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THE EVOLUTION OF ALPS, APENNINE AND TYRRHENIAN BASIN: CONTRIBUTION FROM PETROLOGY, GEOCHEMISTRY AND STRUCTURAL GEOLOGY

Workshop in memory of Piera Spadea, Giuseppe Cello and Lauro Morten

Cosenza, June 7-9, 2007

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MESOZOIC TO PRESENT TECTONO-MAGMATIC EVOLUTION OF THE CENTRAL-WESTERN MEDITERRANEAN AREA

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Triassic magmatic rocks, spatially associated with Jurassic ophiolites, are distributed along the Apennine-Alpine-Dinaride-Hellenide orogenic belts around the Adria continental plate. They can be related to a rifting phase precursor of the Jurassic oceanization that produced multiple oceanic basins: the Western Tethyan (Ligure-Piemontese) basin at the western margin, and the Serbian, Mirdita-Pindos basins of the Subpelagonian Zone at the eastern Adria margin.
The western ophiolites of the Alpine-Apennine system up to the Betic orogenic belt display exclusively MORB (Mid-Ocean Ridge Basalt) affinities and structural features which indicate discontinuous oceanic crust generation along a "slow-spreading" system characterized by passive lithospheric extension and tectonic denudation of large sectors of subcontinental mantle peridotites.
In contrast, the Subpelagonian Zone ophiolitic complexes are characterized by the juxtaposition of two subparallel belts, of MORB-type to the west, and of Supra Subduction Zone-type (SSZ) to the east, implying the development of intra-oceanic subduction processes within a pristine oceanic basin located between the Adria and Pelagonian continental blocks.
Subsequently, the Cenozoic volcanic provinces of the Central-Western Mediterranean appear to be related to the evolution of a series of subduction zones formed during Africa-Eurasia convergence, including the relative migration of trench-arc systems, opening of inter-arc basins, and the development of post-collisional, as well as within-plate (impactogenic) rifts. They belong to two main tectono-magmatic associations: 1) orogenic, subduction-related volcanism in Sardinia (Oligo-Miocene), Eolian Arc, and Roman Magmatic Province (RMP); 2) anorogenic suites in Sardinia and Iblei-Etna-Sicily Channel (Neogene-Quaternary), as well as Veneto Volcanic Province (Paleogene).
The space-time distribution and petrogenetic affinity of orogenic magmatism from Provence/Sardinia to the Eolian Arc and RMP, can be best accounted for by a single "evolutionary process of subduction", starting from the Middle-Late Eocene beneath the Paleo-European continental margin and migrating southeastward with time through the opening of the Ligurian-Balearic and Tyrrhenian interarc oceanic basins. In the eastern peri-Tyrrhenian border, post-collisional intensive lithospheric rifting and tectonic collapse of the Apennines generate large amounts of Pliocene-Quaternary orogenic magmas which overlie a nearly vertical subducted slab. This magmatism includes the Roman Magmatic Province sensu lato (RMP-s.l.) and the Internal Apennines Volcanism (IAV), and consists of high-K calcalkaline, potassic (shoshonitic) and ultrapotassic (leucitites, leucite basanite and minor lamproites and kamafugites) products. Integrated petrological and geochemical studies of these rocks (and associated mantle xenoliths) indicate that most of them could have been generated by a restricted partial melting range (F < 5-10 %) of extremely inhomogeneous phlogopite-veined lithospheric mantle sources, resulting from subduction related K-metasomatic processes. Moreover, the presence of both intermediate anorogenic and subduction related geochemical features in Mt. Vulture magmas support the existence of a slab window beneath the central-southern Apennines, which could have allowed inflow of subduction components to intraplate mantle sources. This slab discontinuity may mark the transition between the already collisioned Adriatic and the still subducting Ionian lithospheric slabs.
Extension-related anorogenic volcanism of Iblei-Etna-Sicily Channel and Veneto mainly consists of basic magmas ranging in composition from tholeiites to Na-alkali basalts/hawaiites, basanites and nephelinites. In Sardinia, the Pliocene-Quaternary volcanism produced comparatively more potassic magmas: from subalkaline basalts, alkali basalts/trachybasalts to basanites, locally associated with rhyolitic and phonolitic differentiates. The ubiquitous presence of the HIMU geochemical component in all these volcanic products, irrespective of their belonging to the European or North African domains, lends support to the existence of a Cenozoic asthenospheric mantle plume - supposed to extend from the eastern Atlantic to Central Europe and western Mediterranean - which could therefore represent the provenance of this component.

THE STUDY OF ULTRAHIGH PRESSURE METAMORPHISM (UHPM) IN COLLISIONAL OROGENS AND ITS CONTRIBUTION TO THE EARTH'S SCIENCES

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The occurrence of coesite in continental crust (Chopin, 1984), once considered as a mineralogical oddity, is now envisaged as a rule in most collisional orogens.
The peculiarity of UHPM is that, in lack of a careful petrographic study it is difficult its identification since the index minerals (coesite and microdiamond) and structures are totally destroyed during the post-climactic exhumation and replaced by lower-P greenschist- or amphibolite-facies mineral assemblages. Therefore, the UHP index minerals escaped to retrogression mostly occur as micro-inclusions armoured (and then preserved) in less significant but stronger phases (such as garnet, Na-pyroxene, kyanite, zoisite), which may be unambiguously identified by means of more sophisticated analytical techniques (such as Microraman Spectroscopy and TEM).
In the last 20 years, the multidisciplinary studies on the UHPM, including petrology, geochemistry geochronology, and stable isotopes, provided new and stimulating discoveries that contributed to shed light on some Plate Tectonics mechanisms at convergent margins. It was of special interest the results of the study of the fluid-rock interactions during the deep subduction of both continental and oceanic lithosphere, a process of paramount importance to understand the magma generation at convergent margins.

STRUCTURE OF THE SOUTHERN APENNINES: GEOLOGICAL, GEOPHYSICAL AND THERMOCHRONOLOGICAL CONSTRAINTS

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In the southern Apennines fold and thrust belt, thermochronological indicators record exhumation of sedimentary units from depths locally in excess of 5 km during the last 10 Ma. Integrated field geology and subsurface information indicate markedly different shallow and deep structural styles. The shallow part of the thrust belt includes both Mesozoic-Tertiary carbon-

ate platform and pelagic basin successions, together with unconformable Miocene siliciclastics. Collectively these units, completely detached from their original substratum, form a highly displaced allochthon that has been carried onto a footwall carbonate succession essentially continuous with that of the foreland Apulian Platform. The footwall carbonates (6-8 km thick) are deformed by open folds, associated with relatively low-displacement reverse faults involving the basement. Therefore, a switch from thin-skinned to thick-skinned thrusting occurred as the Apulian Platform carbonates – and the underlying thick continental lithosphere – were deformed during the latest shortening stages. Apatite fission track data, showing cooling ages ranging between 9.2±1.0 and 1.5±0.8 Ma, indicate that exhumation marks these recent orogenic stages, probably initiating with the buttressing of the allochthonous wedge against the western margin of the Apulian Platform. Pliocene-Pleistocene foreland advancing of the allochthonous units largely exceeds the total amount of slip that, based on cross-section balancing and restoration, could be transferred from the buried Apulian Platform carbonates to the overlying allochthon. This suggests that emplacement of the allochthon on top of the hinterland portion of the Apulian Platform carbonates was followed by gravitational readjustments within the allochthonous wedge, coeval – and partly associated with – thick-skinned shortening at depth. The related denudation processes are interpreted to have played a primary role in tectonic exhumation.

MANTLE PROCESSES IN THE LITHOSPHERE: THE STUDY CASE OF PERIDOTITES FROM THE JURASSIC LIGURIAN TETHYS.

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Orogenic peridotites, cropping out as km-size bodies in collisional belts, represent unique study cases to enravel the mantle processes they underwent after isolation from the convective asthenosphere and accretion to the thermal lithosphere.
Alpine-Apennine ophiolitic peridotites derive from the oceanic lithosphere of the Jurassic Ligurian Tethys: they were exhumed from the sub-continental mantle lithosphere to the sea-floor during the lithosphere extension leading to the opening of the oceanic basin. During exhumation lithospheric peridotites were percolated by diffuse and focused porous flow by MORB-type melts. Appearance of MORB melts in the extending system during Jurassic times strongly suggests that lithosphere stretching and thinning, already active during Triassic times, induced almost adiabatic upwelling of the underlying asthenosphere and its partial melting on decompression. Accordingly, lithosphere extension, asthenosphere partial melting, melt percolation and intrusion in the mantle lithosphere were closely related and mutually dependent (Piccardo, 2007; Piccardo et al., 2007, and references therein). Melt-peridotite interaction transformed pristine mantle protoliths from the sub-continental lithosphere to different types of granular rocks, hereafter referred to as *reactive*, *impregnated* and *replacive peridotites*.
Reactive spinel (Sp) peridotites crop out on km-scale areas and show granular textures with variable grain size. They consist of pyroxene-depleted Sp harzburgites and dunites showing peculiar micro-structures indicating: (1) peridotite interaction with pyroxene(-silica)-undersaturated melts; (2) incipient crystallization of the percolating melts. They show a significant decoupling between bulk and mineral major and trace element compositions. Model calculation indicates that the percolating melts, corresponding to MORB-type melt increments formed by rather low degrees (1-5%) of fractional melting on (-garnet)-Sp-facies DM asthenospheric mantle sources.
Impregnated plagioclase (Plg) peridotites crop out as km-scale areas and are significantly enriched in Plg (up to 15-20% by vol.). Peculiar microstructures indicate peridotite interaction with silica-saturated melts and their interstitial crystallization. Model calculation indicate that percolating liquids were single melt increments with MORB affinity generated by 1-6% fractional melting of Sp-facies DM asthenospheric sources (Piccardo et al., 2007; Piccardo and Vissers 2007).
Replacive spinel peridotites are spinel harzburgites and dunites and crop out in the form of m-scale to decameter-scale bands, which sporadically contain single crystals or veins of new Cpx, up to a few cm in diameter and poikylitic on olivine (Ol), cm-scale euhedral Cpx and fuzzy pyroxenite and gabbroic dykelets (Piccardo et al., 2007). Cpx composition indicates that they attained chemical equilibrium with liquids varying in composition from Normal to slightly LILE-enriched MORB (Piccardo et al. 2007). Some replacive harzburgite channels were preferential ways for upward migration of melts showing alkaline affinity, as indicated by the composition of interstitial magmatic Cpx (Piccardo et al., 2007).
On the basis of field evidence on the mutual relationships of the different rock types (i.e. *the different mantle processes they record*), the composite scenario of mantle processes accompanying exhumation of the lithospheric mantle at an extensional, pre-oceanic, setting is proposed.

References

Piccardo G.B., 2007. The Jurassic Ligurian Tethys, a fossil ultra-slow spreading ocean: the mantle perspective. Geol. Soc. London, Spec. Publ., in press.

Piccardo G.B., Zanetti A. and Müntener O. 2007. Melt/peridotite interaction in the Lanzo South peridotite: field, textural and geochemical evidence. Lithos, 94 (1-4): 181-209.

Piccardo G.B. and Vissers R.L.M., 2007. The pre-oceanic evolution of the Erro-Tobbio peridotite (Voltri Massif - Ligurian Alps, Italy). J. Geodyn., in press.

THE NORTHERN CALABRIA HERCYNIAN CONTINENTAL LITHOSPHERIC SECTION

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The Calabride complex (Ogniben, 1969) or Sila nappe (Bouillin, 1984) occupies the highest geometric position in the Northern Calabria nappe stack. In the past this thrust sheet was subdivided in a considerable numbers of tectonic units, however the age and natures of the tectonic contacts has been debated. New data allow to define the Calabride thrust sheet cropping out in Catena Costiera and Sila as a single structural element consisting of a continuous continental lithospheric section, structured during Hercynian-late Hercynian time and passively remobilized during Tertiary.
The geothermobarometry data shows a metamorphic gradient increasing from east to west. According to these data the deepest parts of the lithospheric section outcrop in the northern Catena Costiera and in the northwestern edge of the Sila massif (Piluso and Morten, 2004). These portions are constituted by strongly serpentinized peridotites, migmatites, granulites and Grt-gneiss. The contact between mantle and crustal rocks is marked by mafic granulites representing underplating gabbroic magmatism. Towards east, in the Sila massif, the huge late-Hercynian granitoid batholiths intruded at the contact between lower-intermediate crustal rocks and the shallower crustal levels on which mesozoic rift related sedimentary sequences were deposited.
The physical conditions inferred from deepest crustal rocks are 0.9-1.1 Gpa, P and 750-800°C, T for granulitic metamorphic climax (Piluso and Morten, 2004). Graessner and Schenk (2001) calculate values of 0.6 GPa at 770°C and of 0.4 GPa at 740°C for rocks cropping out in the western and in the eastern part of the Sila massif, respectively. In both Sila and Catena Costiera after metamorphic climax an adiabatic decompression occurs with ΔP of 0.2 - 0.4 GPa. The P-T path document a post-Hercynian thermal anomaly, likely due to an astenospheric upwelling that caused partial melting in the upper mantle. The upper mantle partial melting probably is responsible of the underplating magmatism that produced gabbro intrusions during decompression. Geochronological data on gabbros are lacking, however a Permian age can be assumed by comparison with underplating magmatism documented in the Alps (Malenco-Ivrea-Sondalo). These thermobarmetric data depict an extensional tectonic event earlier precursor of Tethyan rifting.

