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Roberto Malaroda

Permian anatexis of surface conditions in the Argentera Massif

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SEZIONE II

(Fisica, chimica, geologia, paleontologia e mineralogia)

Geologia. — *Permian anatexis of surface conditions in the Argentera Massif.* Nota [(*)] del Corrisp. ROBERTO MALARODA [(**)].

RIASSUNTO. — Il carattere superficiale dell'anatessi permiana dell'Argentera è dimostrato dalle deboli e molto diverse azioni metamorfiche di contatto, dalle associazioni mineralogiche che caratterizzano i contatti medesimi e dalla presenza, in alcuni punti, di apofisi e livelli di vetri « dacitici », talora brecciati, che seguono il contatto e che si suppone dovessero costituire anche delle cupole in affioramento.

The Argentera Massif lies in the Maritime Alps, and is primarily composed of migmatites, with subordinate masses of premigmatic gneisses and granites. Its southern part includes pre-Mesozoic sedimentary outcrops of Carboniferous and Permian ages.

It is generally agreed that these beds are later than the migmatic event that gave rise to the framework of the massif. They appear in the form of particular outcrops: the Carboniferous is confined to a narrow strip in the Tinée Valley, while the Permian though substantially present throughout the southern area, varies considerably in thickness even over short distances and may even be altogether absent.

These phenomena are certainly due in part to original sedimentary inhomogeneities and to pre-Werfenian erosion, itself directed by the morphology produced by Permian tectonic movements. However, my recent researches (Malaroda, 1979) have shown that the disappearance of the Carboniferous and Permian cover is partly due to its transformation into migmatites.

The present work deals in detail with the characteristics of the anatectic cores of the Fontanalba, Valmasque and Merveilles valleys (Fig. 1), which are of particular significance in explaining the very superficial nature of the anatexis in question.

The first interesting locality is the Baisse de Fontanalba. The Baisse corresponds to a vast outcrop of migmatic rocks, mostly biotite anatexites. The outcrop stretches in a thin eastward tongue running along the Chiappe de Fontanalba Fault, and meets up with the anatectic dome outcropping around Lac de Ste. Marie to the NE (Fig. 1; Malaroda, 1979, Pl. I, Fig. 2).

(*) Presentata nella seduta dell'8 novembre 1980.

(**) Istituto di Geologia, Paleontologia e Geografia Fisica della Università di Torino e Centro di Studio sui Problemi dell'Orogeno delle Alpi Occidentali del CNR. The subject of the present Note was discussed at the 26^{th} Geological International Congress (Paris, 7–17 july 1980), in the section 1, symposium 3.3.

