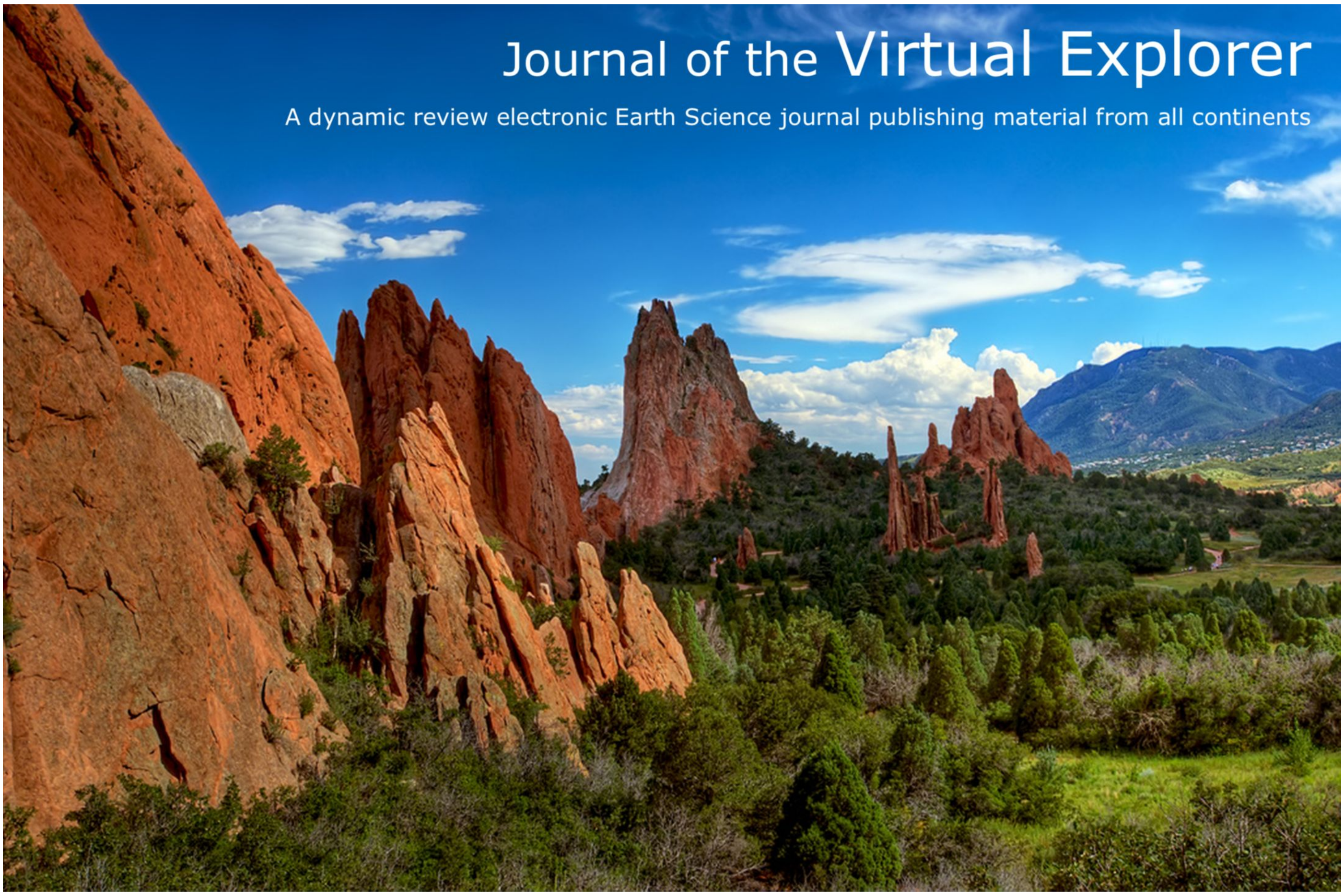

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Petrogenesis and geodynamic control of intraplate Cenozoic volcanism in Italy

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Abstract: The Cenozoic evolution of the Mediterranean area has been characterized by various subduction processes and related volcanism (calcalkaline, shoshonitic and ultrapotassic series), in the framework of a general convergence between the African and Eurasian plates and interposed microplates.

Intraplate volcanism closely following or accompanying (in space and time) the subduction-related magmatism also occurred in three main Italian provinces along rift systems: a) Veneto, within the Adria microplate (an “African Promontory”); b) Iblei (Sicily) within the northernmost part of the African lithosphere; c) Sardinia, a drifted fragment of the European lithosphere. In Veneto (Paleogene) and Iblei (Neogene-Quaternary), transtensional rift volcanism developed as foreland reaction to collisional processes along the Alpine and Maghrebian chains respectively, generating basic magmas ranging in composition from tholeiites to Na-alkali basalts and nephelinites. In Sardinia, Neogene-Quaternary volcanism - related to general tensional tectonics of the central Mediterranean - produced comparatively more potassic magmas ranging in composition from subalkaline basalts, alkali basalts/trachybasalts to basanites, locally associated with rhyolitic and trachyphonolitic differentiates.

A review of petrogenetic studies, based on incompatible element and Sr-Nd-Pb isotope systematics for both lavas and associated mantle xenoliths for the three volcanic provinces, leads to the following constraints: 1) the primary magmas, from tholeiites, alkali basalts to basanites and nephelinites, were generated by decreasing melting degrees (30% to 3%) of progressively deeper lithospheric mantle sources (*ca.* 30 to 110 km depth); 2) extensive and multiple enrichment processes by OIB-type alkali-silicate metasomatizing melts widely affected all mantle sources; 3) a previously depleted lithospheric mantle (DM) is enriched by prevailing HIMU metasomatic geochemical components in both Veneto and Iblean provinces in analogy with other north-african volcanic districts, whereas in Sardinia distinctly more potassic EMI signature predominates (in addition to HIMU), as commonly observed in the European lithosphere.

