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Roberto Malaroda

The Crystalline-Permian contact in the upper Roja Valley (southern Argentera) is an anatectic front

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SEZIONE II

(Fisica, chimica, geologia, paleontologia e mineralogia)

Geologia. — *The Crystalline-Permian contact in the upper Roja Valley (southern Argentera) is an anatectic front* (*). Nota (**) del Corrisp. ROBERTO MALARODA.

RIASSUNTO. — La mobilizzazione anatettica che interessa l'estrema parte meridionale del Massiccio dell'Argentera (« granite de Valmasque » e « granito di Entracque-Tenda » *auctt.*) è, almeno in parte, di età post-Permiano medio. I contatti, finora ritenuti stratigrafici, fra Permiano e migmatiti sono in realtà quasi ovunque corrispondenti ad un fronte anatettico più o meno penetrante entro la copertura sedimentaria.

The migmatites and granites of the Argentera Massif have always been regarded as Carboniferous or pre-Carboniferous. The fossiliferous middle Stephanian beds and the " mollieresite " (the last may be even older, at least lower Stephanian or Westphalian) appear to be transgressive, in fact, over the Crystalline, even though they have since been folded and reduced to tectonic slices, and even though they are weakly metamorphic (Faure-Muret, 1955, pp. 154 and 192). The Permian cover is still more clearly transgressive on the Crystalline, as it is on the middle Stephanian and " mollieresite "; these deposits, indeed, show very little evidence of tectonic deformation and metamorphism.

Radiometric measurements of the central core granites and a few peripheral granites and anatexites have given mean values of 286–293 m.y. (Ferrara and Malaroda, 1969) (1), *i.e.* the lower-middle Stephanian (Asturian ?) phase.

Migmatite and granite pebbles from the basement rocks are also present in the " mollieresite " and Permian conglomerates. The array of geological data, therefore, appeared to confirm the radiometric dating in suggesting that the Crystalline Massif must be earlier than the middle Stephanian or, even, that most of the massif must be pre-Hercynian (Malaroda, 1970, p. 633).

My ongoing studies of the southern sector (Bieugne or Beonia Valley, right hand tributary of the upper Roja Valley, France), however, show that, at any rate on a local scale, the Permian is not transgressive on the Crystalline, *i.e.* the present contact between the Permian and its underlying migmatites is very often an anatectic front.

It should be recalled, at this point, that Permian beds are plentiful at the SE and S end of the Argentera Massif whereas, on the central and northern

(*) Presentata nella seduta del 14 giugno 1979.

(**) Istituto di Geologia, Paleontologia e Geografia Fisica della Università di Torino e Centro di Studio sui Problemi dell'Orogeno delle Alpi Occidentali del C.N.R.

(1) The range for the micas/ages was rather wide (fringe values: 323 and 197 m.y., i.e. Namurian to upper Triassic). These variations, maybe due only to methodological reasons, are not in conflict with the polyphasic nature that other lines of approach have suggested as typical of the metamorphic and migmatic phenomena of the Argentera Crystalline.

areas, they are totally absent, and the Werfenian quartzites lie directly on the Crystalline. These southern Permian beds are attributed to the Saxonian (Faure-Muret, 1955, p. 160) and can be observed as various series of detrital rocks, some of which are very thick. Its northern outcrops begin a little above St.-Sauveur-sur-Tinée to the West and Rocca dell'Abisso to the East and extend over the Tinée, Vésubie and Roja valleys (Fig. 1).

