STRUCTURAL FEATURES ROUND LAS BORDAS, VALLE DE ARÁN, CENTRAL PYRENEES

BY

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On the suggestion of Prof. Dr L. U. DE SITTER I undertook in the summer of 1955 the detailed mapping of some particular intricate folding combined with some intrusive rocks of different kinds in the vicinity of the village of Las Bordas in the Valle de Arán.

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I want to extend my thanks also to Mr M. WÜRTH, general manager of the "Productora Fuerza Motrices", the company which is constructing hydro-electrical works in the Valle de Arán, for his kind permission to visit the galeries in construction between Beños and Bosost and other works, and his keen interest in my work.

The territory which has been mapped on the scale of 1:5.000 lies south and north of the Garonne river between its affluent from the north — the Barrados river —, and the great bend to the north of the Garonne river itself and its affluent from the south — the Jueu river. The south facing slope is bare, well exposed and inhabitated, the north facing slope is heavily wooded and badly exposed except along the Jueu river were the hydro-electrical construction has made artificial exposures.

The geology of the Valle de Arán has been described for the first time by CARALP (1887—1888). Since then very little work has been done until the small scale map by CALEMBERT (1951), and the map and description of the region north of Bosost by BARTHOLOMÉ (1953). The survey of the Leiden school is represented by the general paper by DE SITTER (1954a) on the Central Pyrenees, and the Valle de Arán in more detail by DE SITTER (1954b). Our small region is a part of the territory mapped by FRANCKEN (1954), whose work served as a base for our survey.

The southern slope is covered above 1400 m altitude by moraine material, containing blocks ranging from a few centimeters to some meters in diameter. The bottom of the valley contains but little alluvium upstreams of the confluence of the Jueu and the Garonne, but below this point the valley is filled with moraine material.

The stratigraphical sequence exposed in this small region contains from top to bottom:

Devonian
Silurian
Lower Paleozoic.

The Paleozoic of the Central Pyrenees has been described by DE SITTER (1954a) and we refer the reader to this paper for more general aspects. In our region most of the formations are more or less metamorphic due to syntectonical migmatization of the Lower Paleozoic.

The Ordovician, as it is commonly called although we are completely ignorant about the situation of its boundary with the Cambrian, contains micaschists and biotite gneisses, which northwest of La Bordeta show a post tectonic thermal metamorphism in the form of recrystallization of andalusite, staurolite and muscovite. These rocks have been intruded by a muscovite granite and pegmatites to which we will refer again later on. Along the top of the Ordovician locally a thin limestone band is developed, which can be compared to the Caradoc limestone which reaches an enormous development round the Liat Lake in the NE.

The Silurian is represented by its wellknown black slate facies, here often indurated, and strongly tectonized. It has been reduced tectonically to a very narrow strip and appears as a zone of only 12—13 m thickness in the tunnel between Beños and Bosost. It certainly acted as the lubricating horizon between the complicated Devonian folds and the much more quiet upper surface of the Ordovician.

The Devonian consists of an alternation of blue-grey limestones, calcareous slates and slates, the latter often containing pyrite. East of Las Bordas the limestones are replaced by graded sandstones. The thermal metamorphism has recrystallized the limestones and the slates are spotted by andalusite. On the map the boundary of this metamorphism has been drawn, it follows roughly the outline of the Ordovician outcrop.

As mentioned before the Ordovician contains intrusions of muscovite granites and pegmatites, both mostly intruded concordantly. Locally the pegmatites become so numerous that we get a banded rock. Their thickness varies from 10 cm to tens of meters. They were folded together with schists as is shown by fig. 1. Often the shape of the pegmatite veins shows considerable boudinage (fig. 2). Calcareous schists are metamorphosed in garnet bearing rocks. The margins of some of the pegmatites show a much finer grain. Besides these leucocratic intrusions in the Ordovician we find a zone of exposures of porphyrite dykes in the Devonian, extending along the south bank of the Garonne. These rocks contain largesized phenocrysts of sericitized felspar (albite), much quartz and felspar in the matrix, further biotite, carbonates and sericite. Accessory minerals are apatite, zircon and ore.