Regional studies on the associated mantle xenoliths and peridotite massifs suggest that the OIB-type metasomatic agents were possibly active at least since the Mesozoic (Wilson and Bianchini, 1998; Beccaluva *et al.*, 2001b; 2005b) resulting from the remobilization of older components (long-term isolated crustal lithologies recycled within the mantle by previous orogenic cycles), plausibly trapped in the deep transition zone (410-660 km depth). Activation of deep mantle material, ultimately resulting in the studied intraplate volcanism could be interpreted as a far-field dynamic response of the neighbouring Cenozoic subductions, which could have produced localized mantle upwellings. Therefore, the intraplate volcanism of the Central Mediterranean area may reflect a physical (not compositional) effect of the coeval Cenozoic subductions which could have triggered convective instabilities further remobilizing deep mantle domains.

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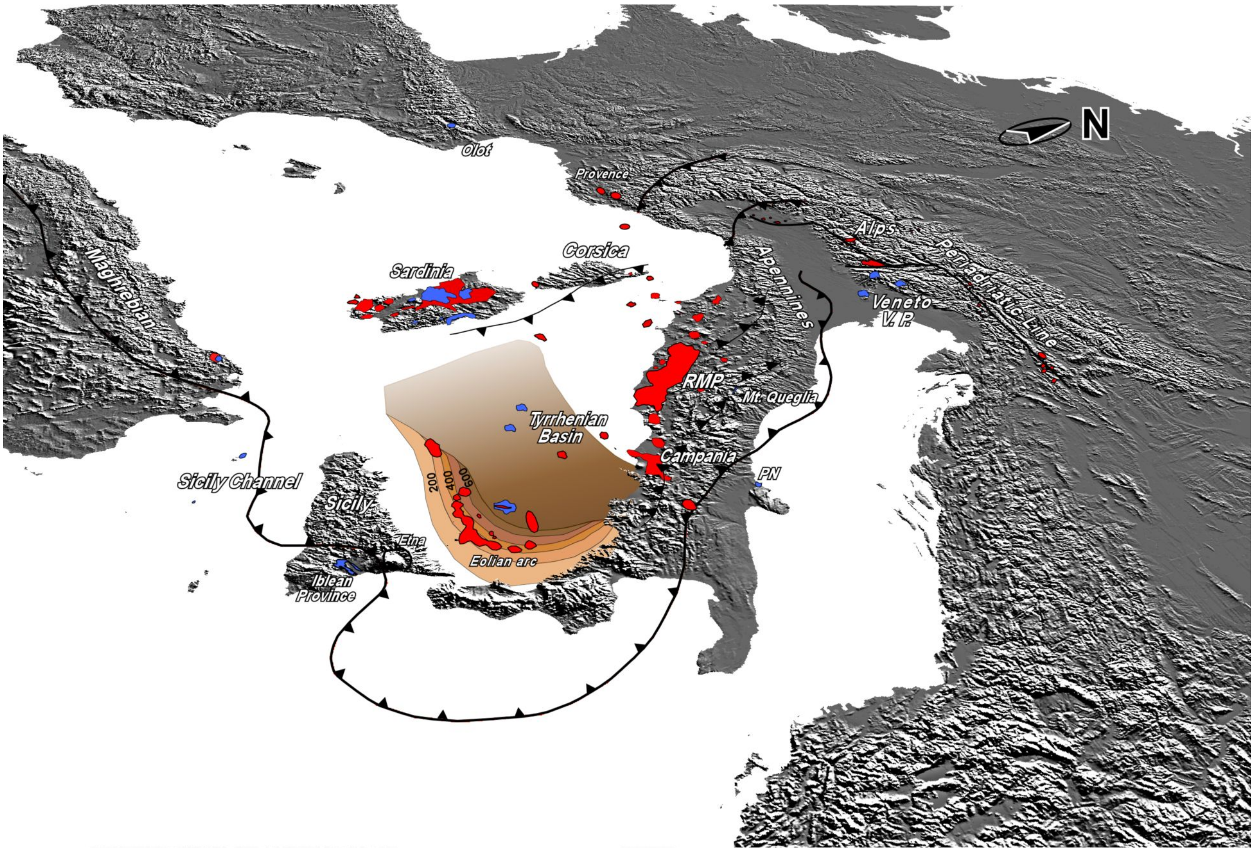
Introduction

Plate dynamics represents a key factor to control lithospheric rifting and by implication, magma generation. "Active" rifting may occur over mantle plumes that influences thermal, rheological and geochemical features of the magma sources (Wilson, 1989; Wilson and Downes, 1991; Wilson and Patterson, 2001; Campbell, 2001; Courtillot *et al.*, 2003). "Passive" rifting may be related to differential stress in the lithosphere often resulting in low volcanicity rifts, mostly along transtensional tectonic systems (Barberi, 1982; Wilson, 1989; Sengor and Natal'in, 2001).

Figure 1. The central Mediterranean area



Tectonomagmatic sketch of the Central Mediterranean with indication of orogenic (red) and anorogenic (blue) volcanic districts. Compressional fronts of Alpine and Apennines/Maghrebian Chains are reported after Carminati and Doglioni (2004). The inferred configuration of the subducted Ionian slab is based on earthquake hypocentres and seismic tomography data (Piromallo and Morelli, 2003).

Extension and rifting close to convergent plate boundaries may be influenced by the mode of subduction, triggering convective instabilities in the upper mantle and allowing inflow of sub-lithospheric components that modify the within-plate magma sources (Wortel and Spakman, 2000; Bianchini *et al.*, 2008; Beccaluva *et al.*, 2010)

In the central Mediterranean the Veneto (Paleogene), Iblei (Neogene-Quaternary) and Sardinia (Neogene-Quaternary) volcanic Provinces represent the major within-plate magmatic events which occurred during the Cenozoic over an area of more than 4,000 km^2 (Fig. 1). The Veneto volcanism rests on the Adria microplate, i.e the northern extension of Africa; the Iblei volcanic province (SE Sicily) rests on the African lithosphere, whereas the Sardinia volcanic province rests on a continental block which drifted and rotated during the Oligocene-Miocene away from the paleo-European continental margin.

The overall tectono-magmatic features of these three provinces are typical of intraplate setting, although the volcanic events were close - in space and in time - to orogenic volcanism related to recent subduction zones (Beccaluva *et al.*, 1983; 1987; 1994; 2005a, Alagna *et al.*, this issue; Conticelli *et al.*, this issue; Carminati *et al.*, this issue): 1) the Alpine collisional belt and the Periadriatic orogenic magmatism neighbour the Veneto volcanic district; 2) the Eolian arc magmatism neighbours the Iblean volcanic district; 3) the calcalkaline *s.l.* orogenic magmatism in Sardinia closely preceded the intraplate volcanism in the same areas.