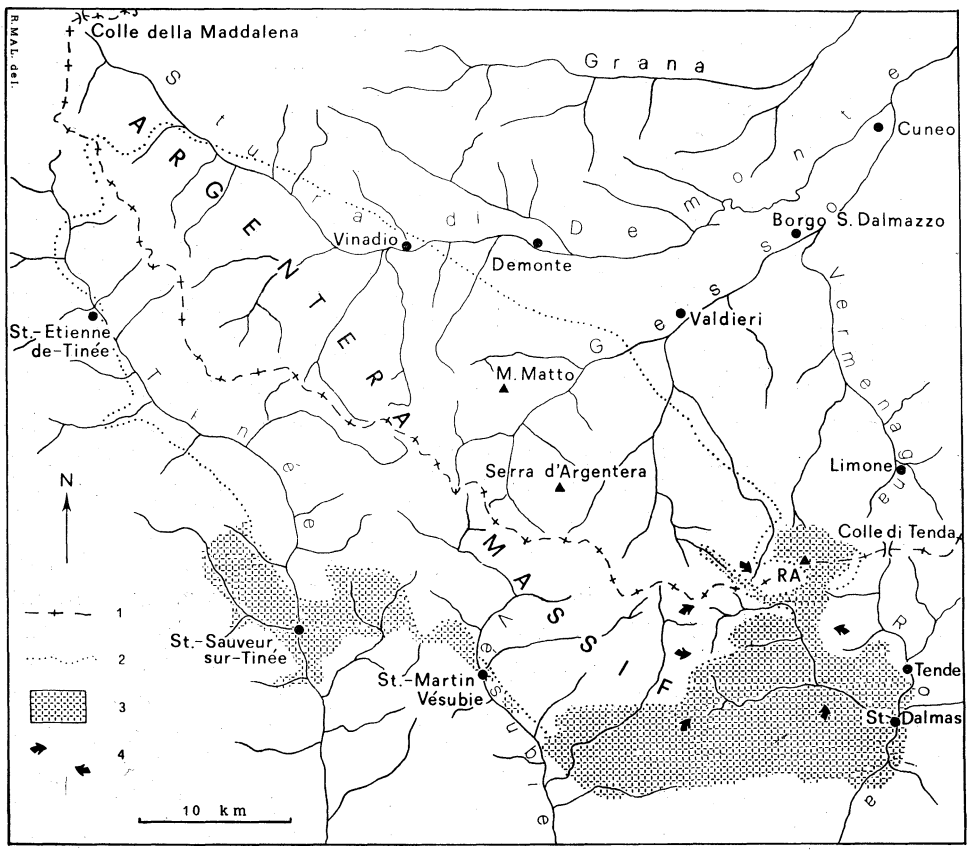

Fig. 1. – Sketch-map of the Maritime Alps, which extend from the Colle della Maddalena to the Colle di Tenda: 1) French-Italian border; 2) boundary of the crystalline massif; 3) area in which Permian sedimentary beds are present; 4) area examined; RA = Rocca dell'Abisso.

These Permian series include: conglomerates consisting of cristalline elements, andesites, dacites and rhyolites; red pelites; very distinctive green pelites ("Pietra della Roia"); conglomerates and sandstones with clasts mainly composed of quartzites. On them, the lower Werfenian cover may be either discordant or subconcordant but a gap is, anyway, always present. Lower Werfenian beds consist of white conglomerates and arenaceous quartzites with a distinct crossed bedding, and green yellowish or violet pelites.

The Permian is totally devoid of fossils, apart from occasional trace fossils that provide no stratigraphic indications; vulcanite intercalations of extre-

mely limited thickness have been reported in a very small number of places. The deposits being frequently heteropical, the convergence of the facies, their very local significance, and the marked differences in thickness, make it very difficult to draw a clear picture of the stratigraphic relationship between the various Permian series. An attempt made by Faure-Muret (1955) in the area between Gordolasque and Bieugne valleys distinguished four superimposed series:

d) *Capeirotto Series*. Red pelites, sometimes with sandstone intercalations and carbonate nodules. Thickness: 0–200 m. Does not outcrop in the Val Roja basin.

c) *Bego Series*. White, red or pink sandstones with occasional conglomerates and pelite intercalations. This is the most extensive of the four series. Its thickness varies from 400 to 1000 m.

b) *Merveilles Series*. Pelites, mostly green, but locally with violet indentations particularly at the top. Restricted intercalations of pelites with pebbles or even, though locally only, of conglomerates or sandstones. Carbonate concretions, occasionally of considerable size, are common. These are usually gathered in levels. The green pelites correspond to the " Pietra della Roia " described by earlier workers (Roccati, 1916). Thickness: 0–500 m.

a) *Inferno Series*. A conglomerate complex with very occasional pelite intercalations. The cement of the conglomerate is either arenaceous or pelitic. At the base of the series, where micaceous limestones are found it may even be arenaceous-carbonatic. Carbonate nodules are found at several levels. The pebbles are mainly of volcanic rocks (usually rhyo-dacites and, locally, andesites). At the base of the series conglomeratic sandstones with crossed bedding are represented. The colour is red-violet or greenish. Thickness: 0-700 m.