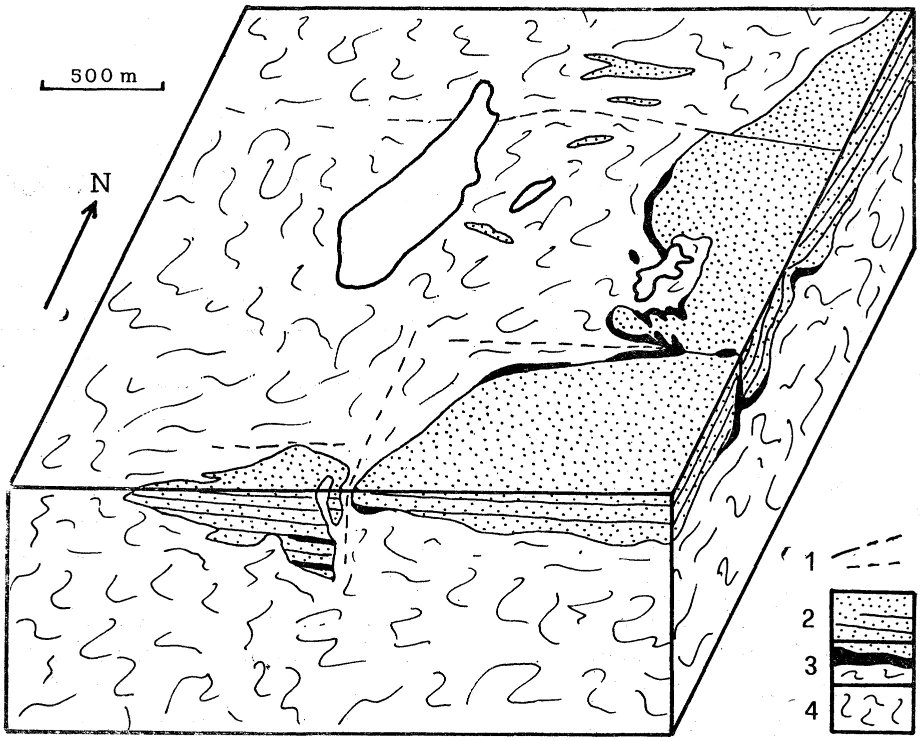

Fig. 1. – Block-diagram of the upper Valmasque and upper Val de Fontanalba. The large lake almost in the centre of the upper face is Lac du Basto. The two smaller lakes to the E are the unnamed lake at the elevation point 2397 on the 1 : 25.000 topographic map, and, further to the E, Lac de Ste. Marie. The Baisse de Valmasque lies on the top front edge of the diagram near the fault line. The more southern of the two faults in the eastern sector is the Chiappe de Fontanalba Fault; the Baisse de Fontanalba lies at its western end. 1) Pre-migmatic fault lines and (broken lines) their relics within the anatexites; 2) Middle Permian conglomerates, conglomeratic sandstones and pelites; 3) Areas where vitrification of the sediments is more marked; "dacitic" glasses; "dacitic" breccias with plagioclase blastite matrix; 4) Anatexites and other subordinate anatectic rocks.

Here the Permian series, while virtually maintaining its average attitudes, is crossed or followed along the bedding by white to reddish vitreous apophyses that clearly represent peripheral expansions of the migmatites (Pl. I, Figs. 1 and 2; Pl. II, Fig. 1).

When examined under the microscope the vitreous masses still display at the borders the original detrital structure. The following features can also be made out to a greater or lesser extent in these points:

– groundmass consisting of a more or less developed devitrified glass;

– clastic grains more or less distinctly reabsorbed by the groundmass;

– development of new minerals: biotite, plagioclase, haematite, abundant apatite, and occasionally tourmaline and calcite;

– frequent and sometimes abundant final generation of chequered albite.

When these apophyses are thick their core is violet–green, looks perfectly like a volcanic rock with porphyric tendencies, and has a structure and composition which recall those of the dacites.

Under the microscope the groundmass of these " dacites " is trichitic. When their structure is porphyric this is due to the presence of phenoblasts, mainly albite, and sometimes K-feldspar, chessboard albite, quartz or calcite or phenoblastic aggregates composed of several crystals of the same mineral or of several minerals (Fig. 2).

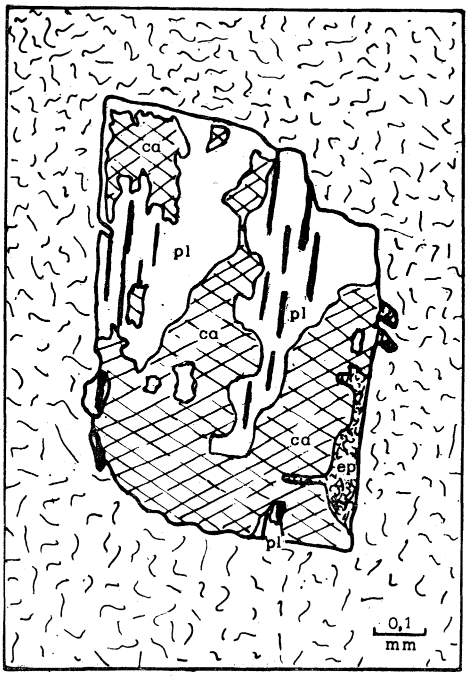

Fig. 2. – Fragment of the "dacitic" breccia between the anatexites and the Permian sediments. Divide between Fontanalba and Valmasque valleys, Valmasque side. Thin section detail showing, in a glassy trichitic groundmass, a composite phenoblast of cloudy chessboard albite (*pl*), plus calcite (*ca*), plus orthite (*ep*).

Irregular patches of trichitic glass can also be detected in the bordering sandstones and conglomerates with glassy groundmass. Chessboard albite or albite + calcite phenoblasts often appear in the sandstones alongside the boundary of the main " dacite " trichitic glass.

The transition from Permian sediments to biotite anatexites occurs through these " dacitic " rocks, or directly from the vitrified sandstones and conglomerates to the anatexites (Pl. III, Figs. 1 and 2). The anatexites are characterised by distinct polyphasic neoblastesis, with three generations of albite, the last one of chessboard albite, and, less commonly, K-feldspar. Here too haematite, apatite and calcite are common.

