DENUDATION OF SUBCONTINENTAL LITHOSPHERIC MANTLE DURING OCEAN FORMATION: A FOSSILE EXAMPLE FROM THE LIGURIAN OPHIOLITES

Giovanni B. Piccardo* and **Elisabetta Rampone****

** Dipartimento per lo Studio del Territorio e delle sue Risorse, Università di Genova, Corso Europa 26, 16132 Genova, Italy.*

*** Dipartimento di Scienze della Terra, Università di Milano, via Botticelli 23, 20133 Milano, Italy.*

ABSTRACT

Ophiolites cropping out in the Alpine-Apennine belt are considered remnants of the oceanic lithosphere of the Jurassic Ligurian Tethys, which was formed from the breakdown of the Apulia continental block away from Europe.

Alpine-Apennine ophiolites show some atypical characteristics, when compared with oceanic lithosphere produced at mid-ocean ridges of mature oceans. The most striking feature is represented by the overall abundance of variably serpentinized mantle peridotites, with subordinate gabbroic intrusions with MORB affinity. Peridotites constitute the depositional basement for the associated volcanic-sedimentary sequence: in fact, MORB volcanites, ophiolitic breccias and radiolarian cherts form discontinuous layers lying on top of the peridotite basement.

As recognized from a long time, ophiolitic peridotites from the Ligurian Tethys have a fertile compositions, significantly different from abyssal peridotites. Based on the association of presumably subcontinental lithospheric, fertile mantle and MORB magmatism in the Ligurian ophiolites, it has been argued that “they were formed during early stages of opening of the ocean, following rifting, thinning and breakup of the continental crust, and were therefore located in a marginal, pericontinental position in the oceanic basin” (Beccaluva and Piccardo, 1978); it has also been substained that “the Ligurian domain was not an ocean in the strict sense: it can be called a mantle-floored submarine domain” (Lemoine at al., 1987).

Ligurian ophiolitic peridotites show variable composition from rather fertile (the External Liguride peridotites) to rather depleted (the Internal Liguride peridotites) (see discussion in Rampone and Piccardo, 1999, and references therein). External Liguride fertile lherzolites have Sr and Nd isotopic compositions ($^{87}Sr/^{86}Sr$ = 0.70222-0.70263; $^{143}Nd/^{144}Nd$ = 0.513046-0.513205) (Rampone et al., 1995), which plot within the depleted end of the MORB field, similar to many subcontinental orogenic lherzolites from the Western Mediterranean area (e.g. Pyrenees and Lanzo North). Internal Liguride depleted peridotites have Sr isotopic compositions ($^{87}Sr/^{86}Sr$ = 0.702203-0.702285) consistent with a MORB-type mantle, but very high Nd ratios ($^{143}Nd/^{144}Nd$ = 0.513619-0.513775) which plot significantly above the MORB field; their high Nd ratios are coupled to very high $^{147}Sm/^{144}Nd$ ratios (0.54-0.56) (Rampone et al., 1996).

External Liguride peridotites display Nd model ages (assuming a CHUR mantle source) in the range 1.9-1.7 Ga: consistent results are obtained with Rb-Sr systematics. The single sample with extremely depleted isotopic compositions gives Nd model ages of 2.4 or 2.1 Ga, assuming, respectively, a CHUR or a DM mantle source. These ages have been interpreted (Rampone et al., 1995) as the ages of accretion of convective asthenospheric mantle to the conductive continental lithosphere, concordantly with many subcontinental peridotites of the Western Mediterranean area.

Internal Liguride peridotites display a Nd model age (assuming a DM mantle source) of 275 Ma: this age has been interpreted (Rampone et al., 1996) as indicative of a Permian partial melting of an asthenospheric mantle source, successively accreted to the subcontinental lithospheric mantle. A Permian depletion by partial melting has been also inferred for the subcontinental peridotite of Balmuccia (Ivrea Zone) which, accordingly, plot, together with samples from Lanzo South, on the trend defined by the Internal Liguride peridotites and the DM source. Partial melting of the asthenosphere during Permian extension of the Europe-Adria lithosphere is well documented by numerous gabbroic bodies with MORB affinity intruded beneath or within thinned continental crust, as presently preserved within the Austroalpine and South-Alpine Units of the Alps (i.e. the marginal units of the Adria plate).

Isotopic data from an Internal Liguride gabbroic body yield well-defined internal Sm-Nd isochron of 164 Ma (Rampone et al., 1998) and provide striking evidence that parental magmas of the gabbros and mantle peridotites from the Internal Liguride ophiolites are not linked by any simple melt-residua relationships, as it is expected and it has been recently demonstrated for oceanic lithosphere formed at mid-ocean ridges.

The Ligurian ophiolitic peridotites record a composite tectonic-metamorphic evolution under decreasing pressure and temperature, indicating a progressive exhumation starting from lithospheric mantle depths, where they have been previously equilibrated at P-T conditions compatible with an intermediate continental gradient. During this decompressional evolution, mantle peridotites were intruded, from Triassic to Jurassic times, by MORB magmas generated by deeper asthenospheric sources. During Late Jurassic they were exposed at the sea-floor, where they were discontinuously covered by MORB volcanites and radiolarian cherts.

In conclusion, the mantle peridotites which floored the Jurassic Ligurian Tethys was old (Proterozoic or Permian) subcontinental lithospheric mantle which underwent exhumation and tectonic denudation during the formation of the Jurassic oceanic basin. The most suitable geodynamic process to account for the tectonic denudation of large sectors of subcontinental mantle peridotites is the passive extension of the continental lithosphere. The exposure of sub-

continental mantle on the ocean floor is an unique feature testifying the early stages of inception of an oceanic basin by means of passive lithospheric extension.

This setting is presently recorded in embrionic oceans, like the Red Sea, and at passive margins, like the Galicia passive margin.

REFERENCES

Beccaluva L. and Piccardo G.B., 1978. Petrology of the Northern Apennine ophiolites and their significance in the Western Mediterranean area. In: H. Closs, D. Roeder and K. Schmidt (Eds.), Alps, Apennines, Hellenides. Schweizerbart'sche Verlagbuchhandlung, p. 243-254.

Lemoine M., Tricart P. and Boillot G., 1987. Ultramafic and gabbroic ocean floor of the Ligurian Tethys (Alps, Corsica, Apennines): in search of a genetic model. Geology, 15: 622-625.

Rampone E., Hofmann A.W., Piccardo G.B., Vannucci R., Bottazzi P. and Ottolini L., 1996. Trace element and isotope geochemistry of depleted peridotites from an N-MORB type ophiolite (Internal Liguride, N. Italy). Contrib. Mineral. Petrol., 123: 61-76.

Rampone E., Hofmann A.W., Piccardo G.B., Vannucci R., Bottazzi P. and Ottolini L., 1995. Petrology, mineral and isotope geochemistry of the External Liguride peridotites (Northern Apennine, Italy). J. Petrol., 36: 81-105.

Rampone E., Hofmann A.W. and Raczek I., 1998. Isotopic contrasts within the Internal Liguride ophiolite (N. Italy): the lack of a genetic mantle-crust link. Earth Planet. Sci. Lett., 163: 175-189.

Rampone E. and Piccardo G.B., 1999. The ophiolite - oceanic lithosphere analogue: new insights from the Northern Apennines (Italy). Geol. Soc. Am. Bull. Special Publication (in press).