Faure-Muret pointed out that the Merveilles Series is totally absent from the area to the South of the Pas de l'Arpette Fault. Biancotti (1975) has related this heteropical character to the ENE—WSW synsedimentary faults. As a result, the area South of the Col de l'Arpette Fault displays an uninterrupted sedimentation of reasonably homogeneous conglomerates from the bottom to the top of the Permian deposits. In the light of this Biancotti proposed a different formational arrangement, in which the Inferno Series is subdivided into the Lac Long Supérieur Formation plus a Cime des Lacs Member of the Verrairiers Formation, and the Merveilles Series is demoted to the position of a second member of the Verrairiers Formation.

The Merveilles Series provides an invaluable stratigraphic marker wherever it occurs. Since this is the case in most of the area where relationships with the Crystalline take place (Fontanalbe, upper Valmasque, upper Vallée des Merveilles), I think that it is clearer to continue to use Faure-Muret's subdivision until a more applicable Stratigraphy can be worked out from an accurate sedimentological study of the Permian conglomerates.

As to the Tectonics, the Permian displays a block structure. Each block has its own attitude, usually monoclinal with weak dipping. The blocks are separated from each other by vertical faults, the most extensive of which having a strike between 80° and 120°. As I have already stated, some of these faults were responsible for the synsedimentary movements during the Permian; they were again set in motion at the changeover from the Werfenian to the Anisian (Biancotti, 1974), and sometimes in the Alpidic times as well. Very different tectonic conditions have been described by Aicard, Autran, Giraud and Longan (1968). These workers have interpreted the complex situation observed around Lac des Mesches and the Vallauria Mine as a succession of small, narrow isoclinal folds. Similar structures are not to be seen elsewhere in the area, even though tight-radius folds are occasionally shown on the sections drawn by Faure-Muret.

Depending on the particular case, any one of the three Permian series outcropping into the Bieugne basin may appear overriding the crystalline basement. *The contact has hitherto been always regarded as sedimentary-stratigraphic. In reality*, even though it might appear possible in some cases, and in spite of the fact that the outcropping at many points is such as to make observation difficult, *this contact* certainly *corresponds*, throughout the Bieugne basin (*i.e.* even for the confluents Vallée des Merveilles, Valmasque and Val de Casterine), *to a variously advanced migmatisation front* overrunning the Permian cover at nearly every point [2].

In addition to the difficulties already mentioned, there are three main reasons why this phenomenon has not been noted before:

– In most instances, the contact is not between granites and Permian sedimentary rocks but between anatexites and such rocks. Apart from the fact that many workers still feel it impossible to distinguish anatexites from other metamorphic gneisses, even those who are prepared to recognise them as migmatites find it hard to credit the idea that these rocks can make a sharp contact with beds that still preserve all the features of weakly transformed sedimentary rocks. The inevitable conclusion reached, therefore, is that the anatexites originated from a metamorphism older than the sediments, and hence that the latter are transgressive.

– The contact metamorphism is often negligible, to the point that even a precise inspection reveals little more than a slight hint of fusion of the sedimentary rock, or occasional impregnations of iron oxides or carbonates. On the other hand, there are indeed contacts, albeit infrequent, in which the sediment is completely (at least to the naked eye) vitrified to a range of several metres, and others where the carbonate nodules of the Inferno and Merveilles series have been totally transformed into marbles.

(2) In some cases, however, it would seem that there has simply been a rise in temperature, followed by metamorphism, but not by overrunning of anatexites into the Inferno beds.