References

Bouillin J.P., 1984. Nouvelle interprétation de la liasion Apennin-Maghrébides en Calabre; conséquences sur la paléogéographie tethysienne entre Gibralter et les Alpes. Rev. Géol. Dyn. Géogr. Phys., 25: 321-338.

Graessner T. and Schenk V., 2001. An exposed Hercynian deep continental crustal section in the Sila massif of northern Calabria: mineral chemistry, petrology and a P-T path of granulite facies matapelitic migmatites and metabasites. J. Petrol., 42: 931-61.

Piluso E. and Morten L., 2004. Hercynian high temperature granulites and migmatites from the Catena Costiera, northern Calabria, southern Italy. Per. Mineral., 73: 159-72.

PALEOGEOGRAPHIC, PALINSPASTIC AND KINEMATIC CONSTRAINTS AND SPECULATIONS ON THE SIZE OF THE LIGURIAN OCEANIC CRUST. IMPLICATIONS FOR THE CONVERGENT PHASE.

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A major element for reconstructing the geodynamic evolution of the Western Tethys area is to provide a reasonable guess for the dimensions (length, width, and possibly thickness) of the Ligurian oceanic crust. The Ligurian oceanic basin (LOB) separated in the Jurassic and Cretaceous the Europe and Iberia plates to the NW from the Adria block to the SE and disappeared during convergence between Europe and the Adria-Africa Plate. The ophiolite and radiolarite rocks of the Alps and Apennines that testify the existence and suture of this ocean basin give a Middle-Late Jurassic time span for the spreading stage.
Several data, methods and lines of evidence can be utilized to speculate and obtain a guess for the LOB size:

a) the duration of ophiolitic magmatism given by the radiometric ages from gabbros and plagiogranitic dykes and by the basal biostratigraphic ages of the radiolaritic cover;
b) the kinematic divergent path (distance) traveled by Eu + IB and AF + AD during LOB opening;
c) palinspastic restorations and shortening estimates of the oceanic Ligurian Units;
d) age and type of Tyrrhenian calcalcaline magmatic arc products correlatable to subduction of oceanic crust, seismic tomography data and modelling.

a) radiolarian biostratigraphic data from the base of cherts lying in sequence directly on top of the Ligurian basalts and radiometric ages on gabbroic and plagiogranitic rocks give constraints on the time span during which gabbro-basalt magmatism occurred. Confronting the radiolarian (late Bajocian-early Kimmeridgian) and radiometric (164 to 150 Ma) ages we obtain a minimum time span of 10 Ma and a maximum of about 30MA for the duration of oceanic magmatism. Whether this magmatism was representative of classic MOR spreading processes is indeed debatable, although the clear MORB geochemical affinity of the Internal Ligurian ophiolites proves the true oceanic nature at least for the central part of the basin.
b) kinematic data. Several reconstructions of the EU/AF motion, based on the Atlantic paleomagnetic data give constraints on the maximum length and velocity of the EU/AD path. For the early opening stage (Late Jurassic), most authors assume a joint motion between Africa and its Adria promontory, hence we can take the EU/AF velocity (2-4cm/yr) and length of path traveled (400-600km) as maximum figures also for the EU/AD motion (see Schettino and Scotese, 2002). If we consider the presence of a transcurrent rail separating Africa from Adria, these figures would be considerably reduced. A reasonable estimate for the LOB spreading which accounts also for geolocic data is 250 km width at < 1cm/yr rate.
c) palinspastic restorations with balanced cross sections of the oceanic (Ligurian) units are not available and would be very hard to calculate, due to their intense tectonic disruption and unrooted basement. However, we can obtain a guess considering the upper crustal balanced cross sections available for the orogenic units of the Tuscan continental cover involved in collision that give 50% average shortening (see Finetti et al., 2001). This could provide a minimum figure also for the more deformed and internal Ligurian Units that lay on oceanic basement.
   As a test for dimensions of the accreted part of LOB we can try to calculate the 'unrolled' (if not balanced) width of the Ligurian Units, parallel to the Apenninic vergence. We can also include the Ligurian Units deprived of their oceanic? basement, the metamorphic ophiolitic units of Corsica and those buried in the Tyrrhenian Sea and utilize the average crustal shortening data from the collisional belt.
   Utilizing these data we obtain an average width of the 'unrolled' oceanic crust of 100km for a northern (Liguria) section and 300km for a southern section (Corsica-Tuscany). If convergence was very oblique (as hypothesized by several Authors) these estimates would not represent necessarily a minimum width.
d) Calcaline magmatic arc products, seismic tomography and modelling.

We can obtain a guess for the amount of subducted oceanic crust also comparing the data on back-arc calcalcaline magmatism of Sardinia and offshore Corsica that can be related to subduction of the Ligurian oceanic crust, and also we can confront the present tomography sections and modeling across the Tyrrhenian Sea that show the deeper (possibly oceanic) segment of subducted Apenninic crust (Faccenna et al., 2001). All these data seem to constrain the length of subducted LOB crust to a maximum of very few hundred km.
Finally a synthesis of all the geological characteristics of the Ligurian Units (type of oceanic crust, petrography, tectonics, orogenetic processes and accretionary tectonics) can help to complete the picture of this demised ocean.
We will be glad to host an open discussion on the above speculations and on the following open problems:

1) was the Ligurian-Piedmont basin crust truly oceanic, or for the most part was it exposing subcontinental mantle covered by scattered basalt volcanism ?
2) was the role of lateral (transcurrent) motion overpassing the orthogonal component in both divergence and convergence between the Iberia and Adria plates? This role implies a non-cylindric approach in the palinspastic reconstructions.

References

Faccenna C., Funiciello F., Giardini D. and Lucente P., 2001. Episodic back-arc extension during restricted mantle convection in the Central Mediterranean. Earth Planet. Sci. Lett., 187: 105-116.

Finetti I., Boccaletti M., Bonini M., Del Ben A., Geletti R., Pipan M. and Sani F., 2001. Crustal section based on CROP seismic data across the North Tyrrhenian-Northern Apennines-Adriatic Sea. Tectonophysics, 343:135-163.

Schettino A. and Scotese C., 2002. Global kinematic constraints to the tectonic history of the Mediterranean region and surrounding areas during the Jurassic and Cretaceous. In: Rosenbaum and Lister, Reconstruction of the evolution of the Alpine-Himalayan Orogen. J. Virtual Explorer, 8: 149-168,

TECTONIC EVOLUTION OF THE CENTRAL MEDITERRANEAN FROM THE MESOZOIC TO THE PRESENT

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The tectonic evolution of the central Mediterranean region has been traced through a quantitative kinematic model, based on: *a*) A new Pangea fit for the late Ladinian (230 Ma), together with a plate motions model of the break-up of this supercontinent from the Middle Triassic to Chron M25 (Schettino and Turco, in preparation); *b*) A recent kinematic model for the evolution of the Western Mediterranean region during the Late Oligocene to Early Miocene (33 - 19 Ma) interval (Schettino and Turco, 2006); *c*) A new set of tectonic reconstructions for the opening of the Tyrrhenian basin (Turco and Schettino, in preparation).
In the proposed fit of Pangea the Adriatic promontory has been offset eastward with respect to the African Plate to avoid a large overlap with the Eurasian Plate. The model of break-up of Pangea predicts that from the late Ladinian (230 Ma) to the Middle Norian (210 Ma) the Atlantic rift propagated along the Saharan and Tunisian Atlas up to intersect the Ionian basin, which was possibly still subject to the early phase of spreading (Permian to Early Triassic). In this instance, the old ridge was forced to re-orient according to the new spreading direction.
Furthermore, the northern margin of the Permo-Triassic Ionian basin was affected by a new rifting event, recorded into Mt. Facito Formation (Lagonegro succession) (Fig. 1).
During the next stage, from the middle Norian (210 Ma) to the Pliensbachian (185 Ma), the Ionian spreading center became extinct and Adria-Apulia started to separate from the Eurasian Plate to form a promontory which remained by then fixed to Africa. This new, more northern, rifting phase, affected the Carnian-Norian carbonate platforms that were developed along the European margin of the Ionian basin, the La Spezia area and the Lombard basin. It was along this rift zone that the Ligure-Piemontese ocean developed during the Jurassic, a process that led to the formation of a narrow continental slice separating the oldest Ionian basin from the new Ligure-Piemontese rifted area. This slice of thinned continental crust hosted the Panormide platform (Fig. 2). To the North, during the Sinemurian (195 Ma), the break-up of the Calcare Massiccio platform formed the Toscana-Umbria-Marche basin.

Fig. 1 - Plate tectonic reconstruction of the late Ladinian (230 Ma) fit of Pangea and plate motions model for the late Ladinian-middle Norian stage. Legend key for all figures: **AT**- Atlantic Rift; **IB**- Iberian Plate; **IN**- Ionian Ocean; **PD**- Pindos basin; **IM**- Imerese basin; **LA**- Lagonegro basin; **LP**- Ligure-Piemontese Ocean; **PA**- Panormide platform; **AS**- Atlas Rift; **VA**- Valais Ocean; **SA**- Sardinia; **CO**- Corsica; **PR**- Ligure-Provençal basin; **AC**- Calabria.

Fig. 3 - Plate tectonic reconstruction of the early Kimmeridgian (155 Ma) and plate motions model for the middle Pliensbachian-early Kimmeridgian stage. See Fig. 1 for the legend key.

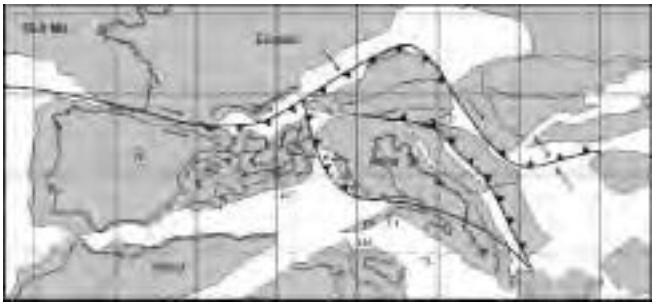

Fig. 5 - Plate tectonic reconstruction of the Early Eocene (55 Ma) and plate motions model for the Ypresian stage. See Fig. 1 for the legend key.

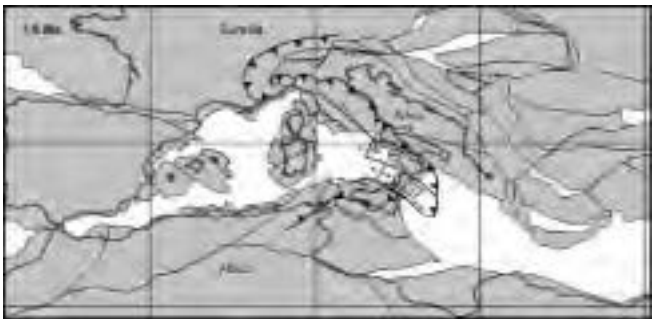

Fig. 7 - Plate tectonic reconstruction of the Early Pleistocene (1 Ma) and plate motions model for the Late Pliocene-Early Pleistocene stage. See Fig. 1 for the legend key.

The third stage of break-up of Pangea started during the Pliensbachian (185 Ma). During this phase the northward propagation of the Atlantic rift caused the relocation of the plate boundaries between Eurasia and Africa. The fault systems of the Atlas region became inactive and a new transtensional boundary formed between North Africa and Iberia (Fig. 3).

Fig. 2 - Plate tectonic reconstruction of the Sinemurian-Pliensbachian boundary (190 Ma) and plate motions model for the Middle Norian-middle Pliensbachian stage. See Fig. 1 for the legend key.

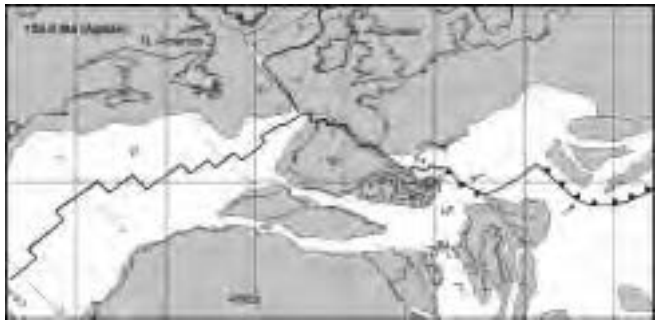

Fig. 4 - Plate tectonic reconstruction of the early Aptian (120 Ma) and plate motions model for the Barremian-early Aptian stage. See Fig. 1 for the legend key.

