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C - WESTERN ELBA

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This part of the field trip (Fig. 1) is devoted to observe the main geological feature of western Elba: i- Mt. Capanne intrusion, a monzogranitic magmatic body with associate dike swarms and microgranite masses and, ii- its thermometamorphic aureole consisting of several types of hornfels after the ophiolite succession.

A) THE OPHIOLITIC UNIT OF FETOVAIA-POMONTE AND PUNTA NERA ZONE, WESTERN MT. CAPANNE THERMOMETAMORPHIC AUREOLA

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Introduction

The Ophiolite Unit of Fetovaia-Pomonte (Fig 2) and Punta Nera (north of Chiessi) (Fig. 4) areas consists of metaophiolites (serpentinites, gabbros with basaltic dikes) and a metasedimentary cover (Mt. Alpe Cherts, Calpionella Limestones and Palombini Shales). This Unit directly lies on the Mt. Capanne monzogranitic intrusion (~6.2-6.9 Ma radiometric data: Juteau et al., 1984; Ferrara and Tonarini, 1985) which produced an evident thermometamorphic imprint on the oceanic rocks. The Fetovaia-Pomonte-Punta Nera area was studied by Marinelli (1959), Barberi and Innocenti (1965; 1966), and Bouillin (1983) which related the Ophiolite Unit to the Complex IV of Trevisan (1951), thermometamorphosed and deformed by the intrusion of the Mt. Capanne monzogranite. Perrin (1975), Spohn (1981) and Reutter and Spohn (1982) recognised a pre-granitoid tectono-metamorphic frame, which the former Author referred to the evolution of the Alpine chain, while the others ascribed to the Apenninic tectogenesis. On the other hand Bouillin (1983) and Daniel and Jolivet (1995) related the ductile deformations of the aureola to the emplacement of the Mt. Capanne magmatic body.

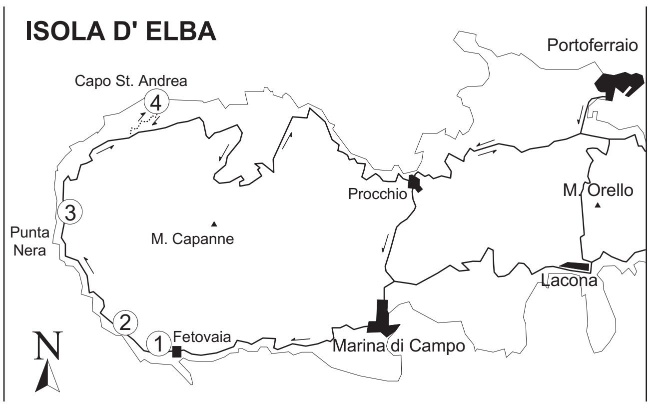

Fig. 1 - Itinerary and stops

According to Spohn (1981) and Reutter and Spohn (1982), the structural setting of Fetovaia-Pomonte and Punta Nera Ophiolitic Unit consists of synmetamorphic east-vergent folds, which were later refolded and discharged westwards (Daniel and Jolivet, 1995) by the uplift of the Mt. Capanne intrusion. The intrusion event produced also the recrystallisation of the oceanic wall-rocks up to the medium-high grade metamorphism (hornblende-hornfels facies: Barberi and Innocenti, 1965; 1966; pyroxene-hornfels facies: Spohn, 1981).

In the Fetovaia area the Ophiolitic Unit is overthrust by a Flysch Unit. This latter is characterised by a Paleogene? calcareous-marly flysch with a basal serpentinite sheet and ophiolitic-carbonate breccias. At the top of the flysch, an olistostrome which includes Calpionella Limestones, Palombini Shales, and cherty and ophiolitic rocks (Spohn, 1981) is present. In this Flysch Unit, Paleocene-Eocene fossils were also found in the limestones and in the ruditic horizons (Fetovaia Breccia) (Lotti, 1886; Perrin, 1975; Spohn, 1981; Bouillin, 1983). The Flysch Unit, which shows only a local weak recrystallisation, was correlated by Barberi et al. (1969) to the corresponding succession of the Trevisan's Complex V, widely cropping out in central Elba.

Structural and petrographic studies, performed for this field trip, confirmed the Spohn's (1981) structural interpretation of the Ophiolite Unit in the westernmost Elba, but added the evidence of a previous tectono-metamorphic transpositive event (Eo-Alpine event?). In the Late Miocene-Pliocene, these polydeformed rocks suffered thermometamorphism due to the Messinian Mt. Capanne pluton, and the successive tectonic discharge triggered by the uplift of the pluton itself.

Itinerary

The trip moves from Portoferraio to Procchio (outcrops of Flysch Units intruded by Messinian porphyries) and Ma-

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rina di Campo (skirting on the right, the eastern side of the Mt. Capanne Massif); from Marina di Campo, we take the road to Fetovaia, crossing the cornubianitic aureola and the southern part of the Mt. Capanne granitoid.

Stop 1. *Fetovaia Pass, along the Mt Capanne western road. Marly-calcareous lithotypes of the Flysch Unit Lithologies and tectonic mesofabric.*

The lithologies (Fig. 2) consist of cm- to dm-thick beds of dark grey marly-limestones and marlstones alternating with subordinate grey-black shales and grey calcareous sandstones and siltstones. This flysch succession includes gabbro and serpentinite olistoliths, and levels of ophiolitic breccias and sandstones. The beds generally dip ~30-40° westwards. No synmetamorphic penetrative tectonic-fabric or evidence of strong thermometamorphic imprint are present. A 1-2 cm-spaced crenulation to fracture cleavage locally affects the rocks. This cleavage, which gently dips westwards, can be connected to the discharge folds due to the uplift of the Mt. Capanne intrusion. Calcite veins (with euhedral crystals) cross-cut vertically the rocks and testify a flattening episode in an overpressured carbonate fluid-rich environment.

At the microscope. The marly and marly-limestones show a local weak recrystallisation, and the primary sedimentary structures are well preserved (e.g. bedding and laminations). These rocks contain variable amounts of quartz grains, white micas and scattered oxides and carbonised plant debris. The shaly lithotypes consist of sheet silicates (including abundant white micas) ± quartz and organic pigment. In particular, in the latter lithotypes weak zonal crenulations (locally marked by alignments of opaque minerals) are present. Secondary veins of calcite are common and generally postdate the crenulations.