– The contact is rather abrupt, and can be macroscopically determined to within a few centimetres at many points. Indentation, rather than gradual transition, is the better description in certain cases. This is true when there is an alternation of different detrital facies; the picture then is one of a differential anatexis, the conglomerate-sandstones being the first to be transformed and the pelites the last (Pl. II, Fig. 2).

The anatectic front reported in this Note, while fitting in very well with the typical pattern of Hercynian metamorphism, with its well-known surficial character and its association with particularly high geothermal gradients, nevertheless upsets the overall geological history of the area. In so doing, it raises a variety of problems for which I have been looking for a solution since I first suspected the existence of this younger anatexis, in 1976.

As far as the Argentera Crystalline is concerned, the front substantiates the view that the massif is polyanatectic, a view frequently put forward, though always without convincing evidence. It is clear, in fact, that the anatexites [3] in the southern sector, for which a younger age was likely on account of the more advanced and sometimes total granitisation of metamylonites (Malaroda 1966; 1973) as well as for other reasons [4], cannot be any older than the end of the middle Permian (about 250 m.y.). The anatexites and anatectic granites in the central and northern parts of the massif, on the other hand, are likely to be older than the granites of the central composite circumscribed pluton [5] radiometrically dated as Stephanian (285–293 m.y.).

Some outcrops of the studied area are of particular significance in assessing the relationship between the Permian beds and their basement, and a few words may be said about them at this point.

At Chiape de Fontanalbe (Fig. 2; Pl. I, Fig. 2), the uprising of the biotite anatexites into the Permian beds (Inferno and Merveilles series) is particularly evident, because the latter have very gentle attitudes, forming a monocline weakly dipping to the East. Some anatexite domes are situated along the vertical 110° striking fault which runs roughly along the axis of symmetry of the extensive Fontanalbe basin. These domes, like some others located a little more to the North, between the fault and Lake St.–Marie, can even be detected at a distance, because the Permian rocks near the contact are

(3) The anatexites of the South of the Argentera Massif, together with other subordinate types of migmatites and with not extensive masses of igneous-anatectic rocks were indicated as "granito di Entraque–Tenda" or "granite de Valmasque" by some of the preceding workers.

(4) Namely, the extraordinary abundance of resisters of various premigmatic rocks, the frequency of granites with a perlgneiss facies, and the greater abundance of cordierite. The two last features were treated by von Raumer (1976, pp. 162–163) as typical of his "anatexis II", though it must be pointed out that he assigned a pre-Carboniferous (Breton ?) date to this event.

(5) According to the terminology proposed by Raguin (see Raguin, 1965).

vitrified and reddened due to the presence of iron oxides. Indentations due to anatectic fusion, or inclusions of small remnants of Permian beds into the anatexites, are found elsewhere in the area bordering Lake S.-Marie.

Indentations between biotite anatexites, Merveilles Series pelites and Inferno conglomerates are common on the right of the Lac des Grenouilles tributary, on the left hand side of the lower part of the Vallon de Fontanalbe.

In the Baisse de Valmasque area, the anatexites rise very steeply, with a subvertical contact, in the gully that climbs up to the pass from the Vallée des Merveilles (Fig. 2). They probably follow the line of a prior N—S fracture. The mule-track leading up to the pass crosses a second uprising of biotite anatexites, which protrudes to form a height difference of about 30 metres between subhorizontal conglomerates, sandstones, and pelites (Pl. I, Fig. 1). The contacts are sharp and the metamorphic effects are negligible (local mobilisation of iron or carbonates, change of colour from red to green). Further to the West, in the direction of Mt. Grand Capelet, and also in the gully already mentioned, there are levels whose carbonate nodules have been completely metamorphosed into marbles or, elsewhere, in which sandstones and conglomerates appear to be in an advanced state of anatexis (Pl. II, Fig. 1). The gully also displays restricted signs of fusion of the siliceous rocks.