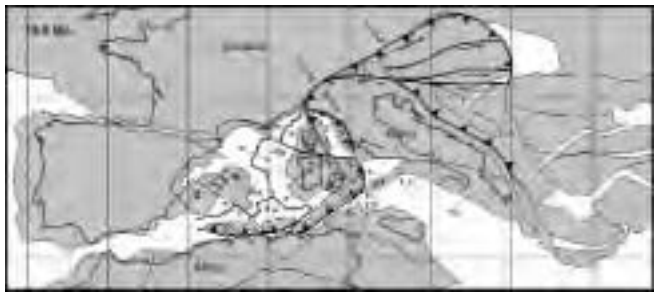

Fig. 6 - Plate tectonic reconstruction of the Burdigalian (19 Ma) and plate motions model for the Early Oligocene-Burdigalian stage. See Fig. 1 for the legend key. Squared barbs represent back-thrusting.

During this time period spreading in the Ligure-Piemontese oceanic basin continued to be active, while the Apenninic and Apulian Jurassic platforms developed.

At about 150 Ma (Kimmeridgian-Tithonian boundary) a new northward jump of the Gondwana-Laurasia boundary caused the separation of the Iberian Plate from Eurasia and the formation of the Valais Ocean. This event also caused the extinction of the spreading center in the Liguride basin. Finally, during the Aptian, the opening of the North Atlantic caused the separation of North America from Eurasia and a subsequent re-organization of the plate motions between Africa and Eurasia, which started to converge (Fig. 4).

During the Cenomanian the south Apenninic and Apulian platforms experienced a major phase of emersion. Where sedimentation continued, the Cretaceous sediments show strong lateral differences in thickness. Moreover, during the Late Cretaceous sin-sedimentary compressive structures are found in these platforms (Ricchetti et al., 1988; Centamore, 2002). In the model proposed here we explain this compressive event with the westward extrusion of the Adriatic Plate relative to Apulia. This extrusion was probably triggered by the collision of the north-eastern margin of Adria with the Eurasian margin. Hence, a new left-lateral transcurrent boundary formed between the Adriatic Plate and Africa in the area between the Gargano and Apulia. The Adriatic Plate reached the present position with respect to the African Plate during Eocene time. There are strong geologic evidences that

convergence between Iberia and Adria during the Cretaceous, the Paleocene and the Eocene caused the subduction of the whole Liguride oceanic lithosphere beneath the Adriatic Plate (Boccaletti et al., 1971; Doglioni et al., 1998) (Fig. 5).
At the beginning of the Oligocene the kinematic framework of the central Mediterranean was still dominated by the TTT triple junction showed in Fig. 5. A slab of European lithosphere was present beneath the Adriatic and Iberian Plates. Moreover, an inactive slab of Iberian lithosphere (Ligure-Piemontese ocean) was present beneath the Adriatic Plate. The process of extension in the Ligure-Provençal and Algerian basins, together with the rotation of Sardinia and Corsica, started in this complex geodynamic scenario. According to Schettino and Turco (2006) the subduction of African lithosphere beneath the Iberian Plate began during chron 13 (33 Ma). At the western Adriatic boundary, where Liguride oceanic crust had been already destroyed by subduction during the Cretaceous-Eocene time interval, the compression associated with the Sardinia-Corsica rotation reactivated the old Liguride subduction system. However, the new continental collision was accompanied by a back-thrust system having eastward (Apenninic) vergence (Fig. 6) and by slip partitioning structures in eastern Corsica. The geodynamic constraint represented by the existence of an eastward subduction system from the Cretaceous to the Eocene excludes that the rotation of Sardinia and Corsica was triggered by a trench retreating mechanism as proposed by Faccenna (2001). In other words, the Ligure-Provençal basin cannot be considered as a back-arc basin.
At the end of the Early Miocene, the Ligure-Provençal-Algerian extension jumped eastward in the Tyrrhenian area. At that time the southern Liguride basin had already been subducted beneath the Sardinian block. In the context of the same convergence system, the subduction of Ionian oceanic lithosphere started as soon as the Panormide platform was accreted to the Calabrian accretionary prism. The small width of this oceanic lithosphere favored its flexural retreating, with a rapid southeastward migration of the Ionian trench and the Calabrian arc (Fig. 7). During the last phase of opening of the southern Tyrrhenian Sea, the Southern Apennines were affected by a left-lateral transcurrent regime.
Regarding the northern Apennines and northern Tyrrhenian Sea, the observation that Adria is fixed to Africa at least since the Eocene, and that the predicted motion of Africa relative to Eurasia is northwestward directed since the Burdigalian, imply that no convergence occurred between Corsica and Adria during this time interval. On the contrary, a left-lateral transcurrent system of faults is expected to accommodate the Adria-Corsica Plate velocity field during the last 20 My. However, the building up of the northern Apenninic chain continued with northeastward vergence for the whole time period. Simultaneously, extension occurred in the northern Tyrrhenian sea and Tuscany area, accompanied by a strong thermal anomaly. Therefore, the mechanism of formation of the Northern Apenninic chain and the northern Tyrrhenian extension remain are still an open problem.

References

Boccaletti M., Elter P. and Guazzone G., 1971. Polarità strutturali delle Alpi e dell'Appennino Settentrionale in rapporto all'inversione di una zona di subduzione nord-tirrenica. Mem. Soc. Geol. It., 10: 371-378.

Centamore E. and Nisio S., 2002. Tettonica e sedimentazione (Lias-Pleistocene) nella media valle del Salto, Rieti, Italia Centrale. Studi Geol. Camerti (2): 53-70.

Doglioni C., Mongelli F. and Pialli G., 1998. Boudinage of the Alpine belt in the Appenninic back-arc. Mem. Soc. Geol. It., 52: 457-468.

Faccenna C., Thorsten W.B., Lucente F.P., Jolivet L. and Rossetti F., 2001. History of subduction and back-arc extension in the central Mediterranean, Geophys. Intern., 145. 809-820,

Ricchetti G., Ciaranfi N., Luperto Sinni E., Mongelli F. and Pieri P., 1988. Geodinamica ed evoluzione sedimentaria e tettonica dell'avampaese apulo, Mem. Soc. Geol. It., 41: 57-82.

Schettino A. and Turco E., 2006. Plate kinematics of the Western Mediterranean region during the Oligocene and Early Miocene. Geophys. J. Intern., 166 (3): 1398-1423,

PLIO-PLEISTOCENE SANDSTONE COMPOSITION OF THE CRATI BASIN: IMPLICATIONS FOR QUATERNARY EVOLUTION

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The aim of this work is to describe temporal variations in Crati Basin Plio-Pleistocene sandstone detrital modes, to testify temporal and spatial changes in source-areas in the northern sector of the Calabrian Arc during Plio-Quaternary times.
The Crati Basin is a L-shaped extensional intermontane basin (Colella et al., 1987) located in the northern sector of the Calabrian Arc. It has developed since the Late Pliocene when the Sila Massif to the south and the Pollino Mountains to the north were already emergd areas, whereas the Coastal Tyrrhenian Range was a less elevated terrane (Colella, 1988).
The basin was filled by progradation of different types of marine fan-delta systems, shelf-type and Gilbert-type deltas of Quaternary age, which represent the sedimentary response to an abrupt tectonic uplift involving basin margins and the basinal topography (Colella, 1988).
The basin margins include crystalline rocks of the Sila Massif, at its eastern margin, and crystalline and sedimentary rocks of the Coastal Range, at its south-western margin, and Apennine sedimentary rocks of the Pollino Mountains at its northern side.
Sandstone samples were collected along the main Pliocene-Pleistocene stratigraphic sections of the Crati Basin and include bathyal, shelfal, coastal and terrestrial sedimentary environments.
The samples were washed, air-dried and sieved at 1ϕ intervals. The 0.50-0.25 mm size fraction was used to prepare thin sections. All thin sections were etched and stained for feldspar and counted using the Gazz - Dickinson method, in order to minimize inconsistencies introduced by comparing samples of different grain size (Ingersoll et al., 1984).
The result of framework modal analysis of Pliocene sands of the Crati Basin shows a quartzo-feldspathic composition. The sand of Nogiano (near Cosenza, on the left Crati Basin margin) is characterized by two different petrofacies: the lower portion of the succession has a quartzo-feldspathic composition whereas in the upper portion detrital modes are quartzo-lithic. The changing nature of petrofacies could suggest that sand having quartzo-feldspathic composition has provenance from granitoid rocks of the Sila Massif, whereas quartzo-lithic sand petrofacies could be fed by the metamorphic rocks of the Coastal Range (Critelli and Le Pera, 2003).
Pleistocene sands of the Crati Basin show a quartzo-feldspathic composition, but richer in the carbonatic (dolomite > calcite) component, with respect to thePliocene quartzo-feldspathic petrofacies, for which provenance from Triassic carbonate rocks of "Monte Cocuzzo" seems important..
In conclusions, changes in petrofacies of the Pliocene-Pleistocene section of the Crati Basin occurred in response to timely differentiated uplift of the diverse sectors of the present-day "Coastal Range", mixed with contributions from the Sila Massif.
Analysis of the detrital mode evolution may contribute to the Plio-Quaternary palaeomorphological and palaeotectonic history of the Crati Basin and their source terranes.

THE TRIASSIC METABASITES OF S. DONATO UNIT (NORTHERN CALABRIA, ITALY): PRELIMINARY PETROLOGICAL FEATURES

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Metabasaltic dykes occur within Anisian-Ladinian deposits of the Triassic metasedimentary sequence of the San Donato Unit (northern Calabria), interpreted as a transitional domain between the Apennine carbonate platform, belonging to the African continental block, and the oceanic Lagonegro Basin. The metabasitic dykes have been investigated for: 1) the Alpine metamorphic evolution, 2) the geochemistry and the geodynamic meaning of the protoliths.
Studied rocks crop out as green to gray-green dykes and sills; they are mainly massive but a metamorphic foliation is sometimes recognizable. An original porphyritic texture is locally preserved in the weakly foliated samples, where plagioclase phenocrysts and aggregates of epidote + actinolite (pseudomorphs on original mafic phenocrysts) are immersed in a microcrystalline groundmass composed of albite, quartz, chlorite, epidote, actinolite and calcite. A first deformational phase (D_1) was responsible for the development of the main axial plane schistosity (S_1). The D_2 phase produces a crenulation of the S_1 with development of a new surface. Locally, a ductile shear event (D_3) produces S-C fabrics.
The mineralogical assemblages are indicative of a polyphase metamorphic evolution: the synkinematic albite + actinolite + chlorite + epidote + quarz + Fe-Ti oxides association developed at the subgreenschist-greenschist facies transition and the albite + calcite + chlorite + quartz + Fe-Ti oxides as-

sociation was related to a transitional facies indicative of an increase of XCO_2 in the fluid phase (Cho and Liou,1987), possibly linked to the shear event.
The studied metabasites have SiO_2 contents ranging from 45.41 wt. % to 49.66 wt%. Scattered CaO, Na_2O, K_2O, Sr, Ba and Rb contents of the analysed rocks are most likely the result of post-magmatic modifications, as also indicated by the high variable values of LOI (4.14-8.84 wt%). Many incompatible elements and transition metals (e.g. Th, Ta, Hf, Zr, Nb, Ti, REE, Ni, Cr, V) may be used to describe the original magmatic features of the metabasitic rocks due to their relative immobility during alteration and low-grade metamorphism. Studied samples plot in the alkali basalt field in the Zr/TiO_2 vs. Nb/Y diagram and display affinity with transitional-alkaline whitin plate basalts in the Ti/Y vs Nb/Y diagram. The Ti/V ratios are in the range 59-79 that are typical values for alkalic basalts. The MORB normalised spiderdiagram show a pattern well fitting with that of P-type MORB as well as the chondrite-normalised REE patterns, which are characterised by LREE enrichment analogue to that reported for the transitional MORB.
The tectonic setting of the St. Donato metavolcanic rocks was also tested using different tectonic discrimination diagrams, where the studied samples mostly straddle the boundary between the within plate basalts and the P-MORB. In the Th/Yb vs. Ta/Yb the samples plot within the MORB-OIB array in the field representative for intraplate basalts generated by partial melting of an enriched mantle source and without evidences of significant continental crust contamination. The geochemical features of St. Donato metabasites are consistent with low grade partial melting of a mixed MORB-plume source with a strong participation of the plume component. Based on regional reconstructions and petrological features the Middle Triassic St. Donato metabasites may document the early phases of continental break-up leading to the opening of the Lagonegro Basin, in the general framework of the Pangea fragmentation and Neotethys rifting.