Looking seawards, on the right we can see a cliff where the upper part of an olistostrome associated with the flysch crops out. It is made up of green to reddish ophiolitic-cherty breccias and olistoliths, and of light grey carbonate breccias (the top carbonate body is affected by west-vergent discharge folds). On the left, a little path reaches the sea, crossing the basal part of the olistostrome, consisting of typical debris flow deposits (including carbonate and subordinate silty and ophiolitic heterometric clasts in a prevailing pelitic matrix), and of some lens-shaped levels of graded polymictic sandstones and microconglomerates with local marly interbeds.

We continue the trip along the Mt Capanne western road and reach the Ogliera Creek.

Stop 2. *Bridge on the Ogliera Creek. Metamorphic slates, limestones and cherts of the Ophiolite Unit (Palombini Shales, Calpionella Limestones and cherts).*

Walking along the road (Fig. 2) we cross an east-facing syncline pre-dating the Mt. Capanne intrusion (Fig. 3). The

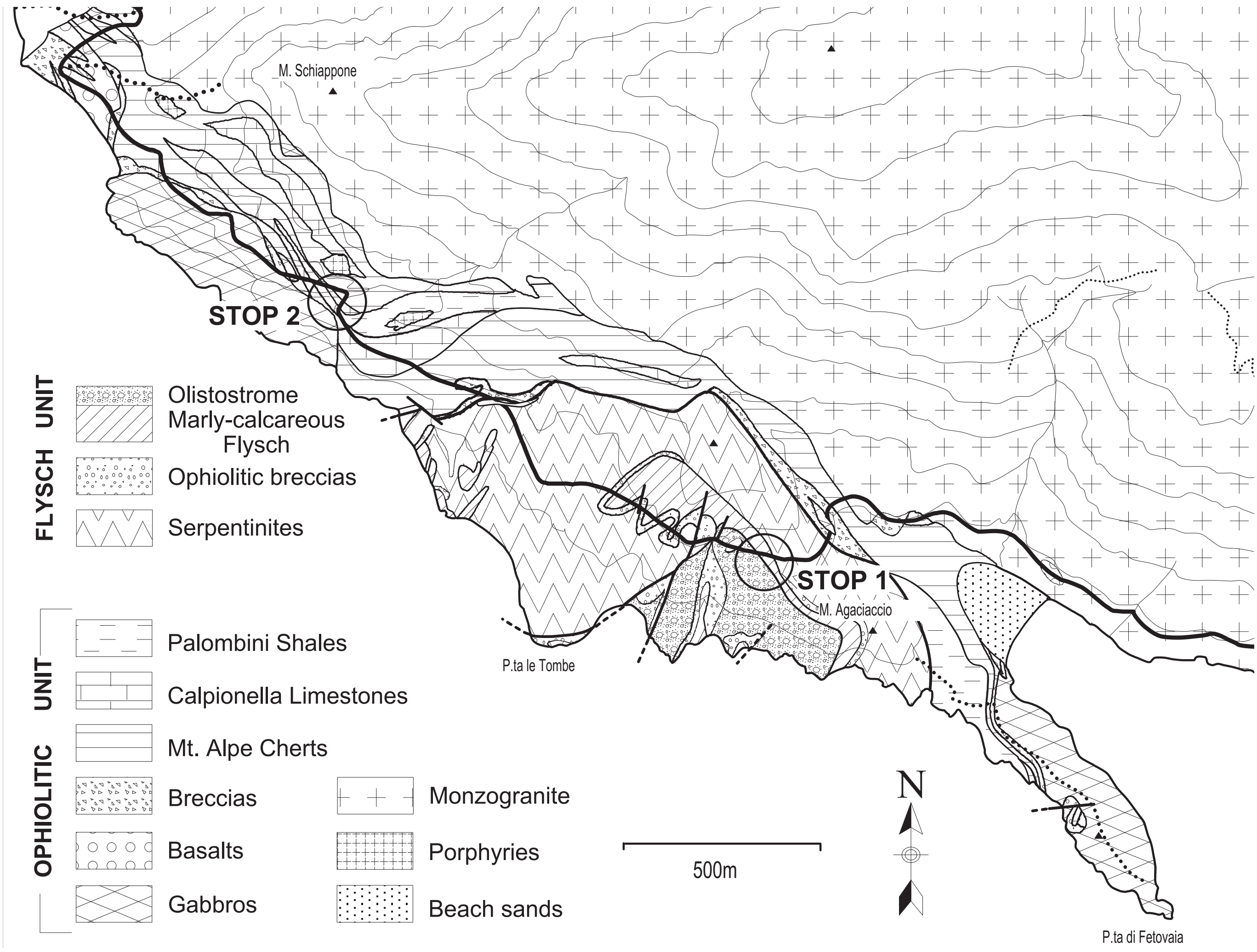

Fig. 2 - Geological map of the Fetovaia-Pomonte area.

syncline is tight to isoclinal with the axial plane dipping ~50° westwards. The core of the syncline consists of Calpionella Limestones, including boudins of Palombini Shales, the limbs are made up of cherts. Within the axial plane foliation (S_2), relics of intrafolial isoclinal rootless hinges are present and testify a tectonometamorphic event which predates the mesofolds formation. The outcrop is cross-cut by a 1-2 cm-spaced crenulation to fracture cleavage (S_3) which is related to the westwards discharge folds, triggered by the Mt. Capanne uplift. In the gate-yard of a cottage, poly-folded metacherts crop out. Thin aplitic dikes are often injected along the main foliation of the rocks.

At the microscope. The rocks are characterised by a medium-grade thermometamorphism. In the less recrystallised slaty lithotypes of the Palombini Shales, a mimetic or static blastesis of brown biotite on the white micas+chlorite±quartz slaty cleavage is present. Other samples show a strong thermometamorphic imprint: whitish strings and irregular areas/spots of clinopyroxene+fe1dspar±biotite±quartz; the same mineral assemblage fills also the later fracture cleavage (at a medium angle respect to the main foliation). These rocks are cross-cut by Fe oxides/hydroxides or adularia±epidote veins.

