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ALPINE MYLONITIZATION OF A HERCYNIAN PLUTON AND IT CONSEQUENCES. THE NÉOUVIELLE MASSIF (HAUTES-PYRÉNÉES, FRANCE)

CHRISTIAN LAMOUROUX, JOACHIM DÉRAMOND

Université « Paul Sabatier », Laboratoire de Géologie-Pétrologie et de Tectonophysique, 38, rue des Trente-six Ponts, 31078 Toulouse, France

PIERRE DEBAT

Faculté des Sciences, Département de Géologie, Dakar Fann, Sénégal

ABSTRACT. — In the plutonic Néouvielle massif (Central Pyrénées, France), the Alpine deformations are: 1) a strong vertical mylonitization of the massif, in the country rock the mylonitized zones become parallel to the surfaces of bedding and become discrete; 2) lately, the mylonitized zones are deformed by oblique centimetric shear zones the density of which varies regionally. The movement along the mylonitized zones and the shear zones cause an uplift of the massif and a southward movement along the southern margin.

This uplift is related to the emplacement of the thrust sheets in the southern part of the Pyrenean range.

THE Néouvielle massif occurs in the Central Pyrénées (south of the city of Lourdes) and intrudes Paleozoic formations of the Pyrénean Axial Zone. It has a granodioritic composition and is cut by filons or veins of tardimagmatic pegmatites and lamprophyric rocks emplaced during the latest Hercynian deformations (LAMOUROUX, 1976).

In the country rock and particularly in the pluton two successive types of mylonitized structures can be observed, each one appearing at a particular scale (fig. 1) (LAMOUROUX, 1976; LAMOUROUX et al., 1979).

The first mylonitized structures are developed at the regional scale and correspond to twelve large mylonitized zones which cut the massif (fig. 2) and its country rock and affect all the formations (Hercynian series, granodiorite, lamprophyric veins (fig. 4). They trend N 110° to N 130° and their dips diverge in a fan arrangement: in the southern part of the massif the dips are northward; in the central part they are vertical; in the northern part, southward. The thickness of the zones varies (from a few meters to a few hundred meters) from one zone to another or within the same zone. Within one zone the mylonitized deformation has a heterogeneous character shown by the irregular succession of the different mylonitized structures (strongly deformed subzones alterning with moderately and weakly deformed zones) at different scales. Deformation took place under (relatively) low temperature conditions as can be deduce from: 1) the low degree of recrystallization of quartz crystals; 2) the frequency and the diversity of deformation features in quartz crysals (ondulatory extinction, deformation bands and ribboned quartz); 3) the abundance of brittle deformation structures in feldspars which do no show signs of recrystallization. Moreover the neogenesis contemporary to the mylonitization (quartz, albite, chlorite, epidote, muscovite, calcite, actonolite) indicates that the conditions are those of the low-temperature part, of the « greenschist facies » (SIBSON, 1977).