Reference

Cho M. and Liou J.G., 1987. J. Petrol., 28 (3): 417-443

CLOCKWISE P-T PATH FROM A METAPELITE OF THE CARDETO METAMORPHIC COMPLEX, ASPROMONTE MASSIF, CALABRIA. EVIDENCE FOR THE EXHUMATION OF AN HP TERRANE?

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Greenschist to low-amphibolite facies metamorphic rocks surfacing in small-sized tectonic windows (lesser than 5 km^2) below the Aspromonte Unit (Calabria Peloritani Orogen, southern sector) were investigated (Fazio et al., *in press*). A combined petrological and structural study allows us inferring a possible P-T path for these metapelites. These rocks, consisting essentially of phyllites and micaschists, crop out near the small village of Cardeto, in the southwestern side of the Aspromonte Massif (southern Calabria).
The rocks were metamorphosed under medium to high-P/medium to low-T conditions and underwent a clockwise P-T evolution. Predominant structural features are those linked to an intense mylonitic deformational phase which leads to the formation of a pervasive stretching lineation frequently, dipping ca. 15° towards SW and a mylonitic foliation dipping ca. 20° towards SW which often represents the main foliation both at outcrop and hand sample scale.
Mineral assemblage stabilities were predicted from pseudosection tool, constructed by means of Perplex software using a corrected bulk composition. Garnet compositional isopleths calculated in the MnNCKFMASH system were used to constrain P-T conditions linked to different stages of metamorphism. Contouring of compositional isopleths of garnet with preserved growth zoning has enabled the determination of the pressure-temperature trajectories experienced by rocks during metamorphism.
The reconstructed path is characterized by an initial stage at 550 °C and 0.7 GPa corresponding to the inner core of porphyroblastic garnet. A concomitant rise of pressure and temperature with a peak pressure of about 0.9 GPa at 570 C° follows. These conditions are linked to the composition of the intermediate zone of garnet. A quasi-isothermal decrease of pressure characterizes the last segment of the path. T and P values of ca. 600 °C and 0.75 GPa were calculated for the composition of the garnet rim representing the last piece of information for the reconstruction of the P-T trajectory.
The clockwise path obtained could represent a tectono-metamorphic history passing through two principal phases: the first probably linked to a crustal thickening (probably due to burial and subduction processes) gave rise to the greenschist facies metamorphism evolving to amphibolite facies conditions; the second, characterized by a quasi-isothermal decompression was presumably linked to an exhumation phase during which mylonitic features have been prevalently developed.
P-T estimates (metamorphic pressure peak at about 0.9 GPa and 570 °C) suggest a more plausible resemblance with the Alpine-type tectono-metamorphic cycle rather than with the Variscan one, also reported in this area (Bonardi et al., 1980).
New P-T data here reported could give a clue for a better reconstruction of the tectonic evolution of this complex sector of Calabrian Peloritani Orogen by comparing the reconstructed path here described with other obtained from rocks outcropping in neighbouring areas with a similar structural position (e. g. Madonna di Polsi Unit, Pezzino et al. 1990).

References

Bonardi G., Messina A., Perrone V., Russo M., Russo S. and Zuppetta A., 1980: La finestra tettonica di Cardeto (Reggio Calabria). Rend. Soc. Geol. It., 3: 3-4.

Fazio E., Cirrincione R. nd Pezzino A. (in press). Estimating P-T conditions of Alpine-type metamorphism using multistage garnet in the tectonic windows of the Cardeto area (southern Aspromonte Massif, Calabria). Mineral. Petrol..

Pezzino A., Pannucci S., Puglisi G., Atzori P., Ioppolo S. and Lo Giudice A., 1990. Geometry and metamorphic environment of the contact between the Aspromonte - Peloritani Unit (Upper Unit) and Madonna di Polsi (Lower Unit) in the central Aspromonte area (Calabria). Boll. Soc. Geol. It., 109: 455-469.

SEISMIC PROPERTIES OF SILICATE AND CARBONATE ROCKS AT PRESSURE AND TEMPERATURE: THE CASE STUDY OF THE PELORITANI MOUNTAINS (NE SICILY)

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The seismic properties of a crystalline aggregate depend on its mineral assemblage, spatial distribution of constituents, layering, grain size fabric as well as the occurrence of oriented fractures within the rock.
In order to put into evidence the relationship between rock fabric, composition and elastic properties as function of pressure and temperature, a suite of silicate and carbonate rocks representative of the composition of the lower crust was investigated.
The petrophysical investigation were carried out according to two different approaches:

– Measurements on sample cubes (43 mm edged) in a multi-anvil apparatus, which allow simultaneous measurements of Vp, Vs (s1, s2) along with anisotropies. The determination of volume changes in the specimen at increasing pressure (Pmax = 600 MPa) and temperature (Tmax = 600°C) permitted also to calculate the density values as a function of P and T;
– 3D velocity calculation based on the LPO of the constituent phases, their abundance in the rock and single crystal elastic properties.

In both cases, elastic properties were related to the structural elements of the rock (i.e. lineation, foliation).
Laboratory measurements pointed out that, in the range of low pressure (up to 200 MPa) where there is a marked increase in velocity as pressure is raised, the seismic properties of the rocks are extrinsic (i.e. crack-related). Further increase in pressure affects the progressive closure of pores and microcracks: velocity-pressure relationship exhibits a quasi-linear behaviour with intrinsic properties of each litho-type.
Both rock type (silicate and carbonate) are characterized by substantial Vp and Vs anisotropy. In particular, the residual anisotropy observed in the linear regime has been attributed to the Lattice Preferred Orientation of the major constituent minerals.

Such result was also confirmed by the LPO-based velocity calculations made on three representative silicate and carbonate rocks, which permitted to calculate the seismic properties and the polarization directions for P- and S- wave propagating in any direction with respect to the structural fabric. Finally, we focused on the relationship between P-wave velocities, Poisson's ratios (Vp/Vs) and densities.
Results obtained may provide a basis for constraining the seismic field data in the Peloritani area.

EROSIVE PROCESSES IN THE TURBOLO RIVER CATCHMENT (NORTHERN CALABRIA)

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This work is focused on preliminary data obtained from a qualitative-quantitative study on denudational processes (soil erosion and mass movements) in the Turbolo River catchment (northern Calabria), representing a left-bank tributary of the Crati River. This catchment has been selected as a test area, because its geological, geomorphological and climatic features make it similar to wide sectors of Calabria, where overall soil erosion susceptibility is high. It extends over an area of about 30 km^2 ranging from 75 to 1015 m a.s.l. The basin is characterized by steep slopes shaped on Palaeozoic metamorphic rocks in its western portion, whereas terraces and gentle landforms are shaped on the Neogene-Quaternary sedimentary terrains (sand- and gravel-dominated with clays in suborder) exposed in the eastern and wider reaches. The climate is typically Mediterranean, mean annual rainfall approaching 1130 mm and mean annual temperature close to 15 °C. The soil temperature regime is *thermic* to *mesic*, associated with a *xeric* to *udic* soil moisture regime (the milder and less contrasting conditions occurring in the uplands).
This work started with air-photo interpretation, followed by a geomorphological survey in the field: the main morphodynamic processes affecting the landscape were described and mapped. Sheet and rill wash dominate, especially in the eastern lowland, whereas badlands rarely occur in the western clayey terrains. The whole sedimentary infilling is also affected by occasional gully erosion. Mass-wasting processes affect upland and lowland areas, landslides being triggered both on the weathered crystalline rocks and the sedimentary terrains, the latter also showing soil creep and soil slip phenomena.
The data obtained were integrated, elaborated and spatialized in a GIS in different thematic layers. On the basis of a DEM, various morphometric parameters were calculated. In addition, key relationships between the main morphodynamic processes and relief properties and land-use were investigated.
Moreover, a quantitative geomorphic analysis of the drainage network, obtained from all the surface drainage trunks detected on topographic maps (1:25,000 scale), was carried out to estimate the overall annual sediment yield and consequently the denudation rates affecting the catchment. This approach is based on the assumption that denudation rates can be approximated to the suspended sediment yield of the drainage system. Long-term research and literature in this field supports that drainage density and related parameters indicating hierarchical organization degree and anomalies of river systems can be successfully applied to evaluate denudation rates, expressed by the denudation index (Tu). Our results estimate for the Turbolo River catchment an amount of soil loss reaching about 1700 t/km^2/year.

FORE-ARC MANTLE PERIDOTITES AND BACK-ARC BASIN BASALTS FROM THE IZU-BONIN-MARIANA SUBDUCTION FACTORY (ODP LEGS 125 AND 195): A MODERN ANALOGUE FOR MEDITERRANEAN OPHIOLITES

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Recent Ocean Drilling Program cruises in the western Pacific Ocean have provided mantle peridotite, basaltic lava and calc-alkaline volcaniclastic sequences that allow comparisons with Mediterranean ophiolites believed to be related to marginal seas characterised by rapidly propagating back-arc extension and slab rollback (e.g. Albania and Cyprus).
Mantle peridotites recovered at the Torishima, Conical and South Chamorro Seamounts (ODP Legs 125 and 195), located on the Izu-Bonin-Mariana (IBM) forearc, are characterised by complex petrochemical features acquired during their high-T evolution. A three-stages-model has been proposed involving in chronological sequence: 1) adiabatic mantle upwelling accompanied by 20-25% polybaric fractional melting; 2) marked depletion in modal orthopyroxene, triggered by upward migration of ultra-depleted melts; 3) late interaction between small volumes of migrating melt and the refractory mantle sequence. Evidence of the first stage is based on the observation that the less-refractory IBM forearc peridotites lie on the trends describing the decompression melting of uprising fertile (asthenospheric) mantle. During this stage, the peridotites were actual mantle sources. The average degree of depletion is higher than that observed in abyssal peridotites, thus indicating particularly hot geotherms. The second stage occurred at relatively lower pressures and is guessed to be firmly related to arc volcanism. Nevertheless, the progressive change of oxidation state of the mantle minerals, meanly decreasing from the Torishima (N Izu-Bonin forearc) through the Conical (N Mariana forearc) to the South Chamorro Seamount (S Mariana forearc), suggests a marked gradient of contributions coming from the subducted Pacific Plate during this event. It is argued that the melt compositions changed from boninitic at Torishima to ultra-depleted MORB at South Chamorro. The third stage determined the petrographic and mineralogical features occurring in all IBM forearc peridotites (e.g. crystallisation of late cpx, embayment of opx porphyroclasts), and likely marks the accretion of the mantle sequence to the thermal boundary layer. It was accompanied by transient geochemical gradients in the migrating liquids due to chromatographic-type chemical exchange with the peridotite.
The West Philippine Basin (WPB) is a back-arc basin that opened in the Philippine Sea Plate (PSP) between the current position of the Palau-Kyushu Ridge (PKR) and the margin of East Asia. Spreading occurred at the Central Basin Fault (CBF) from 54 to 30 Ma. The PKR was active since ~ 48 to 35 Ma constituting a single volcanic arc with the Izu-Bonin-Mariana Arc. ODP Leg 195 Site 1201 is located in the WPB, ~100 km west of the PKR, on 49 Ma basaltic crust formed by NE-SW spreading at the CBF. From ~ 35 to 30 Ma, pelagic sedimentation at Site 1201 was followed by turbidite sedimentation, fed mostly by early Mariana Arc (PKR)-derived volcanic clasts. These volcanics are calc-alkaline, whereas PKR rocks from literature have mostly boninitic and arc tholeiitic affinity; the WPB basement basalts have MORB to arc-like affinity, as expected for a back-arc basin. Sr, Nd, Pb and Hf isotope data highlight the Indian Ocean MORB-like character of WPB basement basalts, suggesting an upper mantle domain distinct from that underlying the Pacific Plate. The geochemical and isotopic features of PKR volcanics reflect higher amounts of subduction-derived components, added mostly as siliceous melts, in the source of arc magmas relative to that of basement basalts. In that respect, Site 1201 PKR volcanics resemble calc-alkaline volcanics of the currently active Mariana Arc. In addition, their calc-alkaline affinity, unradiogenic neodymium, and inferred Middle Oligocene age, suggest they might represent an evolved stage of arc volcanism at Palau-Kyushu Ridge, perhaps shortly before the end of its activity.