These occurrences represent particularly convenient case studies to investigate the petrogenesis of intraplate magmas, to evaluate the possible influence of the neighbouring subduction systems and, more in general, to constrain the regional geodynamic control on magmagenesis. In this paper we review the petrological characteristics of intraplate lavas and associated mantle xenoliths from Veneto, Iblei and Sardinia, in order to define the petrological features of primary magmas and their magma sources, the tectono-magmatic significance of these volcanic events and the geodynamic control on the genesis of intraplate magmas.

Intraplate Cenozoic volcanism in Italy

The petrogenesis and tectonomagmatic significance of the Veneto, Iblei and Sardinia volcanic provinces is discussed taking first into consideration the origin of primary basic melts (MgO>7), namely the P-T-X (pressure, temperature and composition) conditions of mantle sources from which they were generated. Mantle xenoliths, often exhumed by basic alkaline volcanics in the three provinces, were also considered since they represent direct evidence of the lithosphere overlying the magma sources. In fact, the integrated study of near-primary melts and associated mantle xenoliths, and comparison with petrological experimental petrology results (Green and Falloon, 2005 and references therein) can provide important quantitative constraints on P-T-X conditions of magma generation, and extent of partial melting processes (Frey *et al.*, 1978; Beccaluva *et al.*, 1998; 2005b; 2007a).

Geochemical characteristics of basic magmas and associated xenoliths are discussed in terms of the notional mantle components defined for Ocean Island Basalts (OIB) (Zindler and Hart, 1986; Weaver, 1991; Carlson, 1995; Hoffmann, 1997).

In the following sections we discuss the distinctive geochemical features of each volcanic provinces focussing attention on the mantle sources characteristics and P-T conditions of magma generation.

Paleogene volcanism of the Veneto volcanic province

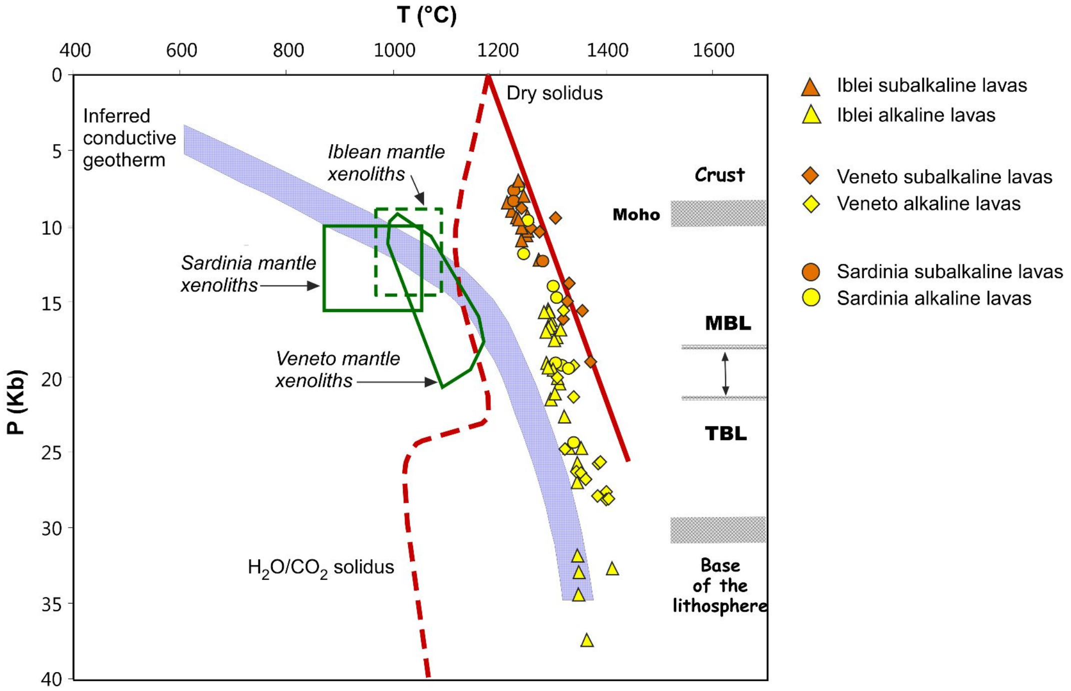
The Eocene-Oligocene Veneto Volcanic Province consists of a number of NNW-SSE oriented eruptive centres related to tensional tectonics of the Adria foreland in response to the Alpine collisional events (Beccaluva *et al.*, 2005b and references therein). The lavas of the Veneto Volcanic Province (< 20 km^3) are represented by relatively undifferentiated magmas which include (mela)-nephelinites, basanites, alkaline basalts, transitional basalts and tholeiites (Beccaluva *et al.*, 2007a). This volcanism bears close analogies with those of the “low volcanicity” impactogenic rifts, strong transtensional systems (Barberi *et al.*, 1982) and similarly characterized by small volumes of scarcely fractionated lavas covering a wide alkalinity range.

Southward, along the Adriatic plate, similar anorogenic magmatic occurrences are represented by the Paleogene Mt. Queglia lamprophyric dykes and Na-alkaline Pietre Nere subvolcanic body (Conticelli *et al.*, 2007; Bianchini *et al.*, 2008; Avanzinelli *et al.*, 2011).

The petrological characteristics of the least differentiated basic magmas are compatible with their segregation from lithospheric mantle sources located between 30 and 90 km depth (Fig. 2). The entire P-T segregation trend plots from *ca.* 9 kb/900°C to *ca.* 28 kb/1400°C between the experimental dry and hydrated-carbonated mantle solidi, approaching the inferred regional geotherm to depth. This suggests that partial melting processes could be easily triggered by local decompression effects, in turn related to a limited intraplate tensional regime.

The lavas of the Veneto Volcanic Province show incompatible element patterns and Sr-Nd isotope ratios similar to those of OIB-type magmas, particularly with HIMU-like affinity (Fig. 3). Pb isotopes confirm that Veneto magmas have a composition intermediate between DM and HIMU components, showing analogies with the magmatic rocks from Pietre Nere and Mt. Queglia (Fig. 4). Note that the extremely high Pb composition of Mt. Queglia lamprophyres could also results by time integrated radiogenic ingrowth (Avanzinelli *et al.*, 2011).