The Calpionella Limestones (as the limestone beds of the Palombini Shales) are dark grey or grey-greenish to whitish banded metalimestones characterised by a granolepidoblastic foliation (fine-grained crystalline limestones alternating with phyllitic or calcschist levels) which predates the thermometamorphic minerals. The latter are well represented in the phyllitic interbeds which are transformed into a whitish monocline diopsidic pyroxene+feldspar+garnet±quartz skarn; scattered clinopyroxenes and garnets are also present in the fine to medium-grained marble levels which locally contain porphyroblasts or granoblasts of quartz and small cubic pyrite crystals. In the skarn levels, weak crenulations (about perpendicular to the foliation) and static garnets (which overprint the foliation) are present. Locally, millimetric/centimetric tight folds deform the foliation and are characterised by "ghosts" of a weak axial plane crenulation cleavage. These metamorphic rocks are cut by veins of calcite+adularia±chiorite±epidote?. The samples collected close to the aplitic dikes (sometimes without tourmaline and including poikiloblastic diopsidic pyroxene) are massive wollastonite+monocline pyroxene+garnet+scapolite (after feldspar)±vesuvianite±p1agioc1ase/k-feldspar±amphibole? skarn without evidence of foliated structures. Both the dikes and the skarn are cut by calcite veins. The grey-greenish cherts are granoblastic biotite quartzites with secondary quartz veins and locally with pegmatitic dike1ets (quartz+k-feldspar+tourmaline with a blue-green pleochroism+muscovite) The static blastesis of quartz+green-brown biotite often obliterates fold structures and foliations. Locally, the biotite is mimetic on older sheet-silicates (muscovite and/or chlorite?) aligned along the main foliation. In some low recrystallised samples, tight to isoclinal folds with pervasive, spaced, zonal crenulations clearly deform the foliation. Small magnetite or pyrite crystals are locally scattered in these rocks.

We continue along the road. About 300 m beyond Pomonte (Punta della Testa) we cross an outcrop of gabbros in contact with the Mt. Capanne monzogranite. The gabbros are locally flaser and are cross-cut by basaltic dikes. The flaser structures are related to oceanic metamorphism. These structures are well-studied in the Northern Apennines and are linked with a HT-LP (up to 700°C) metamorphic blastesis (brown hornblende, pyroxene and plagioclase) overprinted by retrograde mineralogical phases (tremolite/ actinolite, chlorite, etc.). This HT-LP metamorphism is referred to ductile shear zones close to the oceanic ridge (see Cortesogno et al., 1987).

Then, we cross Chiessi and reach the ophiolite outcrop close to Casa Perla, north of Punta Nera (Fig. 4).

Stop 3. *Punta Nera cliff. Ophiolitic Unit (metamorphic gabbros, Calpionella Limestones and Mt. Alpe Cherts).*

The road crosscuts two synclines pre-dating the Mt. Capanne intrusion (Fig. 5). The eastwards facing, tight to isoclinal synclines show a ~60° westwards dipping axial plane. At the core, Calpionella Limestones are present. The synclines are flattened and refolded by westwards vergent open folds, characterised by sub-horizontal axial planes, due to the Mt. Capanne uplift. On the right-side of the road, another later open fold, made up of metaophiolites, cherts and Calpionella Limestones (at the core), is exposed under a wire-mesh. The metaophiolites are strongly foliated (continuous type 1 cleavage). Thermometamorphic garnets are present in the cherts. Farther north, along the road, a thin level of strongly foliated metaophiolites crops out, which constitutes the anticline hinge between the two synclines. Mt. Alpe Cherts and Calpionella Limestones up the slope are characterised by tight to isoclinal folds with refractions of the S_2 spaced axial plane crenulation cleavage (Fig. 6a) and intrafolial isoclinal rootless hinges (Fig. 6b).

At the microscope - The microscopic features of the calcareous-siliceous rocks are similar to those described at Stop 2. The Calpionella Limestones consist of foliated marbles imprinted by HT-LP minerals (monocline pyroxene+wollastonite); the thin pyroxene+wollastonite+k-feldspar+biotite skarn levels are the pre-thermometamorphosed lepidoblastic phyllite or calcschist intercalations within the marbles. These HT-LP minerals are sometimes mimetic on the foliation. Peculiar in these samples are spherical to ellipsoidal radial aggregates of wollastonite. Millimetric to centimetric tight/isoclinal folds (parasitic structures of the mesofolds) deform the foliated structure and show penetrative

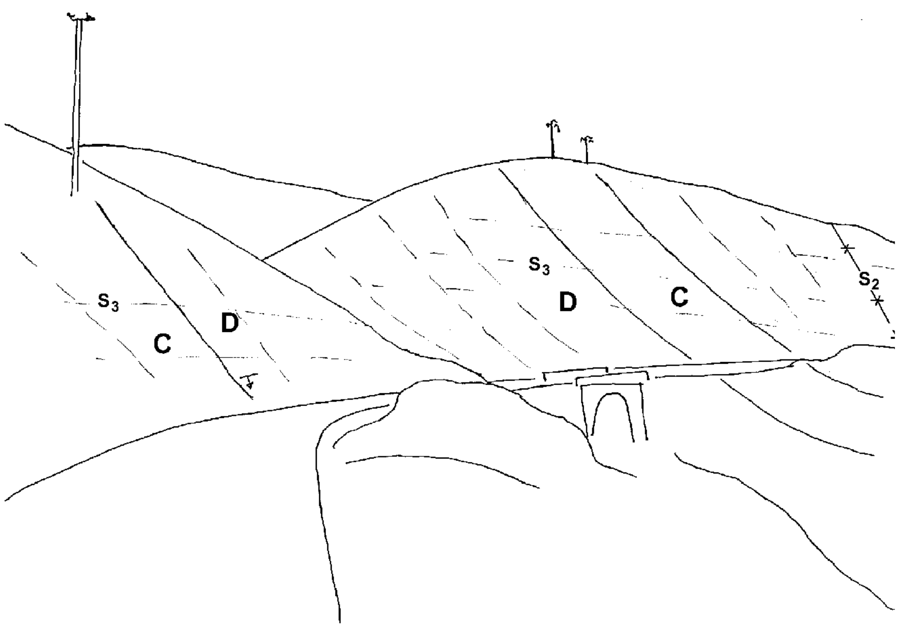

Fig 3 - General view of the Ogliera bridge area: the road crosses a tight syncline S_2 cut by S_3 crenulation cleavage. C- Calpionella Limestone, D- Mt. Alpe Cherts.

mm-spaced axial plane cleavage, often obliterated by thermometamorphism at the microscopic scale. Local intrafolial isoclinal rootless hinges and boudinaged layers of polycrystalline quartz are probably referred to primary cherty layers or to syntectonic veins. The deformed foliation, imprinted by thermometamorphic minerals, is dissected (also millimetric faults are present) by a spaced fracture cleavage likely referable to the discharge open folds; these fractures are filled by calcite; veins of calcite+quartz±adularia are also present.