A LA-ICP-MS STUDY OF MINERAL PHASES OF MAFIC ENCLAVES IN THE RECENT OBSIDIAN LAVA FLOW OF LIPARI ISLAND

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A LA-ICP-MS study has been made on minerals phases of the latitic and trachytic enclaves occurring in the rhyolitic lava flow of Rocche Rosse which represents the last eruptive episode of Lipari island (1230±40 AD). Recent work (Davì, 2007) suggested that RR rhyolites are the AFC product of the co-erupted latites. Moreover there are petrographic evidences that a more primitive magma might be also present in the RR feeding system (i.e. forsteritic-rich olivine xenocrysts hosted in latites).
LA-ICP-MS analyses were made on olivine, plagioclase, K-feldspar and biotite minerals. Rare elements pattern of pyroxenes shows a less fractionated rim and a strong negative Eu/Eu*. All feldspars show strong positive Eu anomaly (Eu/Eu* up to 52). Slightly reverse zoning in Ba and Sr is observed in plagioclase crystals whereas particularly in latites K-feldspar

have Ba content increasing with decreasing Ab content.
Two groups of olivine are present. Olivines A are unzoned and occur in clots only in the latitic enclaves; they are Fo_{90} and show a constant trace elements composition in equilibrium with Mg# 70 melt. On the contrary olivines B, occurring both in latitic and trachytic enclaves, are Fo_{70}; their trace element distributions indicate that are inversely zoned. This compositional zoning may be due to: a) the arrival of a new more mafic magma and/or b) the presence of a more mafic magma at the base of the magma chamber. These conditions can occur contemporaneously and mixing duration, obtained from olivines zoning, are on the order of some years.
It is noteworthy that olivines A are texturally and compositionally similar to those found in the explosive products of the 1888-1890 eruption of La Fossa Cone. The whole data support the hypothesis that the feeding system of recent volcanic activity of Lipari and Vulcano might be characterized by the same magma types. A shoshonitic magma from a deep reservoir (~ 20 km, Peccerillo et al., 2006) can evolve and stop in the crust generating latitic to rhyolitic zoned magma chambers. A sudden arrival of a new input from depth interacts with these resident magmas and triggers the eruptions (La Fossa cone and Rocche Rosse).

References

Davì, 2007. La colata riolitica di Rocche Rosse (Lipari, Isole Eolie): Aspetti magmatologici e vulcanologici. PhD Thesis, Università di Catania.

Peccerillo A., Frezzotti M.L., De Astis G. and Ventura G., 2006. Modeling the magma plumbing system of Vulcano (Aeolian Islands, Italy) by integrated fluid-inclusion geobarometry, petrology, and geophysics. Geology, 34 (1): 17-20.

CRUSTAL XENOLITHS IN THE DACITIC LAVAS FROM PANAREA ISLAND (AEOLIAN ISLANDS)

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The presence of crustal xenoliths has often been observed in the explosive and effusive deposits of the Aeolian Islands. In spite of their common occurrence, no systematic studies have been conducted on such xenoliths. In this work we present preliminary data on crustal enclaves collected in the lavas cropping out in the northeastern part of Panarea Island. The studied deposits belong to the Ditella and Grotta del Tabacco lithosomes, both included in the Palaeo- Panarea Informal Unit (Calanchi et al., 1999). Recent radiometric age determinations indicate that they are younger than 155 Ka (Dolfi et al., 2007).
The hosting products have an andesitic to dacitic composition and a CA to HK-CA affinity. Two main kind of xenoliths have been recognized: a gneissic type and a quarzitic one. A continuum of xenolith types showing intermediate features is also present. In fact the gneissic xenoliths show a gradual variation between different portions of a single enclave, with different structures and modal compositions.
Part of the xenoliths displays a granoxenoblastic structure and a mineral assemblage made of cordierite + sillimanite + plagioclase + quartz + hercynite + magnetite + epidote.
The sillimanite crystals show evidence of reaction; this reaction produces a cordierite moat and small hercynite crystals. The cordierite crystals are affected by a incipient pinite retrogression. The portions with dominant sillimanite gradually pass to zones in which the modal abundance of quartz progressively increases, until they become true quartzites. This variation in the structure and modal composition is marked by the growth of droplet-like quartz crystals inside the euhedral plagioclase crystals. It is worth to note that along the contacts between the quartz grains a thin, glassy film can be observed.
The development of the reaction structures involving the destabilization of sillimanite and the growth of cordierite and spinel has been described for the Hercynian migmatites of Calabrian basement by Piluso and Morten (2004). However, in the crustal xenoliths of Panarea lavas the reaction of sillimanite could be related to the heating of the gneissic rock when it comes in contact with the surrounding lava. The development of droplet-like quartz could witness processes of partial melting of the xenoliths, with the formation of quartzites sometimes present as separate enclaves.
This preliminary data confirm that crustal contamination played an important role in the evolution of Panarea magmas and of Aeolian islands as a whole.

References

Calanchi N., Tranne C.A., Lucchini F., Rossi P.L. and Villa I.M., 1999. Explanatory notes to the geological map (1:10.000) of Panarea and Basiluzzo islands (Aeolian Arc, Italy). Acta Vulcan., 11 (2): 223-243.

Dolfi D., de Rita D., Cimarelli C., Mollo S., Soligo M. and Fabbri M., 2007. Dome growth rates, eruption frequency and assessment of volcanic hazard: insights from new U/Th dating of the Panarea and Basiluzzo dome lavas and pyroclastics, Aeolian Islands, Italy. Quatern. Intern., 162-163: 182-194.

Piluso E. and Morten L,. 2004. Hercynian high-temperature granulites and migmatites from Catena Costiera, northern Calabria, southern Italy. IGC 2004, Spec. Iss., 2. A showcase of the Italian research in metamorphic petrology. Per. Mineral., 73: 159-172.

CLOTTED PELOIDAL MICRITE, FECAL PELLETS AND BIOMARKERS IN THE PREEVAPORITIC CALCARE DI BASE (SOUTHERN ITALY): EVIDENCE OF BITIC ORIGIN

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The Messinian succession in the Mediterranean area represents a classic example of sedimentary evolution from normal-marine to evaporatic conditions. This transition is recorded in the geological record of Southern Italy as a succession of different sedimentary deposits, such as marls and diatomites (Tripoli Formation), transitional carbonates (Calcare di Base Formation) and evaporites (Gessoso Solfifera Formation).
The Calcare di Base Fm still represents an open question as regards their origin and depositional setting. Many authors maintain that the Calcare di Base has been deposited under evaporitic conditions in which the diagenetic processes, carried out by sulphate reducing bacteria, replaced Ca-sulphates into carbonates. They support this interpretation mainly with the presence in the carbonate sediments of moulds and pseudomorphs after gypsum and halite, sulphur deposits, and very low $\partial^{13}C$ isotopic signal.
We analyzed the Calcare di Base cropping out in northern Calabria and in Sicily. In account to elucidate the depositional conditions under which these carbonates formed, namely the physicochemical properties of the water column and the possible role of microbes in the mineralization processes, we adopted a multidisciplinary study developed through sedimentological (microfacies) and microstructural observations (SEM), chemical microanalyses (EDS), organic petrography and geochemical analyses (palynofacies, Rock-Eval pyrolysis and Gas Chromatography/Mass Spectrometry). This methodology allowed to identify organisms not recognizable or not preserved which may have induced biomineralization processes or may be indicative of ancient palaeoecological conditions.
The dominant microfacies consists of peloidal micrite (40% - 50%), characterized by variably sized irregular peloids forming clots with antigravitative fabric. Larger and darker cylindrical-subcylindrical micritic grains (50µm - 500µm), attributable to fecal pellets, are more or less randomly dispersed into the peloidal micrite. The biotic origin of fecal pellets and peloidal micrite is also supported by their bright epifluorescence indicative of high organic matter content. SEM observations, at high magnification, revealed two types of fecal pellest: those containing silt-sized inclusions of siliciclastic grains and those with coccolithophorid moulds but without relevant terrigenous component. EDS maps show that whereas the Ca is more or less evenly distributed, both in the the micrite and fecal pellets, elements suggesting the presence of siliciclastic minerals (i.e. Si, Al) are preferentially clustered in the fecal pellets. In addition carbonate layers show two other facies types: i) a detrital, with very finely gradated layer, and ii) a microbialitic, sometimes with stromatolitic fabric.
Rock-Eval pyrolysis revealed a transitional composition between types II and III kerogen, suggesting a mixture of marine and terrigenous organic matter. Palynolofacies observations, confirming this double contribution, put in evidence a variety of biological inputs testified by amorphous organic matter (algal or bacterial origin), and debris of vascular plants, algae, and arthropod exoskeletons (copepods). Very diagnostic is the constant and strong bacterial signal of the molecular fossils recorded in GC/MS analysis. Bacterial biomarkers are represented by $n\mathrm{C}_{26}$-$n\mathrm{C}_{28}$ *n*-alkanes with no odd-even carbon number predominance, branched *n*-alkanes, hopanes and unsatured fatty acids. These biomarkers, together with the widespread presence

of amorphous organic matter in the palinofacies, corroborate the interpretation that the clotted peloidal micrite represents a bacterial induced deposit.
The comparison between the Calcare di Base facies of Sicily and Calabria, suggests that the deposition of this enigmatic carbonate unit happened in peculiar, but uniform, paleoecological conditions characterized by an oligotypic marine community.

PRELIMINARY GEOCHRONOLOGICAL DATA IN ZIRCON CRYSTALS IN METAMORPHIC ROCKS OF CONTINENTAL CRUST FROM THE FRIDO UNIT (SOUTHERN APENNINES)

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This paper presents preliminary geochronological data on zircon, obtained in-situ using laser ablation (LA)-ICP-MS, aimed to obtain new geochronological constraints on metamorphic rocks from continental crust belonging of Timpa Rotalupo (Frido Unit, Southern Apennines).
The Southern Apennines chain represented an accretionary wedge, developed along the Apulian-Adriatic passive margin of the Neotethys Ocean. It is originated about convergence between the European and African Plates (Dewey et al., 1986).
The Liguride Complex (Ogniben, 1969) represents the uppermost part of the exposed chain deformed during subduction at Eocene time (Knott, 1994).
The Frido Unit (Amodio Morelli et al., 1976) is composed of metamorphosed terranes and includes the ophiolite-bearing terranes. It consist of a polymetamorphosed sequence and associated masses of both continental and oceanic crust (Knott, 1987; 1994; Spadea, 1982; 1994).
According to Cello and Mazzoli (1999) ophiolites of the southern Apennines are connected to the extensional phase that gave origin to the Tethyan Domain, after the Jurassic rifting.
Bodies of continental crust occur near at contact with serpentinites (Spadea, 1982), and are composed mainly by alterated granofels, garnet gneiss, garnet biotite gneiss and leucocratic gneiss.
According to Knott (1987) the mineral assemblage of HP/LT overprint is related to underplating during subduction and it is connected to Alpine event (Amodio Morelli et al., 1976; Spadea, 1982; Gueguen et al., 1997; 1998; Stampfli et al., 2002). The HP-LT metamorphism evolved in the greenschist facies during exhumation of the lower portions of the accretionary wedge.
The gneisses are a medium/high metamorphic continental slice rocks widely exposed for 5 km^2 wide.
The garnet gneisses are brown and show a typical granoblastic texture and a weak foliation, with garnet porphyroclasts standing out in a quartz-rich matrix. Veins of quartz, calcite, pumpellyite and albite are present.
The pre-Alpine mineral association of medium to high metamorphic grade is grt + qtz + pl (Pl1) + kfs ± bt ± ms ± rt. Garnet crystals are present as subidiomorphic and some as poikiloblasts containing quartz, muscovite, biotite, apatite and rutile. Quartz crystals show dynamic recrystallisation. Plagioclase (25-15 %An) shows the Albite twinning. Accessory minerals are zrn ± ap + opaque minerals. Alpine overprint is testified a low-grade mineral assemblage consisting of chl + ep ± stp prh ± pmp ± albitic pl (Pl2).
The leucocratic gneisses are green-grey and show a gneissic texture with the cataclastic-milonitic band. The minerals standing out in a quartz-feldspar rich matrix. The pre-Alpine association is grt + qtz + pl + kfs + bt + ms, instead the cristallization of prh+chl+ep is connected with Alpine overprint. The K-feldspar is present as porphyroclsts. Quartz crystals show dynamic recrystallisation with predominantly subgrains and grain boundary migration. Accessory minerals are zrn ± ap ± ttn ± rt + opaque minerals.
Three gneiss samples were collected for geochronological study (two samples of garnet gneiss and one of leucocratic gneiss).
The selected zircons of garnet gneiss are euhedral and colourless and are 100 - 50 µm in size. The selected zircons of leucocratic gneiss are generally rounded and are 100 - 50 µm in size, they display yellow turbidity.
In garnet gneiss age data for rims and cores of zircons are concordant (1784±31 Ma core and 1779±31 Ma rim; 303±8 Ma core and 280±11 Ma rim) and sub-concordant (700±24 Ma core and 550±14 Ma rim).
In leucocratic gneiss age data for rims and cores of zircons are concordant at 306±8 Ma and 395±11 Ma, respectively.
Analyses on single crystals provide evidence of different period of zircon growth during metamorphic events in gneiss of Timpa Rotalupo (Frido Unit); the zircons of garnet gneiss reflect age values oldest respect to the zircons of leucocratic gneiss, but in all samples are recorded Pan-African and Ercinian events.