Figure 2. P-T conditions of magmagenesis



Calculated P-T conditions of magma segregation for Veneto, Iblei and Sardinia intraplate primary melts, according to Albarede (1992). Results are consistent with phase equilibria constraints (Falloon and Green, 1988; Falloon *et al*., 1988; Hirose and Kushiro, 1993; Hirose and Kawamoto, 1995; Olaffson and Eggler, 1983; White and Wyllie, 1992; Green and Falloon, 2005): tholeiitic basalts, 10-16 kb, 1150-1250°C; alkali-basalts, 14-22 kb, 1200-1280°C; basanites and nephelinites, > 22 kb, 1250-1350°C. Experimental mantle peridotite solidi for dry and H2O-CO2 conditions after Green *et al*. (1987) and Wyllie (1987). MBL (Mechanical Boundary Layer), TBL (Thermal Boundary Layer) and MOHO, conductive geotherm and equilibration conditions of mantle xenoliths from Beccaluva *et al*., 2005b and references therein.

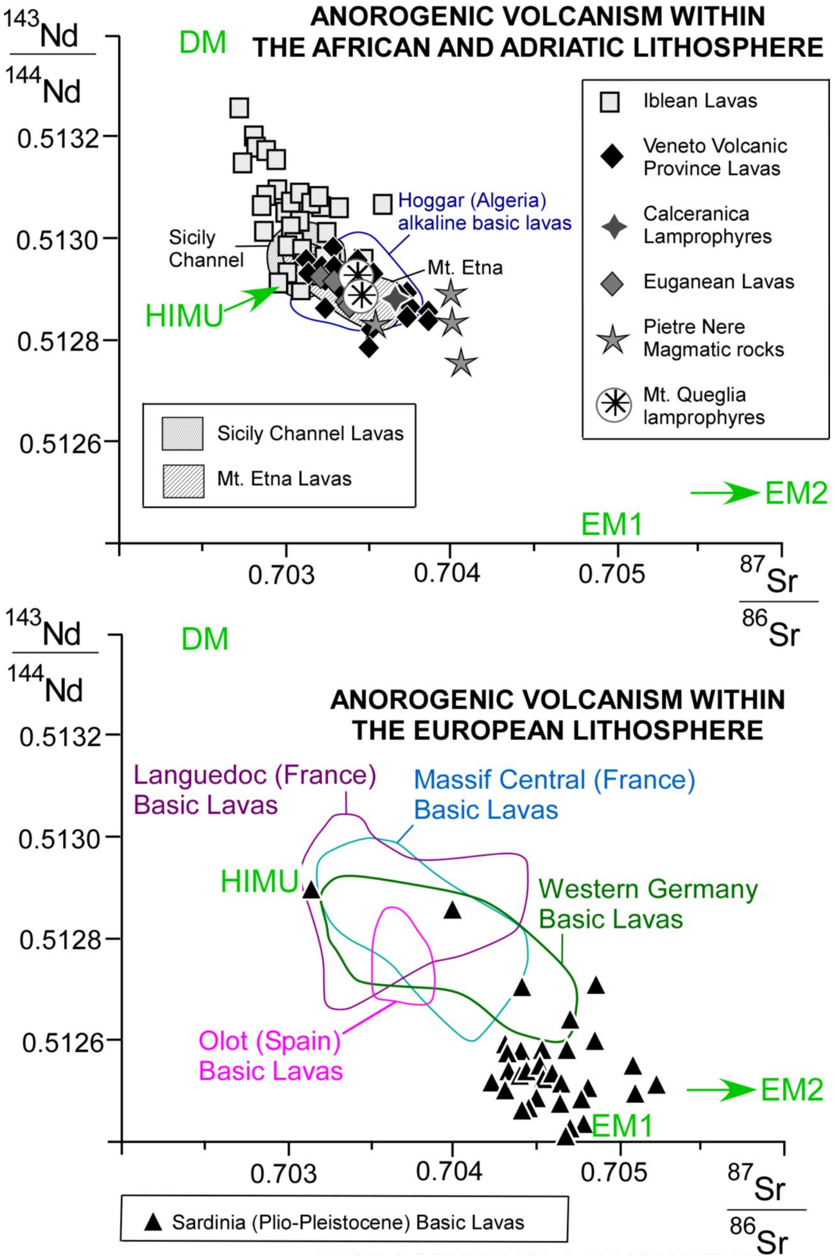
Therefore, geochemical data coherently indicate that the pristine depleted lithospheric mantle of the Adriatic microplate was pervasively enriched by metasomatizing agents with prevalent HIMU-like isotopic and elemental fingerprint, usually referred to as EAR (European Asthenospheric Reservoir; Cebria and Wilson 1995) or LVC (Low Velocity Component; Hoernle *et al*., 1995). The influence of these metasomatic components is widespread from eastern Atlantic to Europe and the Mediterranean area at least since Late Cretaceous (Wilson and Bianchini, 1999; Beccaluva *et al*., 2005b; Bianchini *et al*., 2008).

The most alkaline lavas of the Veneto Volcanic Province often include spinel-peridotite xenoliths that, according to thermobarometric estimates, come from the mechanical boundary layer of the underlying lithosphere at depths not exceeding 50-60 km (P<20kb; Siena and Coltorti, 1993; Beccaluva *et al*., 2001a; Fig. 2). These mantle xenoliths consist of predominant spinel lherzolites and minor harzburgites characterised by widespread metasomatic (pyrometamorphic) textures consisting of spongy clinopyroxene, and variably recrystallized glassy patches (Siena and Coltorti, 1989 and 1993; Coltorti *et al*., 2000; Beccaluva *et al*., 2001a).

These peridotites are variably enriched in Light (L) Rare Earth Elements (REE), showing La_N/Yb_N up to 19.2, related to metasomatic processes (Beccaluva *et al*., 2001a). Metasomatic effects are confirmed by parallel LREE enrichment of the constituent clinopyroxenes (La_N/Yb_N up to 5.7). The metasomatic processes can be accounted for by the addition of 1-6% alkaline basic melt/s to the pristine peridotite matrix (Beccaluva *et al*., 2001a).

