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From northern Gondwana passive margin to arc dismantling: a geochemical discrimination of Ordovician volcanisms (Sardinia, Italy)

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In Sardinia, one of the southernmost remain of the European Variscan belt, a crustal section through northern Gondwanan paleodomains is largely preserved. It bears significant evidence of igneous activity, recently detailed in field relationships and radiometric dating (Oggiano et al., submitted).
A Cambro – Ordovician (491.7 $\pm$ 3.5 Ma $\div$ 479.9 $\pm$ 2.1 Ma, LA-ICP-MS U-Pb zircon age) bimodal volcanic suite occurs with continuity in external and inner Variscan nappes of Sardinia below the so-called Sardic unconformity. The igneous suite represents an intraplate volcanic activity developed through subsequent episodes: i) an intermediate explosive and effusive volcanism, i.e. pyroclastic fall deposits and lava flows, embedded into epicontinental clastic sediments, culminating in silicic ignimbrite eruptions, and ii) mafic effusives. Geochemical data document a transitional, within-plate signature, e.g. the average Th/Ta (4.5) and La/Nb (2.7) overlap the upper continental crust values. The volcanites are characterized by slight fractionation of LREEs, nearly flat HREE abundance. The negative Eu anomaly increases towards evolved compositions. Some prominent HREE depletion (GdCN/YbCN = 13.8), and the high Nb/Y suggest a garnet-bearing source. The high 87Sr radiogenic content (87Sr/86Sr 490 Ma = 0.71169) and the epsilon Nd 490 Ma value of –6.54 for one dacite sample, imply a time integrated LREE-enriched source with a high Rb/Sr, such as a metasedimentary source. The stratigraphy of the succession and the geochemical composition of igneous members suggest a volcanic passive margin along the northern Gondwana at the early Ordovician.
The bimodal Mid-Ordovician arc volcanism (465.4 $\pm$ 1.4 Ma, U-Pb zircon age; Oggiano et al., submitted) is developed in the external nappes (e.g. in Sarrabus and Sarcidano) and in the foreland occurs as clasts at the base of the Hirnantian succession (Leone et al. 1991). The Mid Ordovician sub-alkalic volcanic suite has reliable stratigraphic and palaeontological constraints, as it post-dates the Sarrabese (i.e. Sardic) unconformity and pre-dates the Upper Ordovician transgression. It consists of basaltic – andesites and abundant andesites and rhyolites.
The negative Ta-, Nb-, Sr-, P-, Yb- and Ti-anomalies in mantle-normalized spiderdiagrams and Th/Ta compare with volcanic rocks from active continental margins. Andesite and dacite samples reveal Sr and Nd isotopic compositions consistent with a less depleted mantle source than rhyolites (epsilon Nd 465 Ma = –3.03 to –5.75; 87Sr/86Sr 465 Ma = 0.70931-0.71071). The positive epsilon Nd 465 Ma values of rhyolites (+1.15 to +2.42) suggest that their precursors, with a crustal residence age of $\sim$1 Ga (TDM), were derived from a long-term depleted mantle source. On the whole, the isotopic data for Mid Ordovician volcanites suggest partial melting of an isotopically heterogeneous mantle. The bimodal suite has been unanimously interpreted as a marker of the Rheic ocean subduction.
An Upper Ordovician transitional to alkalic volcanic activity is documented both in the foreland, and in the external and internal nappes (Di Pisa et al. 1992). The Late Ordovician alkalic mafic suite (440 $\pm$ 1.7 Ma) i.e. the Ordovician-Silurian boundary, occurs as sills, epiclastites and lava flows within the post-Caradocian transgressive sequence. The volcanic rocks are characterized by fractionation of REEs (LaCN/YbCN $\sim$ 4.4-13), variable LILE abundances and significant Ta, Nb and LREE enrichments. Th/Ta in the range 1-2 and La/Nb < 1 evidence an anorogenic intraplate setting. The epsilon Nd 440 Ma values are positive (+1.60 to +4.14), reflecting an origin in a depleted mantle source, while the 87Sr/86Sr vary from 0.70518 to 0.71321. Negative epsilon Nd 440 Ma values (-4.76 and -4.62) in trachy-andesites suggest a less depleted mantle source, while the 87Sr/86Sr 440 Ma (0.70511 to 0.70694) and the Sm/Nd up to 0.36 align along the mantle array.

The Late Ordovician alkalic suite suggest a continental rift geodynamic setting, and likely represent an early phase of the major rifting event at the Northern Gondwana margin, that probably attained to the palaeo-Tethys expansion (von Raumer et al., 2003).
Thus, Sardinia as other Palaeozoic terranes issued from the former northern Gondwana margin (as the French Massif Central and Iberia) experienced an evolution from continental break-up to volcanic arc dismantling and subsequent ensialic rifting (e.g. Sánchez-Garcia et al. 2003; Etxebarria et al. 2006; Chichorro et al. 2008; Pin & Lancelot 1982; Pin & Marini 1993).

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