TECTONOMETAMORPHIC EVOLUTION OF THE OPHIOLITIC SEQUENCES FROM NORTHERN CALABRIAN ARC (SOUTHERN ITALY)

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In the Northern Calabrian Arc nappe pile (Southern Italy), the Liguride complex occupies an intermediate position between overlying Hercynian continental crust and underlying Apenninic carbonate units. The Northern Calabria Liguride complex crop out discontinuously in the Sila Massif and Catena Costiera as slices of oceanic lithosphere belonging to the Jurassic Tethys realm. They consist of high pressure/low temperature metamorphic ophiolitic sequences of Late Jurassic- Early Cretaceous age, in which a metabasic and metaultramafic association are the base of a complex metasedimentary cover ranging from pelagic to flyschoid type sediments.
Geochemical characterization indicates a subalkaline basaltic protolith with tholeiitic affinity (T-MORB type).
In the literature, these ophiolitic sequences are subdivided into an upper non-metamorphic ophiolitic unit and a lower HP-metamorphic ophiolitic unit are distinguished. This subdivision contrasts with new petrological data and geothermobarometric modelling (Liberi et al., 2006).
The overall P-T evolution for several ophiolitic sequences from northern Calabrian arc describes comparable paths, in which they underwent HP-LT metamorphism followed by retrogression under greenschist facies conditions. The metamorphic climax is calculated at pressures ranging between 0.9 and 1.1 GPa and 380°C. Moreover, structural analysis of syn-metamorphic ductile deformation suggests that tectonic evolution is quite homogeneous and similar, although different degrees of deformation can be observed. The high-pressure mineral assemblage occurs along a pervasive foliation developed during a compressive tectonic event (D_1) that transposed the original structures. A second tectonic event (D_2) occurred during decompression to 0.4 GPa, producing millimetric to decametric scale asymmetric folds that describe west-verging major structures. onr, extensional brittle structures are responsible for final exhumation of the HP rocks.
The tectonometamorphic evolutions for the ophiolitic sequences of Northern Calabrian Arc are comparable in both thermobarometric modelling and their tectonic history. Differences in maximum pressure reached during metamorphic climax are well explained in a context in which the studied ophiolitic sequences underwent subduction and exhumation processes as tectonic slices inside an Eo-Alpine accretionary wedge.

Reference

Liberi F., Morten L and Piluso E., 2006. Geodynamic significance of ophiolites within the Calabrian Arc. Island Arc, 15: 26-43.

THE LIGURIDE COMPLEX IN THE LUCANIAN APENNINES: THE FRIDO UNIT *MELANGE*

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The Liguride complex is the highest structural element of the Southern Apennine fold and thrust belt. Monaco and Tortorici (1995) subdivided the Liguride Complex into three group: the Oligocene- Middle Miocene turbiditic sequences and two ophiolitiferous units, the Frido and Calabro-Lucano Flysch Units. The upper one, the Frido Unit, is a *mélange* constituted of non-homogeneous polymetamorphic blocks with continental and oceanic affinities and a pelitic-arenaceous-carbonatic matrix, characterized by a very low grade metamorphic imprinting. The age of the sedimentary se-

quence is still debated. Regarding the continental derived blocks, the observed field relationships and geothermobarometric data allow to hypothesize a continental slices provenance from deepest portions of continental lithosphere by striking analogies with rocks cropping out in the northern sector of the Catena Costiera (northern Calabrian Arc), where the deep portion of the Calabride continental lithosphere crops out (Piluso and Morten, 2004). The oceanic derived blocks are constituted of blueschist to greenschist facies T-MORB and relative sedimentary cover. It is suggested that they were included in the matrix after the HP event.
Therefore, the Frido Unit can be interpreted as a sedimentary *mélange*, whose deposition occurred inside a basin adjacent to a growing ophiolitic accretionary wedge and close to a thinned continental margin that could be the Calabride continental margin, affected by tectonic reworking when involved in subsequent Apenninic subduction.

References

Monaco C. and Tortorici L., 1995. Tectonic role of ophiolite-bearing terranes in the development of Southern Apennines orogenic belt. TerraNova, 7: 153-160.
Piluso E. and Morten L., 2004. Hercynian high temperature granulites and migmatites from the Catena Costiera, northern Calabria, Southern Italy. Per. Mineral., 73: 159-72.

THE LIGURIDE COMPLEX IN THE LUCANIAN APENNINES: PETROLOGICAL AND GEOCHEMICAL CHARACTERIZATION OF THE TIMPA DELLE MURGE NON-METAMORPHIC OPHIOLITIC SEQUENCE

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In the Lucanian Apennines the Liguride complex is constituted by an Upper Jurassic- Middle Eocene ophiolitiferous sedimentary sequence, an epimetamorphic sequence including blocks with oceanic and continental affinity, and Oligocene - Middle Miocene turbiditic successions. The non-metamorphic ophiolitiferous sequence is interpreted as a broken formation (Calabro-Lucano Flysch Unit) by Monaco and Tortorici (1995) and as a continuous Middle Jurassic- Oligocene sedimentary succession with an ophiolitic basement (North Calabrian Unit) by Bonardi et al. (1992).
This ophiolitic sequence, cropping out at Timpa delle Murge, Timpa di Pietrassasso and M. Tumbarino, is the most continuous and complete of the Southern Italy. From bottom to top it is composed of: serpentinites after harzburgites, coarse-grained euphotide gabbros passing to fine-grained leucogabbros, porphiric pillow basalts, aphiric basalts, dolerite dikes and pillow breccias with carbonate matrix. The presence of abundant prhenite, pumpellyte, chlorite and epidote suggests a severe metasomatic process in oceanic environment.
Geochemical characterization of basic rocks by XRF and ICP-MS indicates a MORB composition as shown by REE abundances and discrimination diagrams. A tholeitic trend is obtained from projection of ophiolitic suite data on AFM diagram. Spider diagrams show Cs, Pb and K enrichment probably due to oceanic metasomatism
The oceanic basement is covered by a pelagic sequence starting with Callovian radiolarian cherts (Chiari et al., 2001), Oxfordian allodapic limestones and green-violet shales with quartzarenitic intercalation, grading upwards to grey shales alternating with thick quartzarenite beds and black shales (Crete Nere Fm.) of Late Cretaceous- Middle Eocene age (Bonardi et al., 1992). These authors suggest a stratigraphic transition to the uppermost Oligocene (Di Staso and Giardino, 2001) turbidites of the Saraceno Fm.. In this case the Timpa delle Murge ophiolitic sequence represents remnant of an oceanic basin still open during Oligocene.

References

Bonardi G., Amore F.O., Ciampo G., De Capoa P., Miconnet P. and Perrone V., 1988. Il “Complesso Liguride” Auct.: stato delle conoscenze e problemi aperti sulla evoluzione appenninica e i suoi rapporti con l’Arco calabro. Mem. Soc. Geol. It., 41: 17-35.
Chiari M., Marcucci M. and Principi G., 2000 The age of the radiolarian cherts associated with the ophiolites in the Apennines (Italy) and Corsica (France): a revision. Ofioliti, 25 (2): 141-146.
Di Staso A. and Giardino S., 2001. New integrate biostratigraphic data about the Saraceno Formation (North-Calabria Unit; Southern Apennines). Mem. Soc. Geol. It., Vol. Spec. 1: 517-526.
Monaco C. and Tortorici L., 1995. Tectonic role of ophiolite-bearing terranes in the development of the Southern Apennines orogenic belt. Terra Nova, 7: 153-160.

GEOMORPHOLOGY AND SOILS BETWEEN THE COLOGNATI AND TRIONTO RIVER CATCHMENTS (CALABRIA, SOUTH ITALY)

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This work deals with an integrated geomorphological, stratigraphical and pedological study of coastal river terraces between the Colognati and Trionto river catchments in NE Calabria (south Italy).
In the South, low-relief landscapes occur along the northern flank of the Sila Massif as high as 1000 m a.s.l.; in the North, the Sila slope dips strongly down to a hilly coastal belt attaining a maximum height of 480 m a.s.l. This hilly belt is dissected and separated into two main ridges by streams with braided patterns.
The morphology of the ridges was mapped by means of field surveys coupled with topographic map and air-photo analyses. Each ridge is characterized by stepped surfaces, consisting of well-preserved terraces, widely distributed along the river catchments and forming a W-striking staircase geomorphology in the northern ridge front.
Terrace mapping was undertaken along the trunk rivers of the major catchments, mainly in their lower reaches, as landsliding and headward stream erosion affecting valley flanks, cause the old landscape to be progressively destroyed.
Field mapping of the ridges was integrated by terrace mapping using topographic maps and air-photo analyses, thus allowing either wide-size and small-scale surfaces to be detected.
Large-scale topographic maps (1:5000 and 1:10000), air-photos (1:10000) and morphostratigraphic sketches permitted to identify individual surfaces, estimate their heights and interpret them as stepped fluvial terrace surfaces. As a whole, these ridges are interrupted by a flight of five alluvial terraces cutting the folded and faulted Miocene deposits and rarely resting erosively on Plio-Pleistocene marine deposits. These terraces, of Middle to Late Pleistocene age, consist of decimetre to metre-thick fluvial sediments made of subrounded pebble-cobble gravel, sand and silt deposits.
The river terraces are characterized by reddish and clay-illuviated surface soils, although some profiles are buried by younger fluvial deposits or soils. Typical surface organic-mineral horizons are often lacking, and both exposed and buried soils appear truncated by erosion. Some profiles are overprinted by deep eluviated tongues or hydromorphic features. Fifteen soil profiles from a soil chronosequence developed on the river terraces were described and sampled in the field for chemical, physical, mineralogical and micromorphological analyses. Most of the examined profiles completely lack of $CaCO_3$ in their matrix, presumably for its complete absence as parent material. Other few profiles have partly leached matrix carbonate associated with secondary precipitation features, suggesting different parent materials sourced from different paleodrainage basins, otherwise conflicting with the terrace setting and related soil ages.
The micromorphological observations in thin sections from undisturbed samples showed abundant laminated clay coatings, exhibiting typical post-illuvial disturbance and degeneration, and therefore indicating their relict significance. This suggests that the illuvial process is inactive and can be ascribed to climatic conditions with strong seasonal contrast, warmer and more humid than at present (climatic optima of past Quaternary interglacials). Occasional rounded pedorelicts included in some horizons confirm field evidence of erosion and reworking of soil material. Illite and kaolinite (and occasional smectite or vermiculite) represent the main clay minerals, pointing to an overall high degree of weathering of the soil profiles. Their different relative abundance, coupled with iron forms and related weathering indices obtained from selective extraction techniques, the SEM morphoscopic analysis of weathering patterns and degree of primary minerals allowed us to compare the pedogenetic evolution of the soil profiles studied and relate it to their age. This strongly contributed to the reconstruction of Quaternary geomorphic processes and their response to climate changes.