The Sr-Nd isotope compositions of mantle xenoliths from the Veneto Volcanic Province (whole rocks and clinopyroxene separates, Fig. 5) plot between the depleted mantle (DM) and the HIMU components, confirming that the latter represent the isotopic signature of the metasomatizing agent.

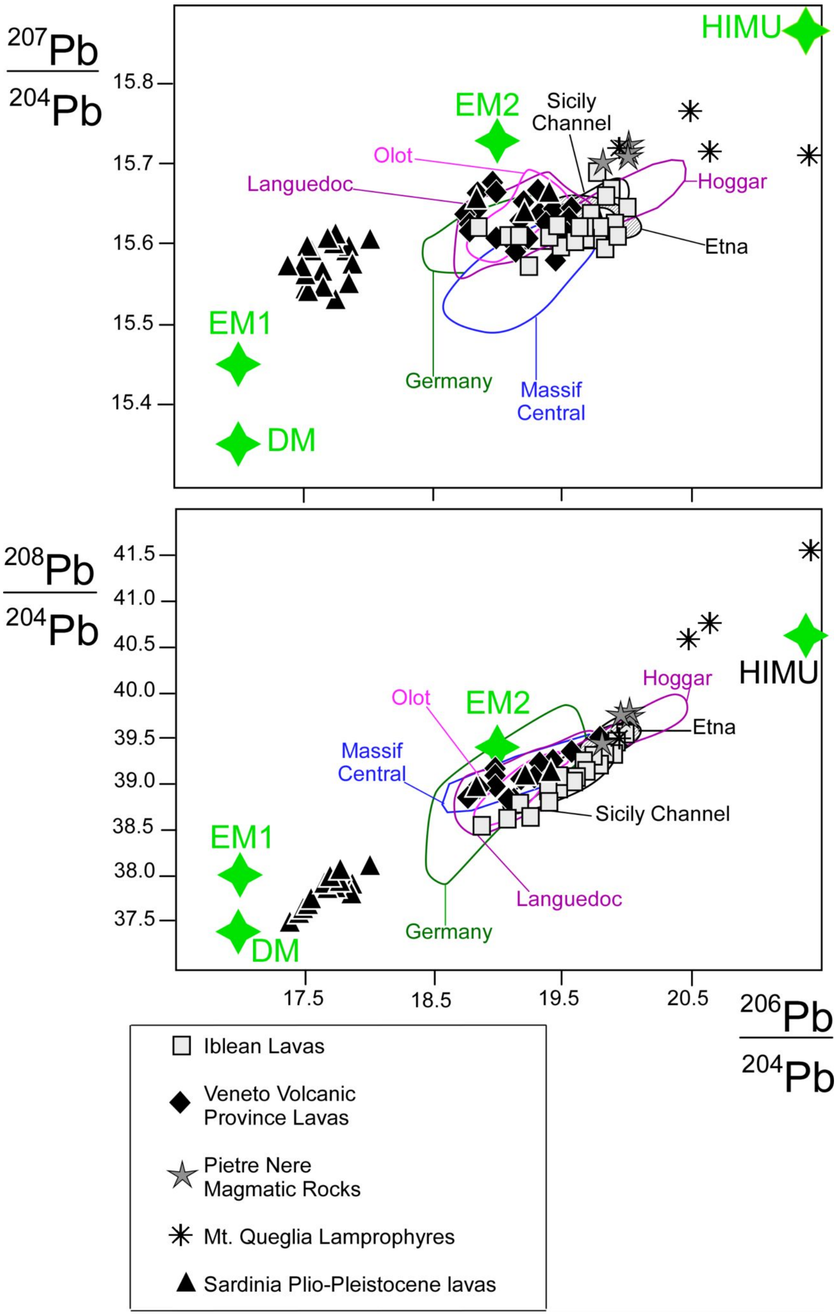
Figure 3. Sr-Nd isotopic composition of anorogenic lavas from the central Mediterranean area



Sr-Nd isotopic composition of intraplate lavas from (a) volcanic districts on the African and Adriatic lithosphere and (b) volcanic districts on the European lithosphere. Data for the Veneto Volcanic Province are from Macera *et al*. (2003) and Beccaluva *et al*. (2007a). Data for the neighbouring Euganean occurrence are from Milani *et al*. (1999). Composition of the Calceranica dykes is from Galassi *et al*. (1994). Data on other magmatic occurrences of the Adria plate, such as Pietre Nere and Mt. Queglia are from Hawkesworth and Vollmer (1979); Conticelli *et al.* (2007), Bianchini *et al.* (2008), Avanzinelli *et al.* (2011).

Data for the Iblean Volcanic Province lavas are from Tonarini *et al*. (1996), Trua *et al*. (1998) and Bianchini *et al* (1999). Data for the Sicily Channel from Esperança and Crisci (1995) and Civetta *et al*. (1998). Data for Mt. Etna from Armienti *et al*. (2004). Compositional field for Hoggar alkaline lavas is from Allegre *et al*. (1981) and Dupuy *et al*. (1993). Data for the Sardinian Volcanic Province from Lustrino *et al.* (2000; 2002), and Gasperini *et al*. (2000) are integrated with Authors unpublished data. Further compositional fields: Massif Central (Wilson and Downes, 1991; Wilson and Patterson, 2001) and Languedoc (Dautria *et al*., 2010) in France, Olot in NE Spain (Cebrià *et al*., 2000) and the western Germany volcanic districts (Wörner *et al*., 1986; Kramm and Wedephol, 1990; Wedephol *et al*., 1994). Geochemical components DM, HIMU, EM1, and EM2 after Zindler and Hart (1986).