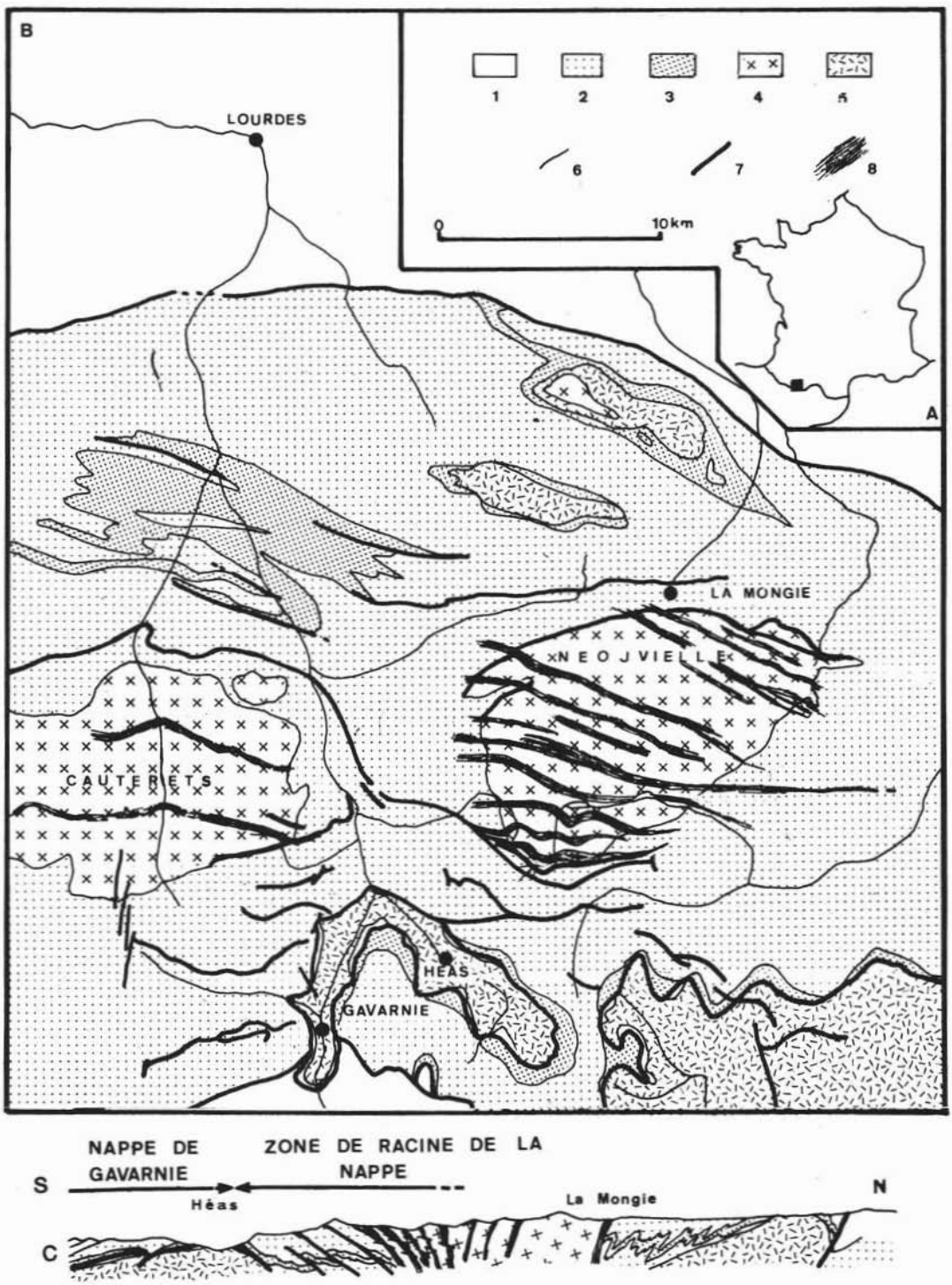


Fig. 1. — *A* - Localisation of the studied area; *B* - Sketch map of the Central Pyrenean Axial Zone; *C* - NS cross section. - 1: Mesozoic and Cenozoic formations; 2: Paleozoic formations; 3: Silurian; 4: granodioritic massifs; 5: Metamorphic basement; 6: Geological contacts; F: Fault and thrust surfaces; 8: Mylonitized zones in the plutonic massifs.