We continue the road which runs along outcrops of metaophiolites (mainly serpentinites and minor gabbros) and of their metasedimentary cover. Near Mortigliano-Colle d'Orano we enter the Mt. Capanne monzogranite. At Zanca we turn to the left and go down to the sea at Capo Sant'Andrea Beach.

B) THE MONTE CAPANNE MONZOGRANITE

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Stop 4. *Capo Sant'Andrea-Punta del Cotoncello area.*

Petrology. The Mt. Capanne pluton (6.8-6.2 Ma, Ferrara and Tonarini, 1985, and references therein) and the related rhyolitic and aplitic dikes (8.5-7.2 Ma, Ferrara and Tonarini, 1985; Dini and Tonarini, 1997) are the oldest magmatic rocks cropping out in the Elba Island. The Mt. Capanne pluton intrudes ophiolitic and Jurassic to Cretaceous pelagic sedimentary successions, belonging to the so-called Complex IV of Trevisan. These rocks form a well developed thermometamorphic aureole all around the Mt. Capanne. The Mt. Capanne intrusion (Main Facies = *MF;* Poli, 1992) consists of a light-grey, medium-to coarse-grained hypidiomorphic monzogranite (Fig. 7).

MF commonly exhibits a marked inequigranular texture due to the occurrence of large karlsbad-twinned k-feldspar megacrysts (up to 10 cm along the c axis; Fig. 8). This peculiar texture can be observed in some outcrops along the outer portions of the pluton and especially at Capo Sant'Andrea, and is also typical of the external parts of other plutons of the Tuscan Archipelago (e.g., Giglio and Montecristo). Besides the megacrysts, *MF* is composed of perthitic orthoclase, quartz, plagioclase and biotite; apatite, zircon, tourmaline, sphene, and monazite occur as accessory phases. Furthermore, in some places the monzogranite contains abundant ellipsoidal, centimetric to decimetric, mafic microgranular enclaves. They commonly constitute 1-2% of the outcrop surface and, locally (e.g., Capo Sant'Andrea), mafic microgranular enclaves tend to increase in abundance and size, reaching metric dimensions. A leucocratic facies *(LF),* forming also the La Serra-Porto Azzurro stock, is randomly distributed inside *MF* of the Mt. Capanne pluton, and lacks any evidence of tectonic or intrusive contacts. *LF* consists of a fine- to medium-grained equigranular rock, ranging from monzogranite to syenogranite in composition (Fig. 7). The paragenesis is similar to *MF*, although with less biotite and plagioclase. Small amounts (<2 vol.%) of primary muscovite can also occur, but mafic microgranular enclaves are absent. It is possible to have a view of *LF* on the marginal portions of the Mt. Capanne pluton, between Colle d'Orano and Punta Nera. Leucocratic veins and dikes, from a few millimetres up to 2 metres in width, commonly crosscut both *MF* and *LF* of Mt. Capanne and La Serra-Porto Azzurro plutons as well as the subvolcanic bodies in the central part of the Island. They consist of microgranites, aplites and pegmatites *(MAP)*. Microgranites and aplites have a fine-grained texture and are composed of quartz, k-feldspar, plagioclase and muscovite±tourmaline±biotite. Pegmatites, on the other hand, have a coarse-grained texture and are composed of quartz, k-feldspar and tourmaline associated to a large variety of accessory phases. The Elba pegmatites are world-famous for their superb, museum quality minerals of polychrome tourmaline and k-feldspar, which