ALPINE MULTISTAGE TECTONO-METAMORPHIC EVOLUTION OF THE SAMO AFRICO COMPLEX BASEMENT ROCKS (SOUTHERN CALABRIA, ITALY)

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The Pressure-Temperature deformation path (PTd) of a key sector of the southern Calabria basement rocks was unravelled by means of microstructural analysis and P-T pseudosections.
In particular the attention is focused on the lowermost basement nappe of the Aspromonte Massif (Samo Africo Complex - SAC), which shows exclusive evidences of a complete Alpine orogenic cycle (Ortolano et al., 2005).
The integrated approach allowed to obtain information about the kinematics and rheology of the SAC lithotypes as well as on its thermobarometric evolution, giving thus a complete representation of the Alpine tectonic evolution.
The eldest identified deformation phase (D_1) is represented by isoclinal folds, producing an axial planar foliation (S_1), defined in the southern sector by low-grade mineral assemblages (qtz + pl + chl + wm + ep ± grt ± rt) and evolving in the northern sector into higher-grade assemblages (qtz + pl + grt + wm + ep ± amph ± chl ± rt ± ttn ± ilm).
This evolution suggests the existence, within the SAC, of an early relic metamorphic field gradient, with grade increasing towards the north, which is interpreted as LT-HP metamorphism related to early Alpine crustal thickening, as recognized in the ophiolitic units of northern Calabria (Schenk, 1980; Van Dijk et al., 2000; Rossetti et al., 2001).
Local crenulation cleavage (S_2) indicates the second deformation phase (D_2), locally leading to the crystallisation of qtz + pl + chl + wm.
A late Alpine shearing event highlights the Oligocene-Miocene exhumation of the nappe edifice (Pezzino et al., 1990) which bring to the formation of a pervasive SW-NE to SSW-NNE stretching lineation, with development of several non-coaxial kinematic indicators, showing a top to NE - NNE sense of shear in the present-day geographic coordinates.
In this scenario, the major counter-clockwise rotation (60°-70°), occurred at the Aspromonte Massif from the Oligocene to Recent southeastward migration of the CPO (Scheepers, 1994), suggests an original Africa-verging (ESE direction) orogenic transport.
The Alpine features of the previous structural and microstructural evidences was also supported by the reconstruction of the multistage thermobarometric evolution of the SAC metapelites through: **a)** garnet isopleth thermobarometry; **b)** theoretical predictions of the P-T stability fields of representative equilibrium assemblages. This approach, which took into account the effective bulk rock chemistry, yielded suitable P-T estimates since the early metamorphic stage and, subsequently, reliable information about the retrograde trajectory on the pseudosection PT space.
Indeed, the prograde evolution of the SAC metapelites showed evidence of a HP-LT early Alpine multi-stage cycle, with P-T evolving from 0.81±0.09 GPa at 520°±12°C towards peak conditions, with northward increasing pressure from 1.12±0.02 GPa to 1.24±0.02 GPa, at relatively constant temperature (~560°C).
A late Alpine mylonitic overprint highlights the presence of a retrograde *quasi*-adiabatic decompression path (0.88±0.12 GPa at 585°±20°C) evolving to a (very late) cooling trajectory, ranging from 0.75±0.05 GPa at 587°±10°C to 0.40±0.05 GPa at 427°±10°C.
The inferred PTd path highlights as the SAC metapelites can be interpreted as a crystalline basement unit exclusively affected by an Alpine orogenic cycle, consisting of a first HP-LT metamorphic stage, probably linked to an early Europe-verging subduction. This was followed by an Upper Oligocene Africa-verging collisional event responsible for the fast extrusion along an adiabatic decompression path.

References

Ortolano G., Cirrincione R. and Pezzino A., 2005. Schweiz. Mineral. Petrogr. Mitt., 85: 31-56.
Pezzino A., Pannucci S., Puglisi G., Atzori P., Ioppolo S. and Lo Giudice A., 1990. Boll. Soc. Geol. It., 109: 455-469.
Rossetti F., Faccenna C., Goffé B., Patrick M., Argentieri A., Funiciello R. and Mattei M., 2001. Tectonics, 20: 112-133
Scheepers P.J.J., 1994. (Ph.D. Thesis, Utrecht University), Geol. Ultraiectina, 112, 352 pp.
Schenk, V., 1980. Contr. Mineral. Petrol., 73: 23-38
Van Dijk J.P., Bello M., Brancaleoni G.P., Cantarella G., Costa V., Frixa A., Golfetto F., Merlini S., Riva M., Torricelli S., Toscano C. and Zerilli A., 2000. Tectonophysics, 324: 267-320

ZIRCONS TYPOLOGY AND CHEMISTRY FOR EARLY MESOZOIC CONTINENTAL REDBEDS OF THE TETHYAN RIFTED CONTINENTAL MARGINS, CENTRAL-WESTERN MEDITERRANEAN ALPINE CHAIN

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Clastic sedimentary rocks are indicators of past environments, giving clues to their compositions and even to their geodynamic settings by means of their compositions. Provenance and geodynamic development of clastic sedimentary successions can be classified by a variety of methods, including petrographic analysis, whole-rock and mineral chemistry. The present study uses petrographic and geochemical methods for Lower Mesozoic continental redbed sandstones from western-central Mediterranean area to decipher the influence of source-rock features, chemical weathering and recycling processes during transport and sedimentation, source-area composition and post-depositional diagenetic reactions, all affecting the chemical record of their compositions and, consequently, evidence concerning their parental affinities.
Typologic study of zircon populations separated from arenitic continental redbeds (Trias-Early Lias) along the internal domains of the western-central Mediterranean Alpine Chain from the Gibraltar Arc to the Calabria-Peloritani Arc, integrated by microchemical determinations, has been performed to assess if this constrain may be used to obtain more comprehensive inferences on the sedimentary evolution of ancient sediments.
Zircons from the Calabria-Peloritani Arc samples are euhedral and, in minor abundance, are rounded and subrounded. Samples from Rif Chain have abundant euhedral zircons, while rounded and ovoidal zircons are less. Zircon crystals from Betic Cordillera are rounded or subrounded, while euhedral zircons are less.
Electron microprobe analyses (Si, Zr, Hf, P, HREE) indicate homogeneous compositions, suggesting provenance from granitoids, whereas typology testifies the existence of two distinct groups. The first group includes arenites from Calabria-Peloritani Arc and Rif Chain. The second group includes arenites from Betic Cordillera. The differences between the two group of zircons may be related to recycling effects in agreement with a geochemical study of Triassic to lowermost Jurassic mudrock redbeds. The recycling effect likely were more striking for the Betic Cordillera samples. Zircon typologies can efficiently integrate geochemistry of mudrocks especially in those complex sedimentary context where arenite-mudrock couplets occurs.
Weathering processes occurring in the source area have been detected using different chemical index of alteration (CIA, CIW and PIA). The chemical alteration for all redbed samples is moderate and in the A-CN-K diagram (CIA index) they plot in the A-K side suggesting a K-enrichment during burial history. The palaeoweathering indices (CIW and PIA ratios) show high values probably related to recycling effect.
A recycling effect is also suggested by the distribution of Al_2O_3, TiO_2, and Zr both on sandstone and shale samples and in the Zr/Sc *vs* Th/Sc diagram. Recycling could significantly affect the weathering indices which likely monitor a cumulative effect including a first cycle of weathering at the source rocks. Weathering occurred under hot, episodically humid climate with a prolonged dry season. The climate alternation in the Early Jurassic favored recycling with the formation of stream channels that eroded the soil profiles during wet-humid conditions, whereas the dry season promoted the sedimentation.
The provenance terranes for the continental redbeds includes the Cambrian through mid-Carboniferous succession of clastics (dominantly quartzite and metapelites), carbonate, radiolarian chert, phyllite. An additional provenance terrane occurring in the basement, including metavolcanic rocks having mafic composition cannot be excluded, even if the importance of a mafic supply is subordinate as shows the Cr/V and Y/Ni ratios.
The close similarity in composition, sedimentary and diagenetic evolution of the redbeds in different sectors of the circum-Mediterranean orogens

suggests a deposition in a distinctive continental microplate (Pseudoverrucano Sub-domain. The studied redbeds represents an important stratigraphic marker to reconstruct the geodynamic events occurred in the Mediterranean area, in which have played an important role a continental block (*Mesomediterranean Microplate*), which separated different realms of the Western Tethys from Middle-Late Jurassic to Miocene, when it was completely disintegrated due to Alpine orogenesis.

A MULTIDISCIPLINARY STUDY OF DENUDATION PROCESSES AND LANDFORMS IN THE VRICA AREA (CALABRIA, SOUTHERN ITALY)

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This study focuses on the analysis of denudation processes and related landforms in a hilly area characterized by a coastal Mediterranean climate, with low mean annual rainfall (700 mm), mean annual temperatures around 15°C, high evapotranspiration rates and summer water deficit. The study area is located close to the town of Crotone, in eastern Calabria (southern Italy), and is of primary importance within the worldwide scientific community for the presence of the Vrica geological section and its recent institution as a geosite. This section represents the Pliocene-Pleistocene boundary stratotype, recorded in a gently-inclined, monoclinal stratigraphic succession, made of deep-sea, grey marly silty clays with arkosic sand and organic-rich *sapropel* interlayers. The top reaching about 160 m a.s.l. consists of gravels and sands intercalated with partly cemented bioclastic calcarenites (uncoformably overlying the clayey succession), which form wide marine terraces of late Middle Pleistocene age. The specific geological and geomorphological context, coupled with the climatic and environmental conditions, make it very susceptible to desertification and soil erosion.
Our study was performed with a multidisciplinary approach, ranging from a geomorphological and pedological survey in the field to aerophoto interpretation, GIS-aided mapping and morphometric measurements, up to mineralogical, geochemical and geotechnical laboratory analyses of key samples.
The landscape appears intensely dissected by surface water runoff and affected by mass-wasting processes. The main landforms and morphodynamic process described in the field and mapped are related to sheet/rill wash (dominating on terraced surfaces and gentle slopes) and gullying (as far as slope steepness increases) and especially badland development in the clay succession. The summit gravel-sand and calcarenites undergo rockfall phenomena and soil erosion, clearly testified by complete absence or severe truncation of topsoil organic horizons (A) and exposure at surface of typical deep, illuvial ones (Bt or Bk).
The badland morphologies are dominated by sharp knife-edged to smooth-shaped “calanchi” and extremely rare, small hummocky “biancana” clusters. Calanchi prevail on 20-40° inclined and eastern-facing slopes. Conversely, mass movements dominate on western and northern slopes with the main scars developed around 10-30°. An important control seems to be played by the monoclinal setting of the clayey strata contributing to an asymmetrical pattern of valley sides.
Both calanchi and biancana landforms occasionally exhibit metre- to decimetre-wide pipe holes at different height along the slopes, as well as a millimetre- to centimetre-thick, microcracked surface crust overlying an inner massive and compacted portion. Selected samples were collected from these different portions for laboratory investigations: analysis of clay minerals using X-ray diffraction techniques, total chemical composition (major and trace elements) by fluorescence spectrometry (XRF), particle size distribution, Atterberg limits, pH, total carbonate by calcimetry, soluble salts in ionic chromatography and calculation of the SAR (sodium adsorption ratio) dispersivity index, total microporosity, permeability, bulk and apparent (skeletal) density using a mercury porosimeter.
An overall qualitative and quantitative homogeneity was found for different properties, such as the particle size distribution (all samples representing clayey silt fractions), the clay mineralogy (including smectite, illite, kaolinite and subordinate chlorite), pH values attesting around a moderately alkaline reaction, SAR > 10, total $CaCO_3$ (on average equal to 19%), microporosity (mean value around 30%). Among the most interesting results there is the evidence that pipes are triggered in or above coarser-textured, more porous and more dispersive layers, presumably enhancing drainage intensity and erosive efficacy of subsurface water through-flow.

PRELIMINARY DATA ON PLANKTONIC FORAMINIFER A BIOSTRATIGRAPHY NEOGENE DEPOSITS CROPPING OUT IN THE M.TE PORO AREA (CENTRAL CALABRIA)

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The stratigraphic succession cropping out in the Piscopio area, near Vibo Valentia, included the following main units. The base of the succession is represented by coarse marine sandstones, Tortonian in age, with conglomerate layers and a fauna characterized only by *Clypeaster* in life position. This unit onlaps an Eercinian crystalline basement and marks a first event of the Tortonian transgression. The successive deposit is made of yellowish poorly cemented sandstones, rich in *Heterostegina papyracea*, with depositional characteristics quite similar to the previous unit. The fossil assemblage includes *Clypeaster* ssp., *Echinolampas* spp., *Terebratula* ssp., and red algae, mostly rhodolites. Frequently *Porites-Tarbellastrea* patch-reefs and small coral build-ups also occur.
An abrupt contact separates the overlying unit, made of blue emipelagic marls, rich in planktonic microfauna and echinoids as *Spatangus* spp. Upside, it grades into tripolaceous marlstones and limestones correlatable with the Lower Messinian “Calcare di Base”. This fact suggests a deepening of the depositional environment before the Messinian “Salinity Crisis”.
Finally, after a sedimentary gap extended from Late Miocene to Early Pliocene, the succession ends with hybrid arenites, characterized by swaley/hummocks depositional structure and clinostratified body assimilable, probably, to tidal dune.
The biostratigraphic study, based on planktonic foraminifera, has been carried uot on the upper part of the Neogene succession with the aim to obtain a better biostratigraphy framework for all these deposits.
Biostratigraphic analyses have been based on quantitative counting of planktonic foraminifera. The main results of the research are: the basal-middle part of the Piscopio section is Messinian in age, and is referable to the *Globorotalia miotumida* Zone MMi13, where specimens of *Globorotalia miotumida* group, *Globorotalia conomiozea* and *Neogloboquadrina acostaensis* dx have been recorded.
From the paleoecological point of view, the basin shows this evolution:
-the basal marls contain samples a planktonic foraminifer assemblages dominated by forms indicative of relatively warm waters, as *Globigerinoides* spp. and *Orbulina* spp. (samples FB9, FB10, FB11);
-upwards, the assemblages of foraminifera are dominated by Neogloboquadrinids and *Globigerina bulloides*, which are considered to be indicative of nutrient-rich waters (samples FB12, FB13, FB14);
-in the samples just below the carbonate beds (Calcare di Base Formation) the planktonic foraminifera fauna is scarce (sample FB15) or absent (sample FB16); furthermore, the foraminifera tests are poorly preserved and often indeterminable;
-the upper part of the section Piscopio can be ascribed to the Pliocene, for the presence of the *Globorotalia inflata* and *Globorotalia crassaformis* (samples FB17A, FB18, FB8C).