Strips of Inferno and Merveilles beds, completely surrounded by biotite anatexites or embrechites and occasionally in the process of transition to these rocks, are to be seen in many localities along the Basto Ridge (Rochers du Basto) in the upper Valmasque: these are particularly noticeable at two localities, one near the point marked on the topographical map with the altitude of 2293 m, the other at a position aligned to the centre of Lac du Basto, SW of a small, unnamed lake for which on the map an elevation of 2397 m is indicated near the effluent (Pl. II, Fig. 2).

Comparable situations, though with very poor outcrops due to the presence of a morainic, debris and wooded cover, can be found on the right flank of the Vallon de Casterine between Jasse de l'Angelière and Mt. du Castel, along the road that climbs up to the Vallon de Fontanalbe.

Even more awkward to examine are the contacts of the two large anatectic outcrops, the first one around the Lac des Mesches consisting of biotite anatexites and amphibole migmatites, and the second, near the Granges de Vallaure Inférieures (referred to as " Tetto Nuovo " by early workers) in the Vallon de Minière, consisting of microgranite-anatexites and biotite anatexites. Their interest lies in the fact that their uprising cross the conglomerates of the Bego Series, *i.e.* the most recent of the Permian formations of the Bieugne basin.

In the Casterine area in particular, it is clear that anatexis has followed prior fault or fracture lines, as indeed can be very plainly seen at Chiape de Fontanalbe. The ancient faults at Casterine and in the upper Valmasque are completely vanishing among the migmatites, even though they leave textural relics in these rocks for a certain distance, and even though they are