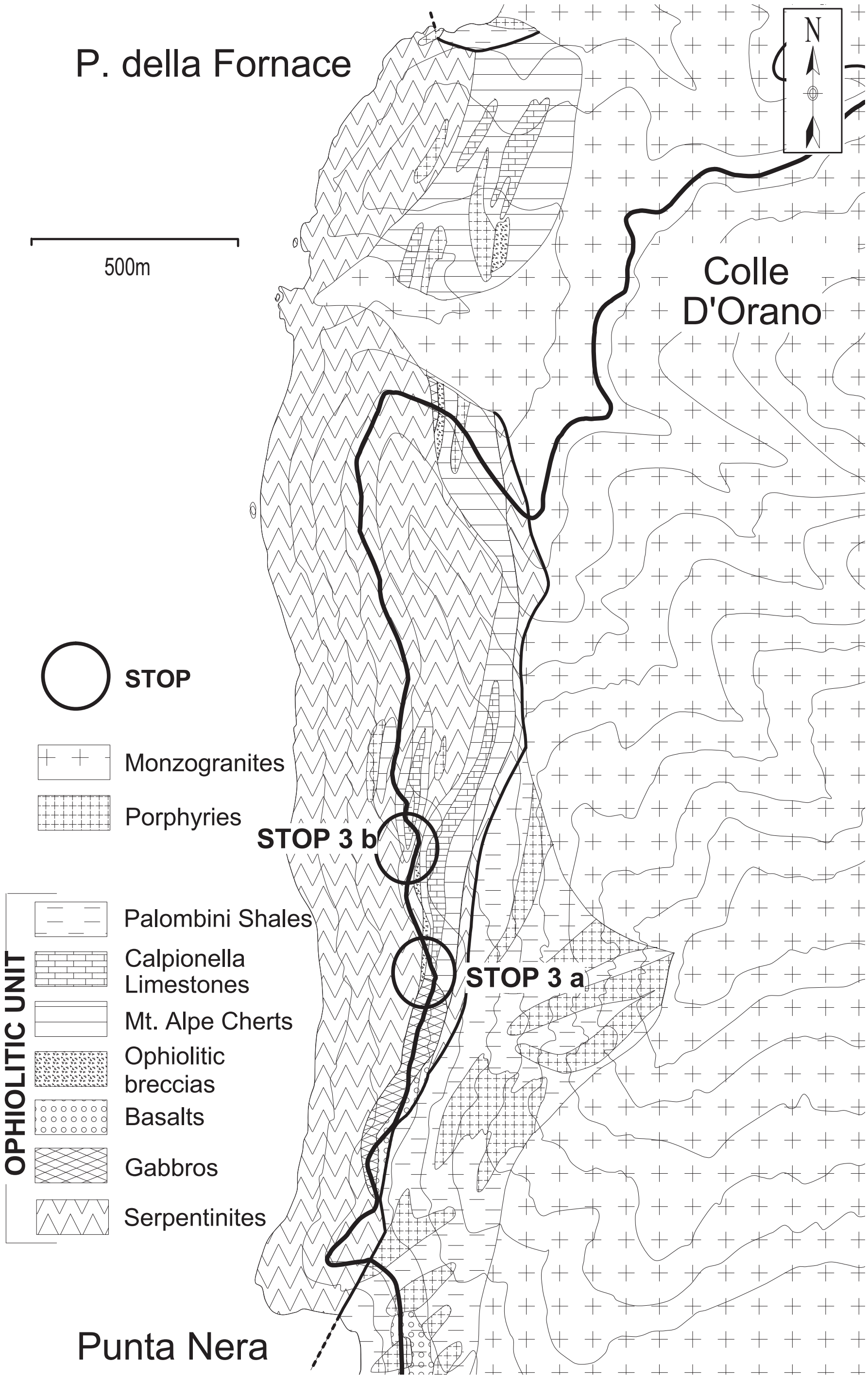

Fig. 4 - Geological map of the Punta Nera area.

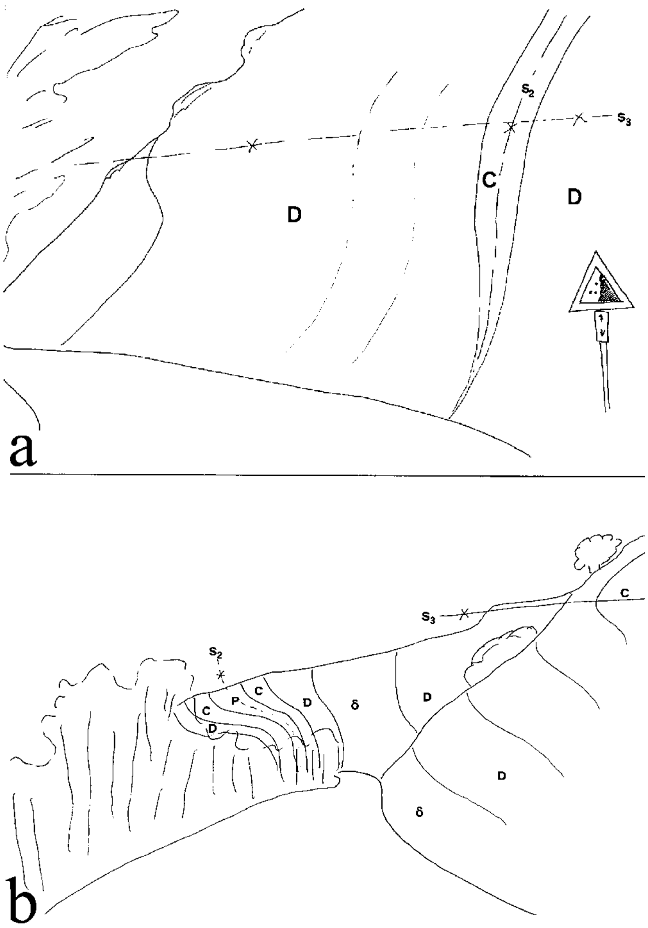

Fig. 5 - a. Nucleation of a D_2 syncline, gently refolded by a D_3 fold, related to the Mt. Capanne uplift, and westward discharge, on the road close to Punta Nera. b. Two D_2 synclines pre-dating the Mt. Capanne intrusion, at Punta Nera. Both synclines are flattened and refolded by a D_3 fold, facing westwards; in the cliff on the right-side of the road, an outcrop is cut into the late open fold. δ- serpentinites, D- Mt. Alpe Cherts, C- Calpionella Limestones, P- Palombini Shales.

can reach dimensions up to several decimetres. Besides *MAP,* some peculiar dikes crosscut the Mt. Capanne pluton near Orano, NW of Mt. Capanne, and at Capo Sant'Andrea. These dikes, hereafter named as Orano Dikes *(OD),* are different from *MAP* because of: (i) the dark-grey to greenish colour; (ii) the sinuous trending indicating that they were injected into the still molten monzogranite; (iii) the presence of mafic microgranular enclaves and k-feldspar macrocrysts, like the *MF;* (iv) the composition less evolved than *MAP* and *MF* (Table 1; Fig. 7). In Fig. 9 a 20 cm wide dike, from the *OD* cropping out at Capo Sant'Andrea is shown.

The Elba Island intrusive rocks have high $^{87}Sr/^{86}Sr_i$ (from 0.71464 to 0.71528) and low $^{143}Nd/^{144}Nd$ (from 0.51209 to 0.51212) (Juteau, 1984). These values, coupled with high $\delta^{18}O$ (i.e., 11.40-11.43; Taylor and Turi, 1976), and trace element data (Poli, 1992) are strongly suggestive for the crustal origin of the parental magmas. The *MF* and *LF* rocks from Elba rocks, however, are the less peraluminous of the overall Tuscan Archipelago and mainland crust-derived rocks (ASI = 1.01-1.16), and together with petrological and geochemical data establish that the monzogranite magmas of the Elba Island are not pure crustal melts, but are somehow contaminated via mixing and/or mingling with sub-crustal magmas (e.g., Peccerillo et al., 1987; Poli et al., 1989a; Innocenti et al., 1992; Poli, 1992).

Mafic microgranular enclaves *(ME*) are commonly present in *MF* of the Mt. Capanne pluton and in the *OD,* forming 1-2 vol.% of the outcrop surface. They consist of dark-grey, fine-grained rocks ranging from tonalite to monzogranite in composition (Fig. 7). They have ellipsoidal shapes and range from centimetres to some meters in size (Fig. 10). The accidental embodiment of k-feldspar megacrysts and plagioclase crystals from the host-granitoid gives *ME* a pseudoporphyritic texture, suggestive of a plastic behaviour during the incorporation into the host-granitoid magma. Fig. 11 shows the relations between *ME* and the host rock. Three main structures are generally encountered: a- k-feldspar megacrysts crosscutting the contact between the enclave and the host; b- k-feldspar megacrysts, completely surrounded by the enclave, leaving a trail with complex textures; c- enclaves exhibiting a schlieren-like trail, suggestive of movements inside the partially molten host. These characteristics, together with the ellipsoidal to rounded shapes, the cuspate margins, and the magmatic texture indicate that *ME* are fragments of mafic magmas injected and mechanically disrupted (mingling) into the host-granitoid magma (e.g., Bacon, 1986; Campbell and Turner, 1985; 1986; Poli and Tommasini, 1991).