The study of the structure of the region was undertaken mainly to record accurately the folds in the Devonian both for their own sake and in order to get a better picture of the thickness of the Devonian involved in this folding. As far as the folds are concerned the map and sections speak for themselves. Long, drawn out isoclinal folds with very much reduced thickness in the limbs and thickening in the hinges. Synclines and anticlines follow one another in a quick succession, and careful measurig of the relation of cleavage and bedding resulted in confirmation of the position of axial planes revealed by the outcrop lines of the limestone.

The total stratigraphical thickness of the beds between the Silurian and the graded sandstone is no more than 200 m, when we assume that no other repititions are concealed between the seven repititions revealed in the sections. In the graded sandstones of Las Bordas a careful mapping by Prof. DE SITTER brought 6 hinges to light (oral communication). The 200 m measured thickness is certainly not the original thickness; this amount must be increased by a factor giving the thinning of each bed and decreased by another factor giving the doubling by means of microfolds. We have no indication what-

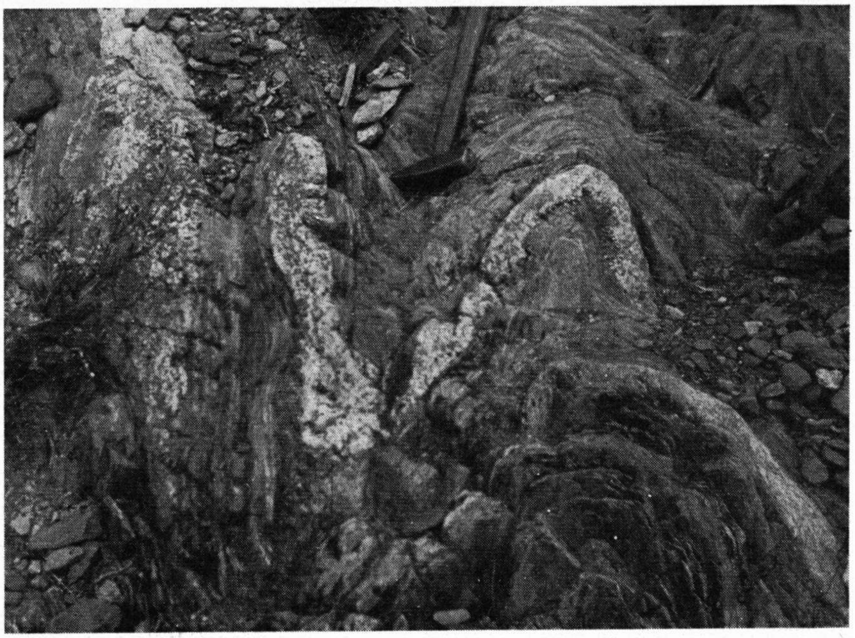

Fig. 1. Folded pegmatite dykes in micaschists, La Bordeta, Valle de Arán.

Fig. 2. Pegmatite dykes showing boudinage in micaschists, same locality as fig. 1.

soever of the importance of either factor, but as they act contrarary we may perhaps assume that they cancel one another.

A particularly interesting phenomenon was observed near the village of Arreu in the basal limestones. Fig. 3 shows this outcrop. The darker patches are pure limestone, the white streaks are metamorphosed calcareous shales containing quartz, calcite, clinozoisite, hornblende and occasionally some penninite and sphene. The cleavage, which caused all the isoclinal folding in this region, has resulted here in isolated notches of pure limestone between streaks of metamorphosed calcareous shales, the latter being smeared out

Fig. 3. Cleavage in metamorphosed alternation of limestone (dark rock) now marble, and calcareous schists (light coloured rock) now a lime-silicate rock, showing flow of schist material crossing the limestone along cleavage planes. Bedding vertical, cleavage oblique from upper left hand corner to lower right hand corner. Outcrop 150 m West of Arreu.

along the cleavage planes. This example of tectonic flow structure seems to be independent of the thermal metamorphism because from other regions similar rocks have been reported outside any metamorphic aureole. It is rather surprising to see that the calcareous shales act as a more incompetent rock than the limestones, because in general we notice that it is the limestone which fills up cracks in the shaly beds. When this process advances further, one can imagine that all traces of bedding disappear and that we get a notched rock consisting of limestone notches in a calcareous shale matrix. The phenomenon can perhaps be compared to the augengneiss texture of gneissified granite.