The second significant area is that on the left side of the Fontanalba Valley. Here a series of 5 anatectic cores can be seen. All are of modest dimensions, with a maximum height of 150 metres and an outcrop length of about 400 metres.

I first began to suspect that the largest of these cores were present when I noted the local irregularities in the attitudes of the Permian layers, which were in marked contrast with the extraordinary regularity of the Chiappe de Fontanalba monocline. They can, indeed, be clearly seen at a distance and thus offer a fine example of anatectic tectonics caused by the diapyric behaviour of the anatectic masses.

The cores are formed of a migmatic rock with the granular appearance of perlgneiss near the contact. If a schistosity appears the anatexite is layered more or less concordantly with the stratification of the nearby sediments near the boundary (Pl. III, Figs. 1 and 2). Distinctly discordant rheomorphous textures are always found at least a short distance away (Pl. IV, Fig. 1).

The contacts between the crystalline and the sedimentary can only be determined as the result of careful, close inspection. They do not result in mechanical discontinuities and occur by transition over no more than a couple of metres, a distance within which, in rocks that are already migmatic, sedimentary structures can still be made out on weathered surfaces, especially if there are pebbles protruding from the walls or if the diaclase surfaces have been reddened by the presence of iron oxides; but they cannot be perceived, on fresh fractures surfaces.

Both rocks, the sedimentary and the crystalline, have in common the appearance of biotite, subsequently transformed into chlorite and white micas, and of at least three generations of albite, the first two heavily sericitised and the third formed of chessboard albite.

Along a gully making the western boundary of the fourth core, going from E to W, debris blocks display the transition from the usual anatexites to a "dacitic" breccia (Pl. IV, Fig. 2) whose matrix, sometimes very scanty, consists of a perlgneiss anatexite that may retain relics of detrital structures. The breccia also includes some fragments of marbles, marbles with epidote, epidotites and, still less frequently, andesites.

The "dacitic" material shows signs of not having been transported and of having been crushed on the spot and permeated along fractures by the anatectic mobilizate, which sometimes shows traces of fuidality (Pl. V, Fig. 1; Pl. VI, Fig. 1).

More evident structures of transport, of the type usual in ignimbrite flows, can be seen on the north-western margin of the Lac de Ste. Marie anatectic dome (Pl. II, Fig. 2).

A third point of interest—the high Merveilles and Valmasque valleys. On climbing to the Baisse de Valmasque from the Val des Merveilles, one meets the contact between anatexites and Permian along the gully leading to the lowest point of the pass. There are several places where metamorphic action has produced marbles or glasses and the metamorphisms is highly variable in intensity from point to point.

A very characteristic structural feature is the well-marked anatectic intrusion that gives rise, right under the crest and on the slope of the Val des Merveilles, to a subcircular outcrop of anatexites within the Permian sediments (Malaroda, 1979, Pl. I, Fig. 1).

Further down, on the left side of the high Merveilles Valley, wery instructive examples of anatexitisation of " dacitic " breccias and/or of Permian conglomerates lying directly above the anatexites are well exposed (Pl. VI, Fig. 1).

The middle and lower Valmasque, with their structurally very high crystalline, outcropping near the Permian cover, is the kingdom of the resisters, sometimes intertongued and aligned, which probably reflect original stratigraphical layers. These resisters are also noteworthy for their size differences and their petrographic heterogeneity.

It seems we can conclude that:

1) All the rocks in this region display clear signs of retrometamorphism, particularly the almost complete destruction of the primary macroscopic biotite, the appearance of chlorite and the sericitisation of the most ancient generations of plagioclase. The recurrence of these phenomena and their localisation along the boundary of the anatectic massif bears witness, I think, in favour of their ascription to pulsations, substantially thermal, though also influenced by other factors, that occurred at the anatexis front as it progressed in space and time.

2) Another reason for thinking that strong and variable vertical and lateral heat gradients were responsible for the Valmasque anatexis is the extreme variety of the contact metamorphism grade, never going beyond the biotite zone and sometimes, when it concerns the " pietra della Roia " pelites, resulting in a thick mineralisation of microchlorite.

3) However, geological rather than petrographic reasons demonstrate that this anatexis took place in a superficial environment. It will be recalled, in fact, that Permian volcanic activity, if it exists, is an exceptional event of minimal extent in the Argentera Massif, whereas rhyolite, andesite and particularly dacite clasts are extremely common in the Permian sediments.