The paragenesis of *ME* is similar to that of the host-granitoid (*MF*), although they have higher biotite and plagioclase contents. The chemical composition of the large plagioclase and k-feldspar crystals is identical to the corresponding mineral in the host-granite, pointing to a xenocrystic origin for these minerals which were incorporated into *ME* during the physico-chemical interaction between the basic and acid magmas (e.g., Vernon, 1984; Frost and Mahood, 1987; Poli et al., 1989a). *ME* can be readily distinguished from the angular and metamorphic enclaves occurring along the contacts between the Mt. Capanne pluton and the country rocks.

Structural analysis. The structural study allows to obtain the orientations of the internal structures of the different magmatic bodies cropping out in the western Elba Island and to compare them with the trend of dikes and fractures cutting the Monte Capanne pluton (Boccaletti and Papini, 1989).

The internal structures consist of planes and lineations, defined in the field by the average orientation of the enclaves and xenoliths present in *MF* and by the c-axes of k-feldspars (Fig. 8) and plagioclases, and by the (001) planes of biotites and muscovites (Pitcher, 1979; Marre, 1982). The fabric of the internal structures gives information on both the intrusive body shape and the emplacement conditions (Fernandez and Tempier, 1977; Fernandez et al., 1983). The internal structures, therefore, are the witnesses of the stresses the magmatic mass underwent during the uplift and solidification phases in the high crustal levels.

The internal structures formed during the emplacement of the magma, from a heterogeneous distribution of crystals and enclaves flowing in suspension in the melted mass, through higher viscosity states (crystal mush) to the complete solidification (Pitcher and Berger, 1972). Since the magmatic phase solidifies with continuity, foliations in granitoids may result from different mechanisms, such as magmatic flow, submagmatic flow, solid state deformations at high temperature, moderate and low temperature (Paterson et al., 1989). These authors suggest some criteria to recognise the foliation origin. For example, a pronounced parallelism of internal structures near the intrusion margins is a good indicator of magmatic foliation that can be used to infer the shape of the intrusive body, as the degree of mineral iso-orientation usually increases at the intrusion margins (e.g., Balk, 1937; Fernandez and Tempier, 1977).

In the of Mt. Capanne pluton, linear and planar structures can be determined by the iso-orientation of k-feldspar and biotite crystals both at micro- and mesoscale in the monzogranitic and in the porphyric bodies. Both biotite crystals and k-feldspar phenocrysts are good markers in the field of the internal structure fabrics because of their crystalline habitus, as the first tend to orient themselves according to the (001) planes and the second arrange themselves parallel to the (010) planes. Fig. 8 shows a spectacular alignment of k-feldspar megacrysts at Capo Sant'Andrea.

Linear structures can be also measured in the field through the iso-orientation of mafic microgranular enclaves *(ME*), which tend to assume ellipsoidal shapes during the emplacement phases, rotating the major axis subparallel to the direction of the maximum strain (Marre, 1982; Ramsay, 1989).

Dikes and fractures develop during the cooling phases. Dikes in the Mt. Capanne pluton, which are usually microgranitic or aplitic,