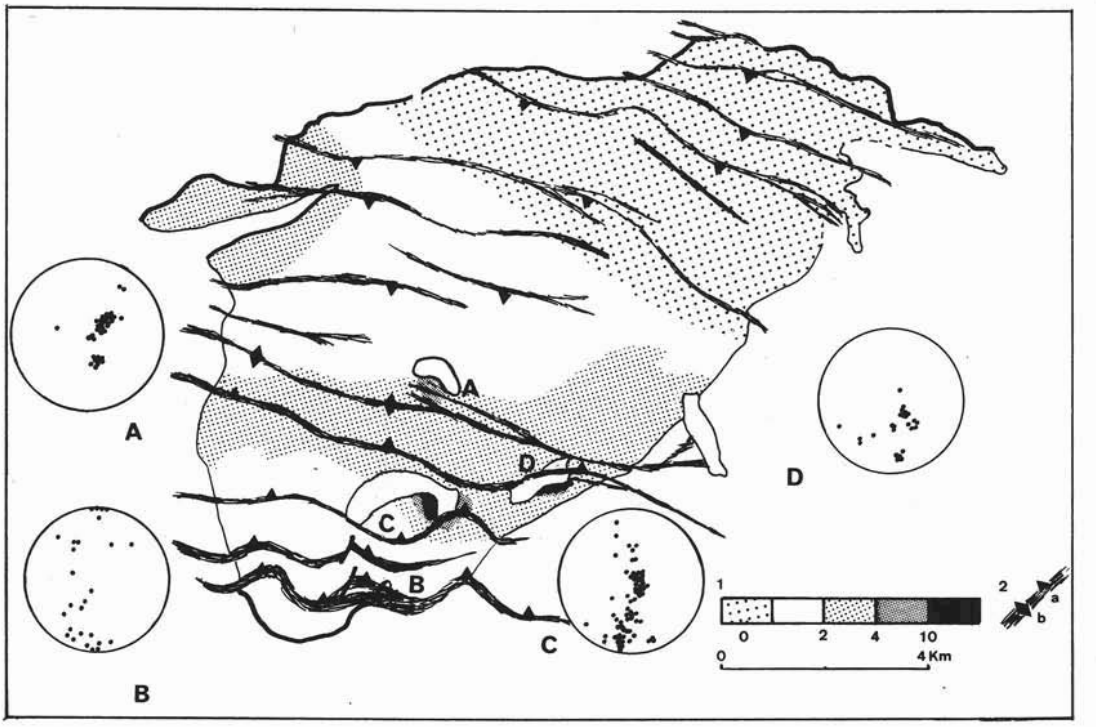


Fig. 2. — Map of shear and mylonitized zones. - 1: Distribution density of shear zones and their orientations: *A* - 45 measurements; *B* - 40 measurements; *C* - 80 measurements; *D* - 50 measurements. 2: Mylonitized zones with (*a*) sense of dip and (*b*) vertical dip.

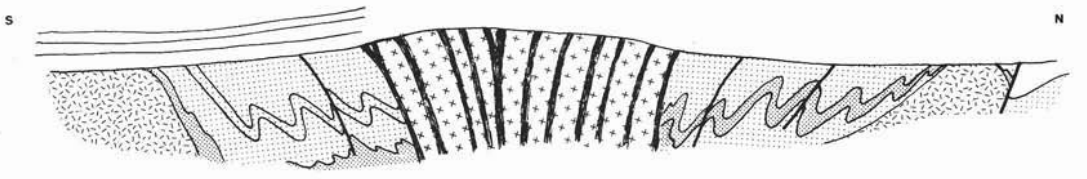
In the country rock, where the Paleozoic formations are strongly rhythmic, the large mylonitized zones rapidly thin out and relate to surfaces of bedding or sometimes (in the fold hinge, for instance) to those of a previous Hercynian cleavage parallel to the mylonitized zones.

The study of the structures in the mylonitized zones (lineations, folds in the aplite veins) and the tectonic contact between different formations (for example the southern contact between the pluton and its host rock) shows: 1) a very weak E-W displacement marked by minor metric transcurrent faults, and disymetrical folds, and mainly; 2) a vertical movement along all the surfaces of mylonites that contributed to a strong uplift of the massif facilited on the other hand by its original conical shape. The vertical movement occurs also in the country rock along the surfaces of the Hercynian cleavage as long as these are probably oriented. This movement must be related to the Alpine episode of general N-S shortening at the regional scale.

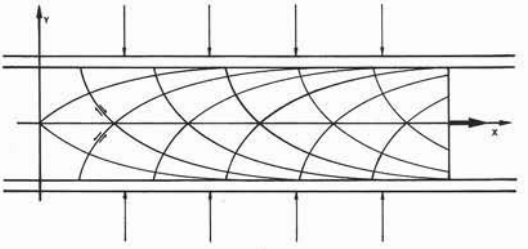
The second type of structures of a larger scale are shear zones, the density of which varies regionally. They are rare or absent in the northern part of the massif, abundant in the central part and present at the southern margin (LAMOUROUX et al., 1979). They are often conjugated and oriented E-W. The well developed shear zones dip northward and the minor conjugated sets, southward (fig. 2).