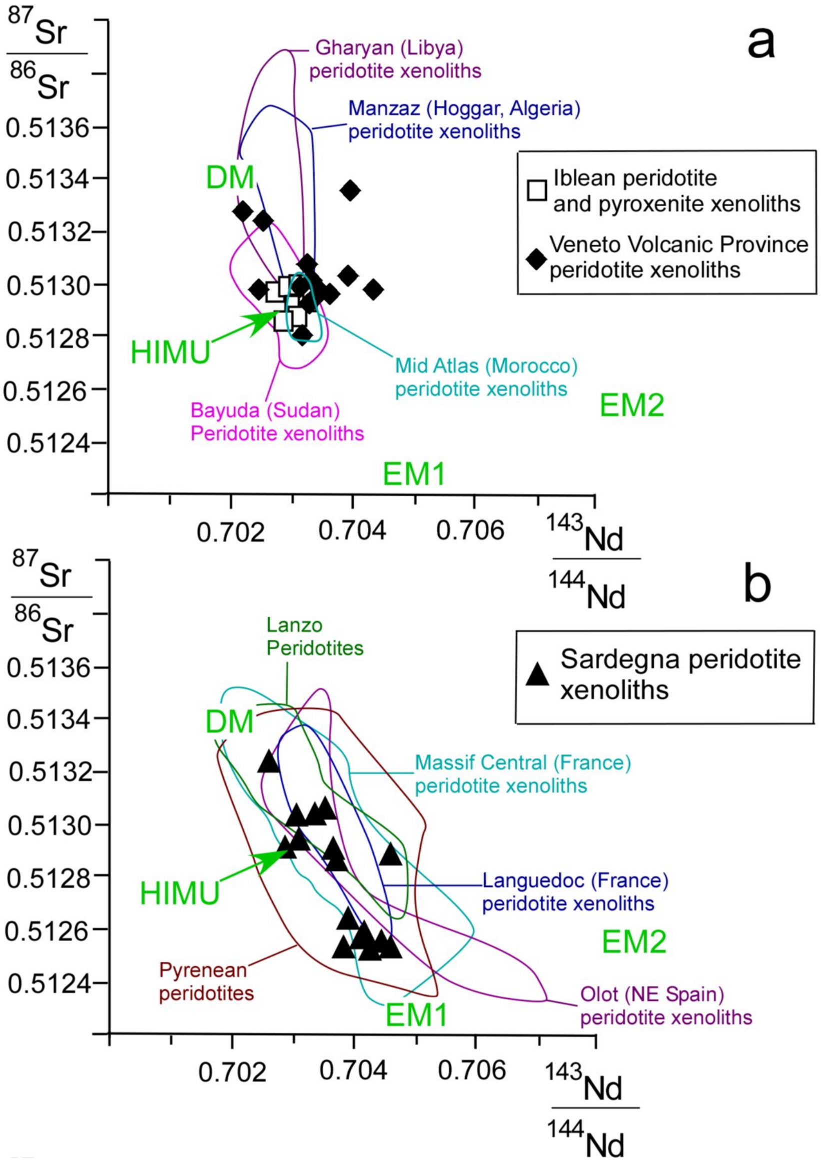
Figure 4. Pb isotopic composition of anorogenic lavas from the central Mediterranean area



Pb isotopic composition of of intraplate lavas from Central-Western Mediterranean.

Data on lavas from the Veneto Volcanic Province from Macera *et al*. (2003) and Beccaluva *et al*. (2007a). Data for the Iblean Volcanic Province lavas are from Trua *et al*. (1998) and Bianchini *et al.* (1999). Data for Sardinian lavas are from Gasperini *et al*. (2000) and Lustrino *et al*. (2000; 2002). The compositional fields of other within-plate magmatic occurrences from the Adria/North Africa domain are reported for comparison: Pietre Nere (Vollmer, 1976; Conticelli *et al.*, 2007; Avanzinelli *et al.*, 2011); Mt Queglia dikes (Bianchini *et al*., 2008); Mt. Etna (Carter and Civetta, 1977); Sicily Channel (Esperança and Crisci, 1995; Civetta *et al*., 1998). Also reported compositional fields of some European volcanic districts: Massif Central (Wilson and Downes, 1991) and Languedoc (Dautria *et al*., 2010) in France; Olot in NE Spain (Cebrià *et al*., 2000) and western Germany volcanic fields (Wedepohl and Baumann, 1999). Geochemical components DM, HIMU, EM1, and EM2 after Zindler and Hart (1986).

Figure 5. Sr-Nd isotopic composition of mantle xenoliths from the central Mediterranean area



Sr-Nd isotopic composition of mantle xenoliths from (a) volcanic districts on the African and Adriatic lithosphere; data on peridotite xenoliths from the Veneto Volcanic Province from Gasperini *et al*. (2006) and Beccaluva *et al*. (2007a); data for Iblean xenoliths are from Tonarini *et al*. (1996) and Bianchini *et al*. (2010a); Other data for African xenoliths occurrences are from (Beccaluva *et al*., 2007b; 2008; Lucassen *et al*., 2008; Wittig *et al*., 2010). (b) volcanic districts on the European lithosphere; data on Sardinian peridotite xenoliths from Beccaluva *et al*., 2001b; peridotite xenoliths from the Massif Central and Languedoc from Wilson and Downes (1991), Zangana *et al*. (1997), Downes (2001) and Dautria *et al*. (2010); peridotite xenoliths from Olot are from Bianchini *et al*., 2007. Data on orogenic peridotite massifs are also reported for comparison (Bodinier *et al*. 1991; Downes *et al*. 1991). Mantle end-member compositions from Zindler and Hart (1986) are also shown.

Neogene-Quaternary volcanism of the Iblean volcanic province

The Miocene and Pliocene-Pleistocene Iblean volcanism developed with subaerial and submarine eruptions, ranging in composition from tholeiitic to nephelinitic lavas along a regional NE-SW lithospheric wrench fault system oblique to the Maghrebian chain in Sicily (Bianchini *et al*, 1998; Beccaluva *et al*., 1998; Di Grande *et al*., 2002).

The Miocene (mainly Tortonian) volcanic phase was dominantly represented by alkaline diatremes; volcanism resumed in the Pliocene with volumetrically predominant tholeiitic lavas, followed in order of decreasing abundance by basanites, alkali-basalts + hawaiites, transitional basalts and nephelinites. This volcanism is therefore similar to that of the Veneto Volcanic Province, and it can be similarly ascribed to a “low volcanicity” transtensional rift system.