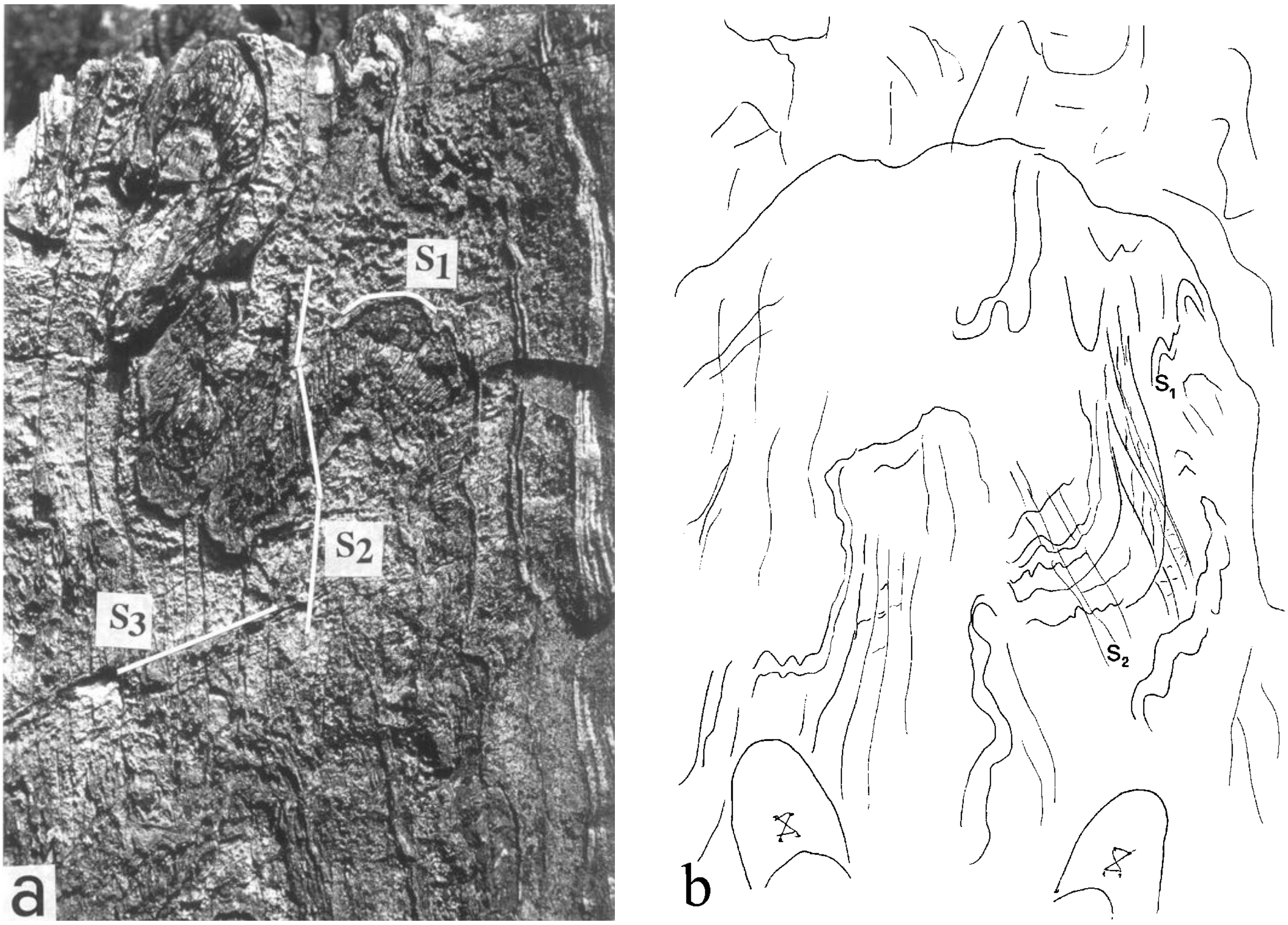

Fig. 6 - Structural features of the cherty limestone (Calpionella Limestones): a) Cleavage refractions of the spaced S_2 crenulation cleavage (looking down the plunge of the folds axis) which is gently folded by the D_3 event (S_3 cleavage); b) intrafolial isoclinal rootless hinges recording the occurrence of an older tectono-metamorphic deformation event.

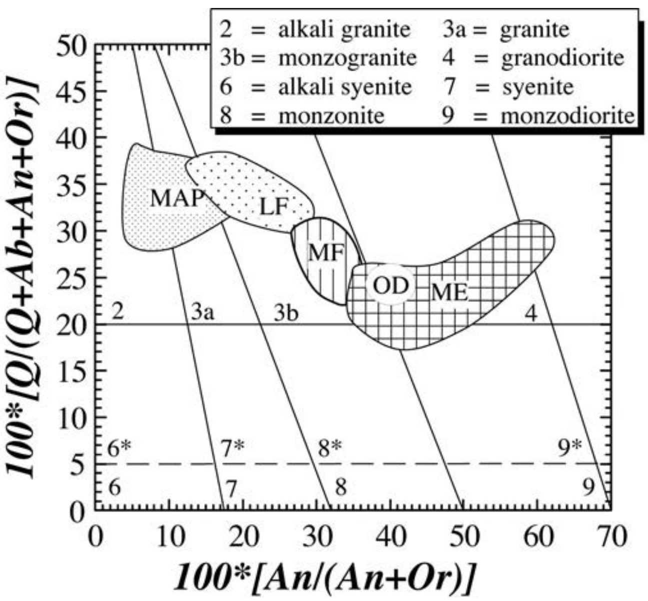

Fig. 7 - Normative classification diagram (after Streckeisen and Le Maître, 1979) for the Mt. Capanne and La Serra-Porto Azzurro magmatic bodies. Data from Juteau, 1984; Juteau et al., 1984; Peccerillo et al., 1987; Poli et al., 1989b; Poli, 1992. Numbers with asterisks refer to rock names with quartz- as prefix.

are persistently iso-oriented in the external part of the intrusion. They have radial and concentric attitude, showing regular angular relationships with respect to the internal structures, so that they have been classified as longitudinal and cross joints (Balk, 1937). When metric to decametric dikes have been sampled, the iso-orientation of the crystals both in and near the dike parallelises to its maximum elongation, as can be seen, for example, at Capo Sant'Andrea (Fig. 9).

Both biotite crystals and k-feldspar megacrysts may display flow structures and accumulations in the monzogranite that indicate a rapid cooling. Their presence is not very common and they are usually developed near the monzogranite margins, as can be seen at Punta del Cotoncello (Figs. 12 and 13).

Altogether, the internal structures of the monzogranite delineate an arcuate pattern near the margins, indicating that the entire pluton crops out. This is also confirmed by the presence of flow structures near the monzogranite margins (e.g., Capo Sant'Andrea-Punta del Cotoncello area) and by the attitude of the dikes. Only in the eastern part of the monzogranite the internal structures do not rotate, instead, they show a constant WNW-ESE direction, which allows to infer that the monzogranitic mass is not completely cropping out, but probably continues under the country rocks and the alluvial deposits to the east. In the internal part of the monzogranite the magmatic foliation evidences two magmatic domes, corresponding to the Giove and Capanne peaks.

The internal structures of the sub-volcanic Marciana porphyries reveal a fan distribution of the magmatic foliation, indicating that they intruded the monzogranite through an extensional fracture NE-SW oriented. The aplitic masses, which crop out in the axial

Fig. 8. - Macroscopic texture of the external portions of the Mt. Capanne pluton, where *MF* is typically enriched in euhedral k-feldspar megacrysts. These megacrysts respond to high-volatile conditions of the acid end member, in the early phases of crystallisation (Vernon, 1986). This is testified by their accidental inclusion in the large mafic enclaves that can be observed at Capo Sant'Andrea, which represent a remnant of a partially mingled and mixed sub-crustal end-member. Note the iso-orientation of the k-feldspar megacrysts (see text for explanation).

Fig. 9 - Orano mafic dike at Capo Sant'Andrea. Note the sinuous trending, and the iso-orientation of c-axis of k-feldspar megacrysts in the host. These characteristics were generated by injection of mafic magma in a crystal-mush represented by the Mt. Capanne Monzogranite.

Fig. 10 - Macroscopic texture of the external portions of the Mt. Capanne pluton at Capo Sant'Andrea. Large ellipsoidal to irregular shaped light grey mafic enclaves are shown. It is also evident the presence of large k-feldspar crystals in both *MF* and enclaves. In the latter case the k-feldspar crystals represent xenocrysts witnesses of the mixing process. Note also the irregular rounded to cuspate contact between the enclaves and the host rocks, which suggest that both enclaves and host were molten at the moment of inclusion (e.g., Vernon, 1984; Bacon, 1986; Poli and Tommasini, 1991).