In the unmylonitized compartiments, the shear zones are dark, a few centimeters-thick, and roughly one meter long. The associated crystallizations are the same as for the mylonitized zones and therefore indicate that deformation occured also at low temperature (Plate I).

The shear zones also affect most of the mylonitized zones with peculiar structural characters: 1) they are thinner than the shear described above; 2) a single set of conjugated shears is generally well developed; 3) they are often associated with a microfolding of the mylonitized surfaces, the shearing ap-



a)



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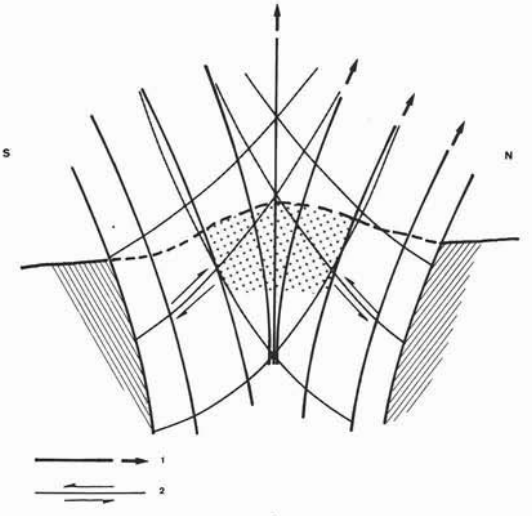

c)

pearing to have resulted from an evolution of the folding.

Displacement measurement show that the uplift of the massif is produced by southward movement along the shear zones in the central part of the massif and along the tectonic southern margins.

In the country rock the shear zones with associated sigmoidal tensional gashes appear in some competent formations (limestones, quartzites) and pass to thrusts.

The study of the deformaions of the pluton and its country rock points out a strong upwelling along large mylonitized zones trending East-West dipping a fan pattern with late development of conjugated shear zones that added to this movement. The deformations are related to a horizontal Alpine regional shortening oriented North-South. The orientation of deformed structures and the direction of shortening suggest a general disposition comparable to a Prandtl cell (KANIZAY, 1962; DÉRAMOND, 1979). In this hypothesis the vertical rigid plates (fig. 3 *b-c*) correspond to the basement outcropping in the northern and southern parts of the area, the Lesponne valley and the Gavarnie basement respectively. This model gives a good explanation of the upwelling of the massif and in the central part (very strong for the pluton massif which is more

d)

Fig. 3. — *a*) NS cross section showing the disposition of the formations before the Alpine orogenesis. *b*) Prandtl model (from KANIZAY, 1962). *c*) Prandtl model (modified from KANIZAY, 1962) sketching the root zone of the Gavarnie Paleozoic nappe: 1 - flow lines (So in the sedimentary formations, mylonitized zones in eruptive rocks); 2 - sliding lines (shear zones of eruptive massif). Topographic surface. Compare the topographic surface with 3 *a*. *d*) Section across the Paleozoic root zone during formation of Gavarnie nappe. The shear zones are shown by the lines.
The fine lines in the eruptive massif show the shear zones.