The structure of the Ordovician basement is much simpler in its outline; a plunging nose with a couple of faults. The faults as traced on the surface have been found back in the galleries of the hydro-electrical works as narrow mylonitized zones which caused considerable trouble to the construction. They contained water and the roof of the tunnel caved badly.

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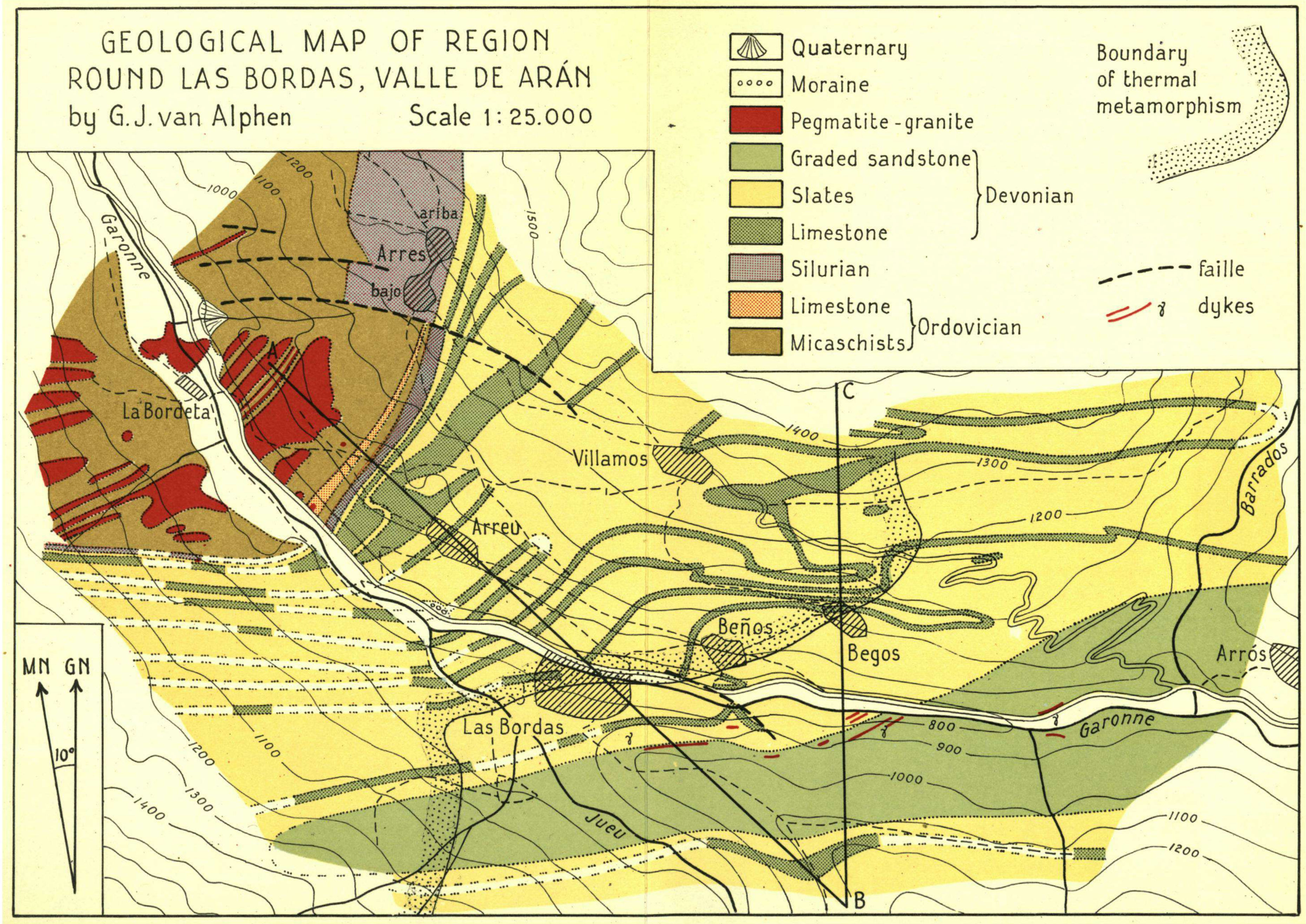
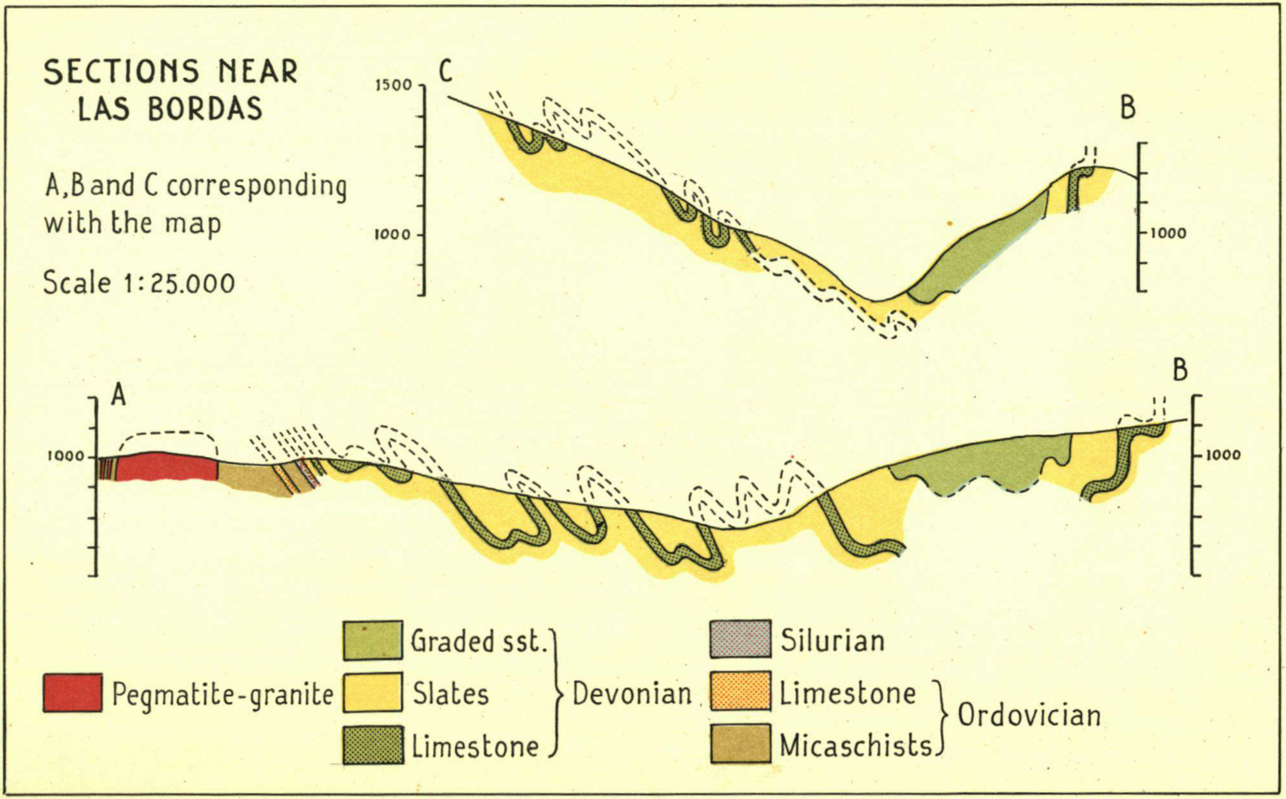

GEOLOGICAL MAP OF REGION
ROUND LAS BORDAS, VALLE DE ARÁN
by G.J. van Alphen
Scale 1 : 25.000
Quaternary
Moraine
Pegmatite-granite
Graded sandstone
Slates
Limestone
Devonian
Silurian
Limestone
Micaschists
Ordovician
Boundary of thermal metamorphism
faille
dykes
Garonne
ariba
Arres
bajo
La Bordeta
Villamos
Arreu
Beños
Begos
Las Bordas
Arrós
Barrados
Jueu
MN
GN
10°
A
B
C


SECTIONS NEAR LAS BORDAS
A, B and C corresponding with the map
Scale 1:25.000
C
B
1500
1000
1000
A
B
1000
1000
Graded sst.
Slates
Limestone
Devonian
Pegmatite-granite
Silurian
Limestone
Micaschists
Ordovician