Table 1 - Chemical and isotopic data for the Elba Island magmatic rocks

	Monte Capanne					Porto Azzurro		
PFacies	MF	LF	MAP	ME	OD	Shosho	LF	MAP
SiO_2	68.6	72.1	75.4	64.4	65.3	49.8	70.6	73.9
TiO_2	0.48	0.30	0.05	0.73	0.55	0.78	0.41	bdl
Al_2O_3	15.4	15.7	13.7	17.4	16.4	15.4	15.9	17.0
F_2O_3	2.93	bdl	0.62	0.91	3.94	2.22	1.78	0.16
FeO	n.d.	2.00	n.d.	3.44	n.d.	4.28	0.84	0.40
MnO	0.05	0.03	0.04	0.08	0.07	0.12	0.03	0.02
MgO	1.28	0.51	0.37	1.10	2.13	6.13	0.74	0.16
CaO	2.61	1.36	0.53	3.15	3.50	6.94	1.37	0.07
Na_2O	3.26	3.25	3.57	4.46	3.39	1.86	3.05	1.39
K_20	4.03	5.08	4.91	3.49	3.77	3.80	4.00	4.92
P_2O_5	0.14	0.21	0.03	0.32	0.17	0.14	0.10	bdl
LOI	0.38	0.48	0.75	0.62	0.82	8.52	1.04	1.94
Mg-V	50.5	34.8	58.2	35.1	55.8	67.2	38.9	38.2
Sc	8	4.5	5	9.1	10			
V	36	-	-	-	49	173	33	6
Cr	34	10	-	56	46	349	37	bdI
Co	7	3.7	6.5	5	5.8	24	3	bdl
Ni	14	-	-	-	29	27	13	10
Zn	57	-	-	-	-	75	40	19
Rb	261	428	365	282	236	191	215	410
Sr	198	125	26	202	254	190	158	7
Y	22	18	24	26	22	19	22	29
Zr	140	139	35	204	153	132	108	39
Nb	12	21	27	16	9	6	5	10
Ba	374	284	32	365	324	630	337	145
La	50	26	8.4	32	39	24	24	bdl
Ce	59	42	15	64	63	51	50	25
Nd	39	22	7.4	29	41	21	25	8
Sm	4.0	6.1	2.9	6.5	7.0			
Eu	1.27	0.72	0.17	0.87	0.98			
Tb	0.74	0.44	0.52	0.55	0.78			
Yb	2.00	0.96	1.90	1.50	1.90			
Lu	0.38	0.12	0.40	0.34	0.34			
Hf	5.5	3.2	1.9	3.3	4.4			
Ta	2.5	3.9	20.0	1.3	2.4			
Pb	52	-	-	-	-	38	47	15
Th	32.0	18.2	9.3	19.0	23	12	34	36
$(^{87}Sr/^{86}Sr)i$	0.71533	-	0.71516	0.71292	0.71132	-	-	-
$(^{143}Nd/^{144}Nd)i$	0.51213 -	-	-	-	0.51220	-	-	-
$^{206}Pb/^{204}Pb$	18.728	-	18.734	18.723	18.730			
$^{207}Pb/^{204}Pb$	15.704	-	15.694	15.699	15.714			
$^{208}Pb/^{204}Pb$	39.015	-	38.965	39.007	39.024			
$d^{18}O$‰	14.30	-	-	-	-			

Legend: MF- Main Facies; LF- Leucocratic Facies; MAP- Microgranite and Aplite dikes; ME- Microgranular Enclaves; OD- Colle d'Orano dikes; Shosho- shoshonitic dikes; bdl- below detection limit: Mg-V- 1OO*[Mg/(Mg+85*Fe)]. Initial values of $^{87}Sr^{86/}Sr$ and of $^{143}Nd/^{144}Nd$ were calculated at an average age of 7.0 Ma; Data are from: Taylor and Turi, 1976; Juteau, 1984; Juteau et al., 1984; Poli et al., 1989b; Poli, 1992; Conticelli et al., 2000.

zone of the Marciana porphyries, intruded the porphyries successively, as evidenced by the structural analysis. Thermometamorphism of the porphyries accompanied this intrusion.

The radiometric data of Ferrara and Tonarini (1985) do not confirm this succession of events, but new datings performed with the $^{39}Ar/^{40}Ar$ method, are in good agreement with the succession of events argued from the structural analysis (Boccaletti et al., 1987).

The relationships between the three main lithologies (monzogranite, porphyry masses, and aplitic dikes) and their evolution are schematised in Boccaletti and Papini (1989).

At Capo S. Andrea, walking along the left-hand side of the beach, it can be possible to view a WNW-ESE trending mafic dike that crosscuts the monzogranite (Fig. 9). The contact is sharp, although in proximity of the contact, inside the host-granite, several metre-sized mafic enclaves can be found (Figs. 10 and 11). The dimensions and number of these enclaves gradually decrease walking away from the contact. This feature can be interpreted as the disruption of the mafic magma during injection into the still partially molten host-granite. In addition, it is worth noting that the monzogranite in this particular area has large k-feldspar megacrysts, with *c*-axis up to 20 cm, aligned along the flow lines of the magmatic intrusion.

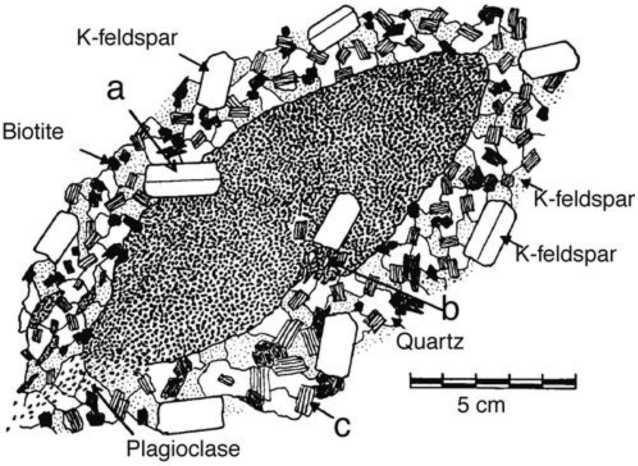

Fig. 11 - Cartoon showing the main textural characteristics of the enclave-host contact. For explanation see the text.

Fig. 12 - Accumulations and fluidal structures determined by k-feldspar phenocrysts in the monzogranite at Punta del Cotoncello

We walk back and reach Punta del Cotoncello, on the right-hand side of the beach. At Punta del Cotoncello the iso-orientation of the *c*-axis of k-feldspar megacrysts is also evident. Accumulations of k-feldspar megacrysts and fluidal whirling structures evidenced by both biotites and k-feldspar phenocrysts are visible (Figs. 12 and 13). The presence of these features indicates a rapid cooling at the margins of the pluton.

Fig. 13 - Fluidal whirling structures (schlieren) evidenced by biotite crystals at Punta del Cotoncello: a peculiar feature of this zone, due to the rapid cooling.

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