In addition, at certain levels the clasts are poorly sorted, petrographically rather uniform, and often of considerable size, right next to the crystalline massif, suggesting that the present crystalline area of southern Argentera is the region of provenance, as also suggested by crossed bedding structures, where present.

I feel that all these volcanic materials came into being in the same way as the " dacites " and the " dacitic " breccias described just now. In other words, these " volcanics " formed at the anatectic front at, or just under, the topographic surface where they were preceding and covering the anatexites. Their present outcrops are remnants of a more extensive volcanitic cover, now nearly always eroded, to which the emerging of this massif gave rise during Permian times at the centre of the southern part of the Argentera (Fig. 3).

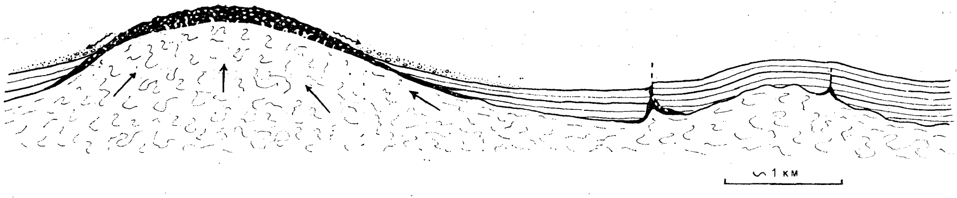

Fig. 3. – Section explaining the inferred mechanism of Permian anatexis in the southern Argentera. " Dacitic " glasses form at the surface or just below the surface, both on the boundary between the anatexites and the sediments and along the bedding planes or at small faults or tears in the cover due to pre-anatectic or syn-anatectic movements. Subsequently, rheomorphous movements of the plastic anatectic masses lead to brecciation of glasses covering them. Brecciation must have been generalised at the top of the anatectic dome, where the maximum thicknesses were established due to entrainment of the lateral materials. The resisters or pre-anatectic rocks in the anatexites and the metamorphic phenomena other than vitrification are not shown in the scheme for the sake of simplicity. In any case these vary considerably from one point to another.

The phenomenon undoubtedly took place repeatedly, in recurring stages, and supplied the whole of the surrounding sedimentary basin with volcanic clasts while anatexis was also continuing, at no great depth, below the basin surface.

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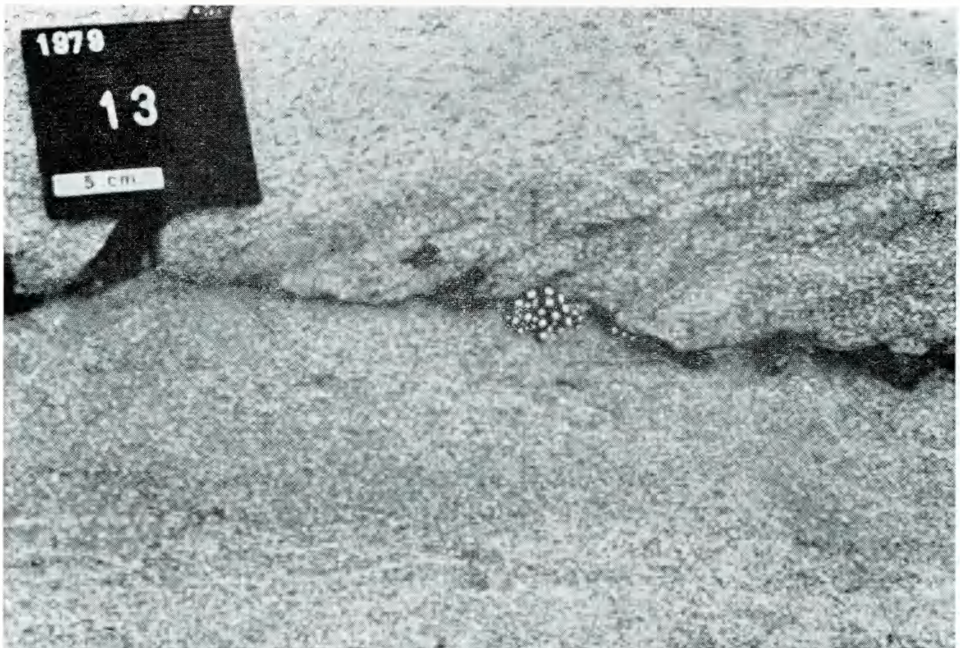

