3 to 5 kms must be considered quite questionable.

The pre-Variscan history of the Cantabrian region can be largely read from the relatively complete Palaeozoic sequence still preserved in the south (Encl. II and III). The most striking feature is the development of two distinct facies, north and south of the León Line; best seen in the Devonian sediments and bearing a strong resemblance to the Bohemian and Hercynian facies, respectively, of Central Europe, (BROUWER, 1968). New evidence suggests that this differentiation commenced much earlier (AMBROSE, 1974; MARTINEZ-GARCIA ET AL, in press; SAVAGE & BOSCHMA, in press). Probably even more striking in our palinspastic reconstruction (Encl. III) is the strong thinning of the sequence against the León Line. This is the result of late Devonian erosion rather than facies change, although the northern Palaeozoic (= Hercynian) facies is considerably thinner than the southern Leonide (= Bohemian) facies.

Practically all of the sediments of both facies provinces are considered to be of shallow-water types and lithosomes may be traced over hundreds of kilometres. This implies relatively stable conditions with the minor changes that did occur being contiguous over a large part of the region. Together, the large area and long period of stability form the basis for the interpretation of a cratonised crust from the beginning of the era.

The subdivision by the León Line into two facies areas has been accentuated by the late Devonian erosion which was much more intense in the north. The limits to the eroded areas were much more gradational than the facies boundaries which is somewhat of a foretaste of the situation during the Early Carboniferous when the differentiation had practically disappeared. These extremely condensed sequences probably also represent some erosive intervals but no valid pattern can be made out. We are left with two major erosive events during the Early Silurian and the Late Devonian as can be seen in the reconstruction (Encl. III). No tectonic structures can be attributed to these intervals so that orogenic activity during the Caledonian and Bretonic episodes has to be ruled out, and epeirogenic block movements appealed to. This is true throughout the whole of northern Spain except for the possibility of somewhat earlier tectonic activity in the West Asturian zone (JULIVERT, 1979).

Sedimentation generally appears to have continued conformably into the Late Carboniferous but differentiation into relative small areas of individual regimes rapidly became commonplace. The strong variations in thickness and in age

of development can only be partially illustrated by a section line as in enclosure III; comparable variations also occur laterally. Old and new boundaries developed, delineating areas of differing sediments, or more often, thicknesses. Of the larger more continuous features the Sabero-Gordon Line (Encl. III) was evident early on and with the Cardano Line is typically a new feature whereas the León Line renews its activity from the Early Palaeozoic. The latter marks the limit of relatively reversed vertical movements in so far that Westphalian sediments are practically absent to the south and attain their greatest thickness far to the north (SAVAGE, 1979). Later relative movements seem to have been reversed for a second time, for Stephanian deposits are limited in extent and thickness to the north and much more extensive to the south (Encl. III). Detailed accounts have been given elsewhere (see SAVAGE, 1979, for references); our reconstruction purely illustrates the situation along the section line.

Not only was the sedimentary pattern during the Late Carboniferous distinct from that of the earlier Palaeozoic periods, the usual flysch and wild flysch deposits contrast in type and rate of deposition with the earlier rocks. While many of the rocks do not represent deeper-water conditions the lithologies and the lack of continuity of the lithosomes are markedly different from the preceding intervals.

The role of the regional linear features in the Late Carboniferous sedimentation pattern is taken to imply that crustal accidents played a major part in their development. Smaller tectonic elements were also active and we also find evidence of real tectonic activity; in particular some wild flysch deposits show that the overlying nappes were being emplaced during sedimentation. Most of the nappes had been thrust into place before the beginning of the Stephanian so that the subsequent molasse was usually deposited unconformably upon them (Encl. I). Where no thrusts are evident, as in the Pisuega Basin and that of the Central Coal Basin the Westphalian and Stephanian successions are conformable. These areas did not escape deformation altogether as almost all Stephanian rocks have been folded and faulted before the deposition of Permian and Triassic rocks.

The relatively long interval of tectonic deformation spanning effectively the greater part of the Late Carboniferous has been interpreted to imply the direct influence of plate movements upon the sedimentary pile in Cantabria (WAGNER & MARTINEZ-GARCIA, 1974). This disregards the stable nature of the early Palaeozoic sequence, the essentially fragmentary pattern of the synorogenic successions and the decollement character of the structures formed (SAVAGE, 1979).

Igneous activity, largely volcanic, was widespread during the Early Palaeozoic; the dominantly basic magmas showing little affinity to a geosynclinal cycle. The syntectonic Late Carboniferous igneous rocks are typically aligned along fundamental features, in particular the León Line. Both volcanics and hypabyssal intrusives occur and may imply derivation from deep crustal events (SAVAGE, 1979).

In conclusion we have to admit that there is little definite

to present on the kinematics of crustal activity during the Variscan orogeny. This much can be seen from the section and palinspastic reconstruction presented (Encl. I and III). A few limitations can be set on the possibilities from the non-geosynclinal nature of the stratigraphy and the probability that the crust was cratonised from earliest Cambrian times. There is no evidence for a metamorphic core to this part of the orogen and our section does not suggest that Palaeozoic rocks will be found at depths greater than 5 kms. This geo-traverse suggests that no connection between the Hesperian Massif and the Pyrenean orogen could pass beneath Cantabria.

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