Accordingly, incompatible element patterns for the Iblean basic lavas mainly display HIMU OIB affinity, and are closely comparable to those of analogous lavas from the Veneto Volcanic Province. Sr-Nd isotope data (Fig. 3) range from the depleted mantle (DM) to HIMU-like signatures (Beccaluva *et al*., 1998; Bianchini *et al*., 1998; 1999; Trua *et al*., 1998). In particular, subalkaline lavas approach the DM composition (^{87}Sr/^{86}Sr 0.70271 – 0.70303 and ^{143}Nd/^{144}Nd 0.51325 – 0.51299), whereas alkaline products show a more marked HIMU-like affinity (^{87}Sr/^{86}Sr 0.70287 – 0.70328 and ^{143}Nd/^{144}Nd 0.51302 – 0.51291).

The HIMU signature is confirmed by the high ^{206}Pb/^{204}Pb ratios (Fig. 4) which range from 19 (in tholeiites) to 19.9 in alkaline lavas (Carter and Civetta 1977; Trua *et al*., 1998; Bianchini *et al*., 1999).

Petrogenetic and thermobarometric estimates for Iblean magmas indicate spinel peridotite lithospheric mantle sources (30 to *ca.* 110 km depth). These are progressively deeper, from tholeiites to nephelinites, with a parallel decrease in the degree of melting (≈ 30 to ≈ 3%; Beccaluva *et al*., 1998; 2005b).

It should be noted that incompatible element and Sr-Nd-Pb isotopic compositions of the Iblean lavas show remarkable analogies with those from the Sicily Channel (Linosa and Pantelleria islands; Esperança and Crisci, 1995; Civetta *et al*., 1998; Di Bella *et al*., 2008), consistently indicating the prevalence of the HIMU metasomatic components in magma sources of the Adriatic and north African plates.

Northward, the Etnean lavas while sharing petrological characteristics with the Iblean products, display a comparatively distinct enrichment of Low Field Strength Elements (LFSE) suggesting a possible influence of the neighbouring Ionian subduction on the Etna volcanism (Beccaluva *et al*., 1982; Cristofolini *et al*., 1987). Detailed Sr-Nd-B isotopic data confirmed that the Etnean mantle sources have been influenced by the Ionian subduction (Tonarini *et al*., 2001).

Spinel-peridotite mantle xenoliths, ranging from lherzolites to harzburgites, are commonly included in the Iblean alkaline lavas, with largest-sized and most abundant samples occurring in nephelinitic Miocene diatremes (Di Grande *et al*., 2002 and references therein). Thermobarometric estimates from CO_2 fluid inclusion data (Bergamini, 1992; Siena and Coltorti, 1993) and crystallochemistry of clinopyroxenes (Nimis, 1998) indicate a pressure range of equilibration conditions between 9 and 15 kb (≤ 50 km, Fig. 2).

Modal metasomatism is widespread and testified by secondary phases including phlogopite and feldspar, spongy borders in clinopyroxene and glassy patches.

REE distribution of peridotites and constituent clinopyroxene confirms interactions between alkaline metasomatic agent(s) and the mantle peridotite matrix inducing general LREE enrichment, with La_N/Yb_N up to 26 in bulk rock (Sapienza and Scribano, 2000; Beccaluva *et al*., 2005b) and up to 20 in clinopyroxene (Perinelli *et al*., 2008; Beccaluva *et al*., 2005b).

Isotopic data by Bianchini *et al*. (2010a) on separated clinopyroxene cluster around the HIMU component (^{87}Sr/^{86}Sr from 0.70271 to 0.70330, and ^{143}Nd/^{144}Nd from 0.51291 to 0.51325, Fig. 5), thus suggesting that the latter represents the geochemical signature of the metasomatizing agents, as already observed for xenoliths from the Veneto Volcanic Province. The Sr and Nd isotopes of pyroxenite samples included in the xenolith population (0.70305-0.70326; 0.51292-0.51299) perfectly overlap the field of the Iblean alkaline lavas.

Neogene-Quaternary volcanism in Sardinia

Within-plate Neogene-Quaternary fissural volcanism in Sardinia took place in concomitance with the Late Miocene rifting phase which ultimately lead to the opening of the Tyrrhenian basin.

Alkaline, transitional and subalkaline differentiation series can be observed in three representative volcanic complexes: alkali basalts/trachybasalts and basanites, to trachyphonolites and phonolites at Montiferro; transitional basalts to quartz-trachytes at Capo Ferrato and Mt. Arci; subalkaline basalts to rhyolites at Mt. Arci (Beccaluva *et al*., 2005b). Although some sporadic events occurred since 12 Ma (Lustrino *et al*., 2009 and references therein), most of the volcanic activity took place in the time span from 4 to < 0.2 Ma, with the climax of subalkaline activity slightly earlier (3.5-3.0 Ma) than that of alkaline volcanism (Beccaluva *et al*., 1985).

The incompatible element abundances of the least differentiated mafic lavas of the various volcanic series exhibit a close correspondence to typical EMI OIB patterns

(Weaver, 1991). Petrological modelling (Beccaluva *et al*., 2005b and references therein) and P-T estimates (Fig. 2) suggests that subalkaline basalts to basanites could be generated at increasing depth (30-80 km), by decreasing partial melting degrees (from 25 to 6%) from lherzolitic sources.

Sr-Nd-Pb isotopic data cover a wide compositional range (^{87}Sr/^{86}Sr: 0.70315 - 0.70534; ^{143}Nd/^{144}Nd: 0.51289 - 0.51235; ^{206}Pb/^{204}Pb: 17.5 - 18.0, Fig. 3 and 4) generally corresponding to EMI geochemical signature except for a few samples showing HIMU-like affinity (Lustrino *et al*., 2000 and 2002; Gasperini *et al*., 2000). It should be remarked that although partially overlapping the field of other Cenozoic European lavas, most of the Sardinian volcanic rocks exhibit extreme EM1 composition. This metasomatic component is more marked in subalkaline basalts (^{87}Sr/^{86}Sr 0.70453 - 0.70534, ^{143}Nd/^{144}Nd 0.51254 - 0.51235), whereas alkali-basalts and basanites are displaced to lower Sr and higher Nd isotopic ratios (0.70315-0.70514, 0.51289-0.51251). This suggests that the EMI metasomatic component was preferentially preserved in the shallow lithospheric mantle (<50-60 km depth) where subalkaline basalts were generated.