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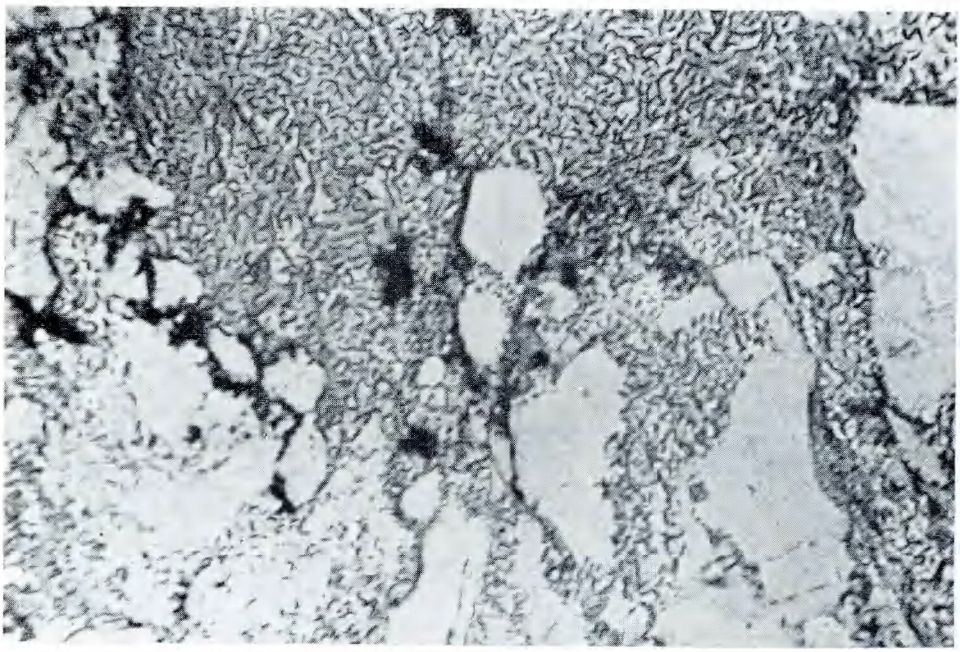

Fig. 2.

EXPLANATION OF PLATES I–VI

PLATE I

Fig. 1. – Reddish apophyses of "dacitic" glass deriving from vitrification of the Permian conglomerates. Left side of the Chiappe de Fontanalba Fault furrow, SSW of the Lac de Ste. Marie. Note the partly concordant partly discordant attitude of the apophyses.

Fig. 2. – Ditto. Same locality.

PLATE II

Fig. 1. – Reddish apophyses of "dacitic" glass into Permian conglomerates. Left side of the Chiappe de Fontanalba Fault furrow, SSW of the Lac de Ste. Marie. Note the small discordant apophysis to the lower left, and the red vitrification along the fracture in the centre.

Fig. 2. – Crest to the NW of the Lac de Ste. Marie, at an elevation of 2650 m. "Dacite" breccia between the anatexites (left side) and the Permian sediments (uppermost right).

PLATE III

Fig. 1. – Conglomeratic metarenite with signs of incipient anatexis. Gully at the western boundary of the fourth anatectic core on the left side of the Fontanalba Valley.

Fig. 2. – Metarenitic anatexite transitional to perlgneiss anatexite. Faint crossed bedding structures still preserved. Same locality.

PLATE IV

Fig. 1. – Anatexite with rheomorphic folds. Fifth anatectic core on the left side of the Fontanalba Valley at some 30 m from its eastern boundary.

Fig. 2. – "Dacite" breccia. Gully at the western boundary of the fourth anatectic core on the left side of the Fontanalba Valley.

PLATE V

Fig. 1. – "Dacite" breccia whose anatectic cement displays a weak rheomorphic fluidality. Gully at the western boundary of the fourth anatectic core on the left side of the Fontanalba Valley.

PLATE VI

Fig. 1. – "Dacite" breccia with anatectic cement, between the anatexites and the Permian conglomerates. Left side of the high Merveilles Valley near the Roche de l'Autel prehistoric carving.

Fig. 2. – "Dacite" breccia between the anatexites and the Permian sediments. Chiappe de Fontanalba Fault furrow, at an elevation of 2430 m. Thin section showing the transition between the new-formed trichitic glass of the "dacite" and the clastics of the conglomeratic sandstones.