DIAGENESIS OF THE SCLERACTINIAN SKELETONS FROM THE UPPER MIOCENE CORAL-REEF CARBONATES, WESTERN CALABRIA, ITALY

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Significantly, coral-reef events in the Mediterranean appear synchronous: most of them are concentrated in the Late Tortonian-Messinian interval. These buildups are characterized by low diversity of bioconstructors and significant siliciclastic supply. In this paper we illustrate the diagenetic history of two coral-dominated buildups located respectively near the military airport of Vibo Valentia and Palmi (Calabria) and their diagenetic processes affected original biomineral composition of primary framework builders.
The Vibo Valentia bioconstruction, having variable thickness from 15 to 30 meters, lies on a succession made of seven meters of coralligenous breccia

followed by six meters of arenitic massive beds. Arenites contain echinoids, bivalves, benthic forams, and ostracods with *Pokornyella italica* and *Arutella saheliensis*, suggesting a Late Miocene ("Sahelian") age.
Original aragonite of the scleractinian corals, constituting the main component of the Upper Miocene buildups in the Mediterranean region, is substituted by calcite neomorphs. The primary framework consists of four scleractinian species: *Porites calabricae*, with the subordinate presence of *Tarbellastraea reussiana*, *Siderastraea crenulata* and *Solenastraea desmoluinsi* showing encrusting organisms, often represented by red algae (rhodolites), are relatively common. Dweller organisms are represented by forams, bivalves, echinoids and bryozoans: their presence is testified by fragments, scattered into sand-sized siliciclastic carbonate sediments. This datum suggests a low temperature of sea water, for the Late Miocene of the Mediterranean area. The bioconstruction is capped by covered marine arenite unit, ten meters in thickness, rich in echinoids, brachiopods, bryozoans and benthic microfauna.
Although coral specimens are diagenetically modified (thin-section microscopy observation, SEM and EDS microanalyses) it has been possible to observe some taxon-related differences in preservation.
The skeleton of *P. calabricae* have been interested by neomorphic processes that completely replaced the early aragonite into calcite. Cavities have been subsequently filled by sparry calcite. On the contrary, coralla of *S. crenulata* and *T. reussiana* preserve traces of the original microstructure, particularly in the inner zone of septa and walls (e.g., distinct boundaries between centers of calcification and fibers comparable to the modern counterparts). The EDS microanalyses and the mapping of the minor elements revealed signals of strontium in the skeleton, suggesting the preservation of relics of the original aragonite phase. Preserved traces of original microstructures have been experimentally studied by thermal annealing of Recent coralla of *Porites* sp., *Cyphastrea serailia* (morphological resemblance with fossil *Tarbellastraea*), and *Siderastraea savignana*. Calcification center zones can be discerned, especially in *C. serailia* and *S. savignana*, even if aragonite-calcite phase transformation resulted in drastic alteration of the original skeletal microstructures.
A group of outcrops extends along the Rocca Campana locality (1 km north of Palmi), they stand ranging from 125 to 75 m above present sea level. The fauna consists principally of ondulose *Porites calabricae* and *Tarbellastraea reussiana* and, subordinately, *Solenastraea desmoluinsi*. The low faunal diversity, the great terrigenous supply and the common presence of bryozoans, could suggest either a big changes in climatic conditions or a deep environmental variations.

PETROGRAPHY AND GEOCHEMISTRY OF OPHIOLITIC DYKES IN THE LIGURIDE UNITS OF THE LUCANIA-CALABRIAN BOUNDARY (SOUTHERN ITALY)

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Ophiolitic sequences are situated in the Lucania-Calabrian boundary (Southern Italy). The ophiolites are composed of serpentinized peridotites, metabasalts and metagabbros. The serpentinites include several bodies of basic ophiolites and high-grade metamorphic rocks (amphibolites, gneiss, granofels). Dykes of metadolerites and rodingites occur in the serpentinized peridotite. Metadolerite dykes also occur in the continental rocks, or as tectonic slices in calcschists and shales.
The ophiolitic sequence of the Frido Unit is affected by oceanic-floor metamorphism (amphibolite facies and greenschist facies) and orogenic HP/LT metamorphism which follows the oceanic-floor metamorphism.
The metadolerites show different types of texture: intersertal, granoxenoblatic and mylonitic. The metadolerites are porphyritic or aphyric. The rocks show cataclastic-mylonitic deformations. The metadolerites are cross-cut by veinscontaining pumpellyite, chlorite, prehnite, plagioclase, actinolite, white mica, quartz, calcite, albite, epidote and lawsonite.
Four different types of metadolerites can be recognized:
- plagioclase and clinopyroxene with intersertal, granoxenoblatic and mylonitic textures;
- plagioclase, clinopyroxene and brown hornblende show intersertal texture and granoxenoblatic textures;
- plagioclase, clinopyroxene, brown hornblende and blue amphibole with intersertal and granoxenoblatic textures;
- plagioclase and quartz with mylonitic fabric.

The magmatic plagioclase (PL1) is saussuritized and sericitized; the plagioclase (PL2) (albite or oligoclase) is re-crystallized by the oceanic-floor metamorphic event.
The composition of the clinopyroxene is augitic. The brown amphibole is hornblende and hornblende-pargasite.
Green amphibole shows two different compositions: hornblende, hornblende-tschermakite and tremolite-actinolite. The analysed blue amphibole is crossite.
Clinopyroxene is armoured by a corona of brown and green hornblende. Crossite corona developed at the expense of brown hornblende and tremolite.
The metadolerites show chemical transformations which can be referred to rodingitic alteration. Metasomatism is suggested by chemical variation. In particular the inverse correlation between CaO and Na suggests a rodingitic trend.
The rodingites intruded in serpentinite show typical phase of rodingitization metasomatic process: Ca-rich garnet hydrogrossularite, pseudomorphous the plagioclase.
Basalts show intersertal texture, the magmatic minerals assemblage it is established from plagioclase and clinopyroxene. Basalts show spilitic alteration.
Ophiolitic chemical study to point out the primary composition derived from MORB-type tholeiitic magmas.
Hydrotermal alteration of oceanic basic rocks by circulating seawater, with accompanying chemical changes in the composition of the rocks and circulating fluid, also has serious implication for both exchange of the element between the lithospere and hydrosphere.

P-T AND DENSITY CONSTRAINTS ON A CHLORITE-AMPHIBOLE-PERIDOTITE (ULTEN ZONE, ITALY)

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The Ulten Zone (Upper Austroalpine basement of the northeastern Alps) is a pre-Alpine basement where crust-mantle interaction can be observed, because of the exhumation of subducted crust incorporating mantle wedge slices. The Ulten Zone mantle peridotites preserve a tectono-metamorphic signature related to the Variscan orogenic cycle. In particular, they record the transition from coarse-grained spinel-facies conditions to fine-grained garnet-amphibole peridotite (Obata and Morten, 1987); the latter marks the metamorphic peak at about 330 Ma (Tumiati et al., 2003). The spinel- to garnet-facies transition is related to the burial of mantle material in response to corner flow in a mantle wedge environment (Nimis and Morten, 2000). Abundant, retrograde amphibole-harzburgites testify to a significant fluid input during the exhumation process that occurred in two stages (Ranalli et al., 2005): a first, rapid stage driven by tectonic extrusion of crustal material and a second slower stage related to slab break-off.
The study of the metamorphic evolution of amphibole-(± chlorite)-harzburgites has been hampered by the lack of suitable mineral assemblages. However, a new sample preserves the mineralogical (and textural) record of two metamorphic assemblages. Relics of a first high-pressure assemblage are coarse-grained forsterite + large (~ 6 cm in length) orthopyroxene porphyroclasts + + anhedral Mg-rich garnet (surrounded by a kelyphitic rim) + diopside + Mg-hornblende (core of large amphibole). The second assemblage consists of fine-grained enstatite and fosterite + Cr-spinel + chlorite neoblasts including Cr-spinel + Mg-hornblende (both as rim of large grains and as fine-grained matrix mineral). In this sample, accessory dolomite occurs in two textural positions: *i*) rare interstitial grains among large olivine of the relic assemblage and *ii*) more abundant larger grains (up to 0.5 mm) in amphibole-rich domains. The latter type occurrence suggests an increase of CO_2 component in the fluid percolating the peridotite. Pressure-temperature estimates by multi-equilibria techniques are 1.6-1.9 GPa, 800-840°C for the high-pressure assemblage while for the fine-grained assemblage the pressure-temperature values are 1.2-1.4 GPa and about 670°C. The retrograde pressure-temperature path outlined by the new calculations is related to the post-Carboniferous exhumation of mantle slices entrained in crustal lithologies.
The calculated density, based on modal and major-element compositions of the retrograde peridotites, at the pressure and temperature values of the final equilibration is about 3.27 g/cm^3. It is worth to note that this value is in excellent agreement with the measured density of an Ulten Zone garnet-peridotite (Burlini and Morten, 1999). Therefore, the minerals transformation and metasomatic enrichment along the retrograde path seems not to affect the density of mantle slices that were incorporated into the crust. Thus, even if the role of the slab break-off model during the final exhumation

stage of the Ulten Zone area cannot be ruled out, the incorporation of high-density mantle material into the buoyant crust may have contributed to the slowing down of the exhumation rate.

References

Burlini L. and Morten L., 1999. Miner. Petrogr. Acta, 42: 181-192.
Nimis P. and Morten L., 2000. J. Geodyn., 30: 93-115.
Obata M. and Morten L., 1987. J. Petrol., 28: 599-623.
Ranalli et al., 2005. Geol. Soc. London Spec. Publ., 243: 159-174.
Tumiati et al., 2003. Earth Planet. Sci. Lett., 210: 509-526.

TIME-EVOLUTION OF BASALTIC MAGMA OF USTICA ISLAND ON LIGHT OF NEW GEOCHEMICAL AND PETROLOGICAL DATA

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Basaltic magma prevails in all cycle of volcanic activity of Ustica Island. Petrology and geochemistry of the products show, with time, an enrichment trend of alkali and REE of the basaltic rocks. Sub-alkaline basalts (SA) characterize the first phases of activity; they show negative spikes of Hf and Ti in the multi-elemental plots coupled with a minor content of incompatible elements with respect to the younger transitional (TR) and alkaline magmas (AB), which are however characterized by negative spikes of Rb and K.

SA and TR basalts are characterized by the absence of clinopyroxenes as phenocrysts. CSD analyses on olivine crystals in SA and TR show a bimodal distribution with common disequilibrium textures whereas in AB basalts the distribution is mainly unimodal around 10micron. All olivines show the presence of Cr-spinels inclusions that might suggested that they are xenocrysts hereditieted from the mantle. However AB Cr-spinel has a high value of Mg# ($50 < Mg\# < 70$) and Al_2O_3 (> 35 wt%) and low value of Cr# ($20 > Cr\# > 30$) and TiO_2 (< 1%); instead, TR and SA Cr-spinel has a low value of Mg# ($Mg\# < 60$) and Al_2O_3 (< 35 wt%) and high value of Cr# ($30 >< Cr\# >< 60$) and TiO_2 (> 1 wt%). In addition the olivine-spinel geotermometer indicates that AB basalts re-equilibrated at lower temperature. LA-ICP-MS analyses indicate that there are significant difference in Ni and Cr of olivines belonging to the different basalts. Olivine from SA and TR basalts are mainly homogeneous and unzoned whereas microphenocrysts of olivine from AB are inversely zoned suggesting a possible re-equilibration with a more primitive magma.
All these differences are difficult to explain by different degree of partial melting of a unique mantle source.
In the Sm/(Sm+Nd) vs Rb/(Rb+Sr) diagram the Ustica basalts plot along two different trends suggesting the presence of an heterogeneous mantle source below the island.
The isotopic signature of SA basalts suggests a provenance from a depleted mantle, MORB-like source whereas AB and TR basalts have an enriched mantle component signature. The isotopic data also suggest that crustal contamination didn't play a significant role in the genesis of sub-alkaline basalts, rather they seem to confirm an origin from a mantle source metasomatised by fluid coming from a subducted slab.
Ustica basalts also show P_2O_5 and Th/Ta vs $^{87}Sr/^{86}Sr$ values suggesting a calc-alkaline imprint in the source during the initial stages. With time melting from an hydrate mantle, depleted in K and Rb and enriched in Na, probably with a lherzolitic-phlogopite composition generated alkaline magmas. The alkaline source increase its contribution with time and predominates in the late stage of activity.