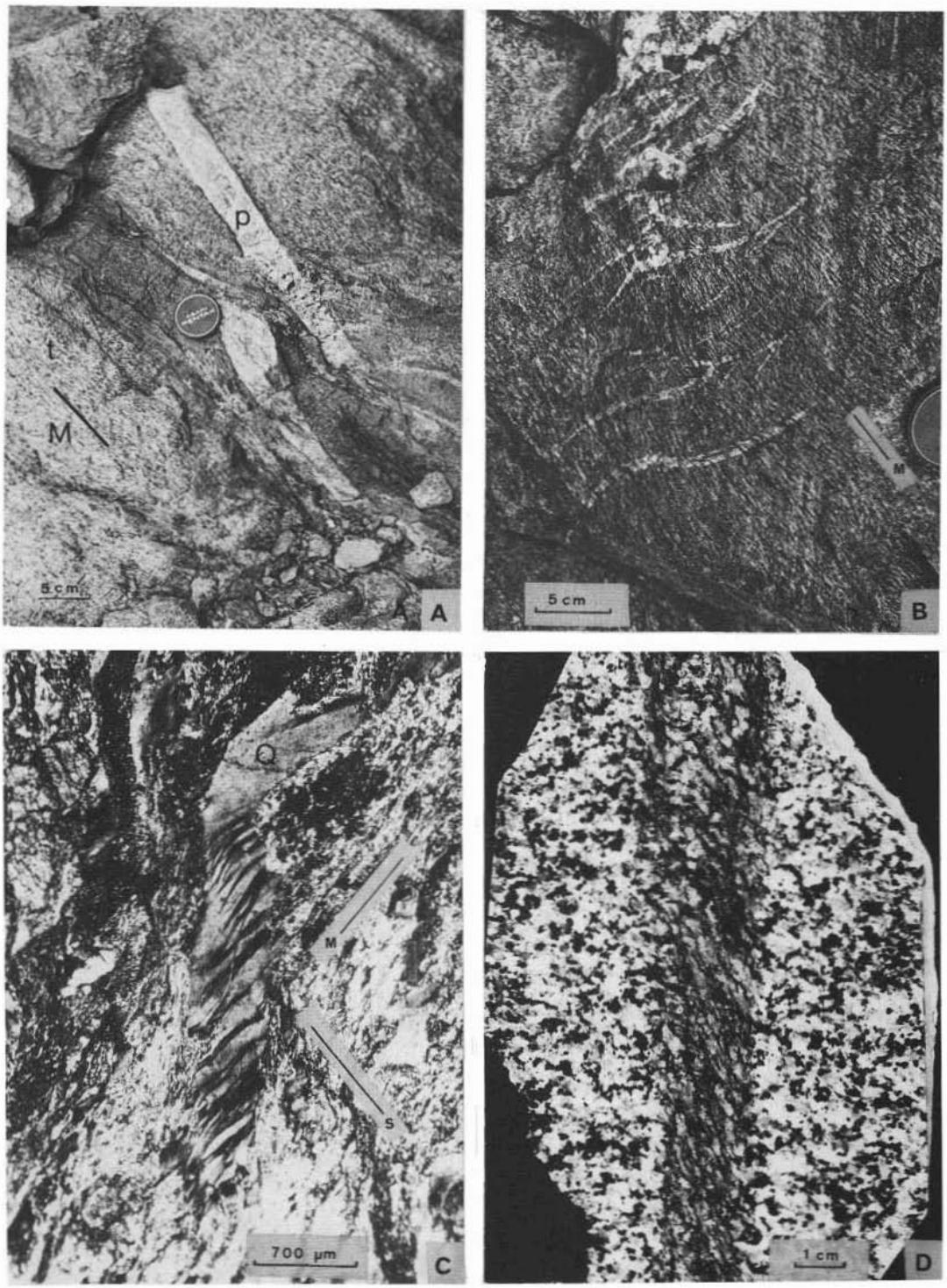

Fig. 4. — *A* - Mylonitic zone in eruptive rock: *M* = mylonitic foliation; *P* = pegmatitic vein. *B* - Tensional gashes in mylonitic eruptive rock: *M* like *A*. *C* - Deformation bands in a quartz crystal in mylonitic granodioritic rock: *Q* = quartz crystal; *M* = mylonitic foliation; *S* = shear zone. *D* - Shear zone in unmylonitic granodioritic rock.

competent than the sedimentary country rocks). During the movement the shear zones develop and correspond to the slip planes of the Prandtl's model (fig. 3 *d*). This model also explains the geometrical and chronological relationships between the mylonitized and the shear zones.

The application of the Prandtl's model implies the mylonitized zones were formed before the regional shortening. However, theses zones affect just as well the latest Hercynian veins of lamprophyre. Therefore, mylonitized zones are probably related to an early stage of the Alpine orogenesis.

The upwelling movement of the Néouvielle massif applies also to other plutons of the Pyrenean Axial Zone (Cauterets, Lys, Maladetta) this had important consequences in the regional evolution, particularly in the development of large nappe structures characteristic of the southern part of the Pyrenean chain.

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