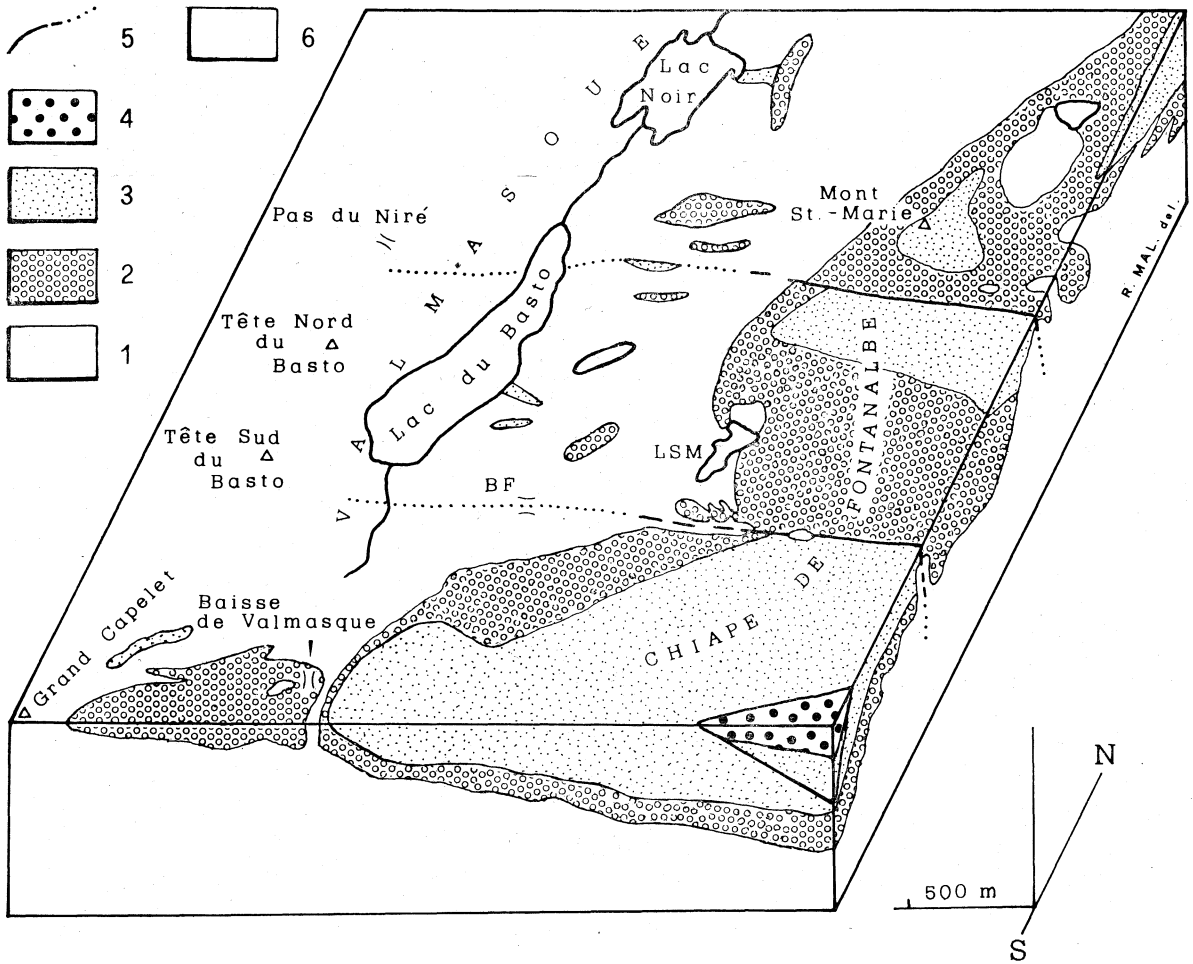

Fig. 2. – Block-diagram of the upper Valmasque and Fontanalbe valleys: BF = Baisse de Fontanalbe; LSM = Lac de St.-Marie. From 1 to 6, formations and phenomena in chronological order: 1) pre-Saxonian crystalline basement, mainly composed of biotite anatexites (not distinguishable from 6); 2, 3 and 4) middle Permian (Saxonian); 2) Inferno Series; 3) Merveilles Series; 4) Bego Series; 5) faults preceding or contemporaneous with the last anatectic phase, their detectable continuation and probable position in areas where they have been totally cancelled by anatexis; 6) biotite anatexites and other anatectic rocks of the post-Saxonian anatectic cycle (not mappable separate from 1 but probably overwhelming 1).

occasionally resumed by post-anatectic movements. These faults, then, took place before anatexis. They cannot be held responsible, as has hitherto been the practice in the interpretation of the local structures, for the outcropping of the crystalline cores or their indentations with the Permian beds.

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EXPLANATION OF PLATES I–II

PLATE I

Fig. 1. – The anatectic core of the Baisse de Valmasque, consisting of biotite and biotite-chlorite anatexites rising into the sandstones and pelites with pebbles (Inferno Series).

Fig. 2. – Telephoto-panorama sketch from the crest bordering the Vallée de Fontanalbe on the right. In the foreground, the small valley following the Chiape de Fontanalbe Fault; in the background, Mt. Clapier. The black colour marks the Crystalline of the background and some of the many small anatectic cores with a distinctive contact aureole lying along the fault valley or between it and the Lac de St.-Marie (not visible in the sketch).

