Variscan amphibolites, once extremely iron-rich silica-poor tholeiites, NE Sardinia, Italy

(1 table)

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Amphibolites, once extremely iron-rich silica-poor tholeiites, crop out as small, discontinuous lenticular bodies up to 250 m in length and about 60–70 m in width at Monte Plebi, in the axial zone of the Variscan chain in Sardinia.

Moderate foliation parallel to the regional schistosity of the surrounding migmatites is recognizable in fine-to medium grained amphibolites. The whole sequence of the Monte Plebi outcrop is from bottom to top:

Layer A, 20–30 m long, 10m thick, stands over the migmatites and underneath layer C. It consists of alternating white and dark bands whose thickness generally ranging from a few milimetres to a few centimetres, may reach a maximum of 80–100 cm for the white bands and of 10 cm for the dark ones. The thickness of dark bands increases from bottom to top of layer A.

Layer B consists of two different lenticular bodies, the first one (B1) enclosed in layer A, and the second one placed at the top of layer A. These layers are made up of a dark-coloured, strongly massive ultramafic rock, with milimeter size garnet crystals. Maximum thickness is 3–5 m.

Layer C, 20–30 long and 6 m thick, shows an alternation of prevailing dark bands and minor white bands. Dark nodules of ultramafic rock similar to that of layer B were also found.

Layer D, 60 m long and 15 m thick, lies at the top of the sequence. It consists of prevailing white and subordinate dark bands.

Ultramafic rocks – Three different lithotypes can be distinguished: i) amphibolite (amphibole 95–98%, opaque minerals 2–5%); ii) garnet amphibolite (amphibole 75–85%, garnet 15–20%, opaque minerals 3–5%), iii) biotite-bearing amphibolite (amphibole 94–97%, biotite 2–3%, opaque minerals 1–2%).

The dark bands – Two different rock types can be distinguished: i) fine-grained rocks made up of amphibole (65–75%), plagioclase (15–20%), quartz (10–15%), biotite (0–2%), opaque minerals (2–3%), rare garnet; ii) coarse – grained rocks made up of amphibole (70–80%), plagioclase (20–30%), and rare opaque minerals.

The white bands – The white bands consist of green amphibole (15–30%), plagioclase (60–75 %), and quartz (10–15%). Small amounts (1–2%) of opaque minerals and rare chlorite are also present.

The ultramafic rocks of layer B show the following geochemistry: SiO_2 37–41%, TiO_2 2.3–4.7%; Al_2O_3,11.9–14; FeO_{tot} 19.1–22.6; MgO 6.6–9.7; CaO 11.1–13.4; Na_2O 1.1–1.7; K_2O 0.7–0.9; P_2O_5 0.3–1.4.

The dark bands seem to be divided in two groups: a) with $SiO_2 \approx 48\%$; $TiO_2 \approx 1.7$; $FeO_{tot} \approx 12.5$; MgO ≈7.4; CaO ≈10; $Na_2O \approx 2.8$; $K_2O \approx 1.0$; $P_2O_5 \approx 0.3$; ÓREE 70–80 ppm; b) SiO_2 44–46%; TiO_2 0.3–0.4; FeO_{tot} 10.2–12.0; MgO 10.4–12.0; CaO 12–12.7; Na_2O 1.3–1.6; K_2O 0.2–0.7; P_2O_5 0.03; Zr 5.5 –11 ppm; Nb 0–2 ppm; Ba 19–48 ppm; Th 0.1–0.2 ppm; ÓREE 6–8 ppm.

The white bands are characterised by SiO_2 mainly in the range 69–71% but values of 63.4 and 54.5 were also found; TiO_2 0.2–0.4; Al_2O_3 14.5–18; CaO 4.3–6.3; Na_2O mostly in the range 4.3–5.2; K_2O 0.3–0.5; P_2O_5 0.2–0.7.

The high alternation of silicic (white) and mafic (dark) rocks on a centimetre to decimetre scale closely recalls the mafic- silicic layered intrusion of Pleasant Bay, Maine and many other localities (see Wiebe 1993 and referenc-

Table 1 Major and trace element data for the ultramafic rocks, dark bands and white bands.

Sample	1 Ultramafic rock	2 Dark band	3 Dark band	4 White band
wt%				
SiO_2	38.61	47.87	44.65	70.63
TiO2	1.97	1.75	0.25	0.24
Al_2O_3	13.56	15.13	17.22	14.52
Fe_2O_3tot	21.95	12.5	10.21	2.50
MnO	0.45	0.21	0.13	0.08
MgO	8.04	7.40	10.36	0.76
CaO	11.40	9.88	12.65	4.33
Na_2O	1.55	2.84	1.31	4.29
K_2O	0.65	1.06	0.74	0.31
P_2O_5	0.69	0.27	0.03	0.09
LOI	1.12	1.09	2.45	2.27
ppm				
Rb	20.7	39.1	27	9.5
Sr	44.7	305.8	415	662.5
Y	98.7	24.8	3.2	4.3
Zr	85.1	22.8	5.5	7.0
Nb	9.6	12.3	0.1	1.3
Ba	54.4	243.5	47.5	196.2
Σ REE	–	77.2	7.9	19.5

es therein). The rocks that mostly approach the basaltic end member are the dark bands of Group a). They are completely different from normal and plume MORB and oceanic island tholeiites, as regards the K, Rb, Ba contents and the K/Rb, and Sr/Rb ratios. The great similarity with the Pleasant Bay rocks and the geology of Sardinia suggest that these amphibolites are Variscan metamorphic rocks derived from older tholeiites injected within shallow silicic magma chambers in a continental rifting environment. The dark bands of group b) show a sudden drop of TiO_2, P_2O_5, Y and ÍREE clearly due to a fractionation of Fe-Ti oxides and phosphates. The ultramafic rocks are extremely evolved cumulate rocks once probably consisting only of fayalite, augite, Fe-Ti oxides and phospates. The uppermost white bands are characterised by strong SiO_2, Na_2O enrichment and by slight Al_2O_3 increase, and may be interpreted as evolved silicic cumulates, rich in acidic plagioclase similar to those observed in the uppermost part of macrorythmic units at Pleasant Bay Maine Wiebe (1993). Intermediate rocks are very scarce: only one sample with andesite composition yielded major and trace elements intermediate between dark and white bands. But all the samples show chemical evidence of interaction between contemporaneous silicic and mafic magmas. Dark bands may have K_2O content up to1.1% probably related to K diffusion from basic to acidic magma. On the contrary, Fe_2O_3tot content of up to 2.5–4.0% and MgO up to 0.8–1.9% in the white bands are clearly anomalous for highly evolved silicic cumulate rocks and may be accounted for only by the interaction with the underlying basic magma. Finally the rounded inclusions of mafic rocks within the white bands represent basic magma drops chemically modified after a long stay in the enclosing silicic magma: in fact most of these drops belong to the more evolved group b) of the dark bands, showing strong depletion of the Fe-Ti oxides and phospates.

References

Wiebe, R. A. (1993): The Pleasant Bay layered gabbro-diorite Coastal Maine: ponding and crystallization of basaltic injection into a silicic magma chamber. J. Petrol. 34,461–489.