Mantle xenoliths, ranging in composition from spinel lherzolites to spinel harzburgites were entrained by alkaline basic lavas from type localities in eastern (Dorgali) and western (Scano) Sardinia. According to CO_2 fluid inclusion data and thermobarometric estimates (Beccaluva *et al*., 1989; Siena and Coltorti, 1993), they represent the uppermost lithospheric mantle (*ca.* 40 km depth). Xenoliths from Dorgali are lherzolites (cpx content varying from 6% up to 16%), whereas those from Scano are mostly harzburgites with subordinate cpx-poor lherzolites (clinopyroxene content never exceeding 10%). Evidence of metasomatic processes is provided by pyrometamorphic textures with feldspar, phlogopite and glassy blebs.

Metasomatic effects, attributable to alkaline agents, are confirmed by LREE-enriched patterns in both whole rock (La_N/Yb_N up to 40.7) and constituent clinopyroxene (up to La_N/Yb_N 45.0).

The Sr-Nd isotope composition of the Sardinian xenoliths (whole rock and clinopyroxene separates, Fig. 5) shows a large range of variation, extending from the DM toward the EMI end-member (^{87}Sr/^{86}Sr 0.70262-0.70461 and ^{143}Nd/^{144}Nd 0.51323-0.51254), conforming to the geochemical fingerprint of the associated lavas.

Deep mantle components and geodynamic control on intraplate magmatism

As shown in the previous sections, the compositional characteristics of the parental basic magmas for the three investigated provinces are compatible with their segregation from the lithospheric mantle between *ca.* 30 and 110 km depth. The solidus condition of magma sources appears fairly close to the regional geotherm inferred for the central Mediterranean area, thus suggesting that partial melting processes could be easily triggered by local decompression effects. The intraplate volcanic activity is therefore compatible with a limited extensional/transtensional regime as in fact observed in impactogenic rift systems oblique to orogenic chains.

In the investigated provinces, the alkaline and deeper magmas show a more marked HIMU-like signature compared to the subalkaline basalts; this suggests a more intensive and probably more recent enrichment, of the deeper lithospheric mantle sources (> 60-70 km, i.e. in the Thermal Boundary Layer; Wilson *et al*., 1995) by the HIMU metasomatizing agents. On the other hand, the subalkaline magmas generated from shallow lithospheric mantle sources display a variable influence of EM components, particularly in Sardinia.

Mantle xenoliths associated to alkaline lavas of the three volcanic provinces generally represent shallow portions of the lithospheric mantle column (< 40-60 km depth, i.e. in the MBL) according to thermobarometric estimates and rheologic characteristics (Siena and Coltorti, 1993; Verde, 1996; Beccaluva *et al*, 2005b). They usually reflect reaction(s) between sub-lithospheric metasomatizing agents and previously depleted lithospheric mantle, inducing variable enrichments of the most incompatible elements (e.g. LREE, LFSE, etc.). The resulting isotopic signatures conform to those of their host magmas, being dependent on the variable contributions of the DM, HIMU, and EM components. In particular, a prevailing HIMU imprint is recorded for both Veneto and Iblean mantle materials, whereas a predominant EMI component, in addition to HIMU, is observed for the Sardinian mantle.

On the basis of the available data Beccaluva *et al.* (2005b) proposed a distinct compositional evolution of the European (Sardinia) and African/Adriatic (Iblei and Veneto) lithospheric mantle: the European lithosphere is characterized by DM, enriched by prevailing EMI metasomatic components whose effects have been recorded at least since the mid-Mesozoic (as recorded in European peridotite massifs), whereas the addition of HIMU seems to have been effective in both European and African lithosphere since the Late Cretaceous (Wilson and Bianchini, 1999).

From the above, two main questions remain open: 1) which is the ultimate origin of geochemical components that metasomatized intraplate magma sources? 2) Is there any influence of the neighbouring subduction zones on intraplate magmatism?

Mantle sources of Cenozoic intraplate magmatic events in the Central Mediterranean area invariably involve OIB-type (HIMU, EMI, EMII, Zindler and Hart, 1986) geochemical components, whose genesis require recycling via ancient subductions (and long-term isolation) of crustal *s.l.* material deep in the mantle (Weaver, 1991; Carlson, 1995; Hofmann, 1997).

The mantle region in which crustal material is preferentially recycled and stored, as a result of subduction processes, is the zone between the Upper and the Lower Mantle (*ca.* 410-660 Km depth) where most slabs flatten. The exclusive OIB signatures recorded in the studied intraplate magmas imply that: 1) any geochemical influence from the neighbouring Cenozoic subduction zones has to be excluded; 2) the old “refertilized” deep mantle regions were repeatedly reactivated releasing the OIB metasomatic agents, which in turn may rise in the overlying lithospheric mantle.

However, subducted slabs of the Mediterranean orogens seem to play a significant role in the genesis of anorogenic intraplate magmas shortly after the end of an orogenic cycle as observed in Sardinia (Beccaluva *et al*, submitted). In this province the anorogenic volcanic fields lies above the *ca*. 800 km long Ionian slab, subducted since the Eocene and currently flattened at *ca.* 600 km depth beneath the Tyrrhenian and Sardinia. The down going slab may have triggered convective instabilities in the surrounding mantle ultimately favouring melting processes at shallower levels.

This interpretation may also stand for the Veneto Volcanic province close to the collisioned Alpine subduction(s) during Paleogene and for the Iblean volcanism neighbouring the southern edge of the still active Eolian arc subduction.

Laboratory and theoretical models (Kincaid and Griffith, 2003; Faccenna *et al*., 2010) have shown the importance toroidal/vertical mantle flows around the edges of a subducting slab. Moreover convective instabilities around subducted slabs have recently been referred to as “splash plumes” (Davies and Bunge, 2006) involving localized mantle upwellings and rising metasomatic agents from the top of the Mantle transition Zone (410-660 km depth) to the overlying upper mantle/lithosphere (Wilson and Downes, 2006; Lustrino and Wilson, 2007; Bianchini *et al*., 2010a; 2010b).

In this framework it is plausible that the subduction processes of the Alpine (*s.l.*)-cycle generated “splash plume” instabilities, favouring intraplate magma generation in the surrounding mantle. Therefore, the studied intraplate volcanism may represent a far field consequence and a dynamic (not compositional) response to the Cenozoic subductions throughout the Mediterranean realm. This hypothesis could explain the timing of intraplate magmatism often nearly coeval or postdating the orogenic (subduction related) magmatism.

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