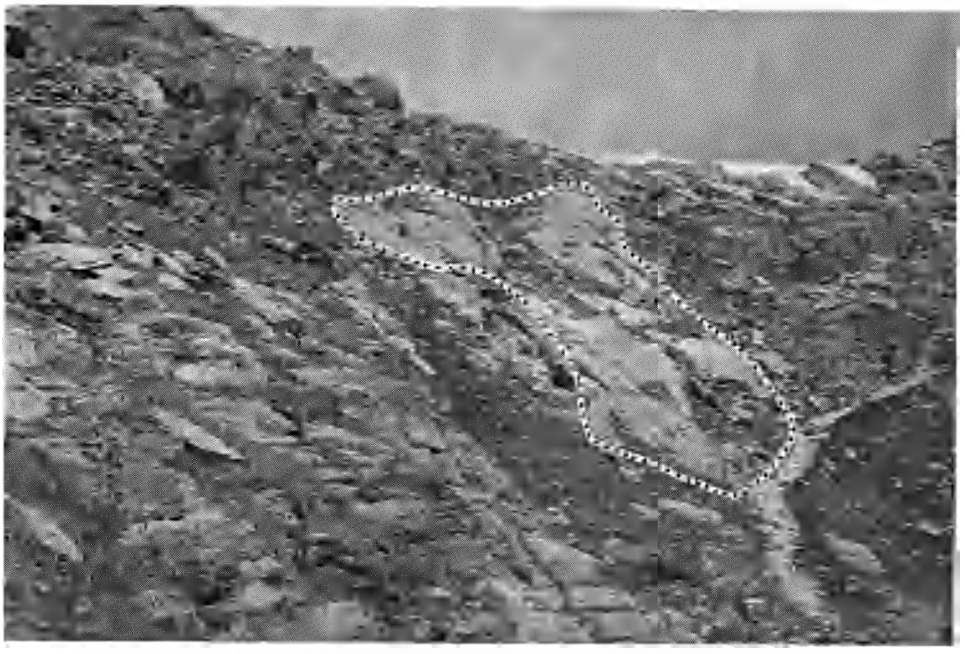

Fig. 1.

Fig. 2.

Fig. 1.

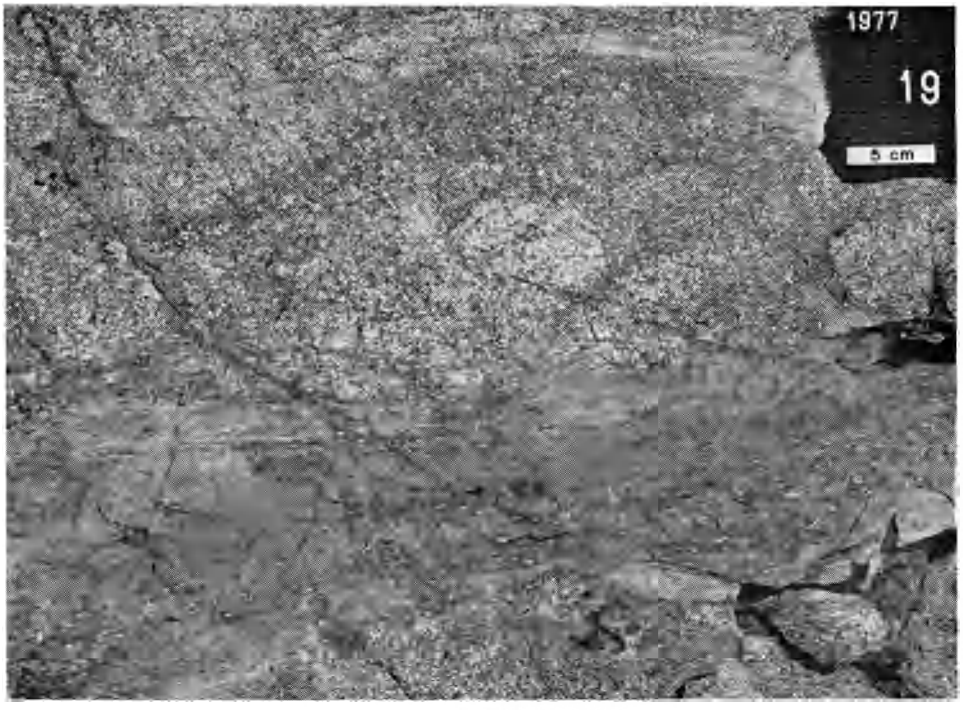

Fig. 2.

PLATE II

Fig. 1. – Anatexis of Permian beds (transition from the Inferno Series conglomerates and the Merveilles Series green pelites; here, conglomerates). Both lithotypes are invaded by biotite embrechites; even when their derivation from conglomerates is evident, the latter may display complex rheomorphic folds. Crest to the W of the Baisse de Valmasque, about 600 m in a direct line from the pass, at 2720 m elevation, 20 m below the crest on its southern side.

Fig. 2. – Sandstones, conglomerates and pelites of the Inferno Series displaying advanced anatexis and surrounded by biotite anatexites. Upper Valmasque, southern part of the Basto Ridge, ESE of the central part of Lac du Basto and SW of the small unnamed lake, whose effluent point has an elevation of 2397 m indicated on the map.