Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 703

Some Thoughts on the Geochemistry of the "Unique" Sample of the "Venice Granodiorite" (Northern Italy)

Sandro Meli (sandrom@ipruniv.cce.unipr.it)[1] & **Raffaele Sassi** (raffaele@dmp.unipd.it)[2]

[1] Dipartimento di Scienze della Terra, Parco Area delle Scienze 157/A, 43100 Parma, Italy
[2] Dipartimento di Mineralogia e Petrologia, Corso Garibaldi 37, 35137 Padova, Italy

In the frame of the ENI-AGIP drilling project (AGIP Mineraria, 1977), a granodioritic crystalline basement buried under a Triassic to Quaternary sedimentary cover was found at the depth of 4711 m, within the Venice Lagoon (Northern Adriatic Sea). Drilling was stopped when the granodiorite was reached, and the granodiorite core obtained therefrom is the only one sample of the crystalline basement underneath the Po Plain.

This rock sample shows a medium grained, holocrystalline, equigranular, isotropic texture. K-feldspar and plagioclase occur as anhedral and euhedral crystals respectively, often altered into sericite. Euhedral biotite is always altered into chlorite + opaques. Quartz shows a weak post-crystalline deformation. Apatite and zircon are accessory components.

Three different enclave types are present in the sample. (a) Mafic micro-granular enclaves (MME). Their mineralogy and texture is similar to that of the enclosing granodiorite, the main differences consisting of a significantly smaller grain size, which supports undercooled crystallizing conditions (Vernon, 1984), and larger biotite amounts. (b) Cordierite + hercynite + biotite metamorphic xenoliths (MX). Large, anhedral, altered cordierite aggregates include biotite and hercynite. Small apatite crystals are arranged into elongated trails. (c) Sillimanite + biotite + hercynite + sericite + biotite + plagioclase + garnet + cordierite surmicaceous enclaves (SE). Sillimanite occur as large skeletal crystals. Garnet is partially replaced by biotite + plagioclase symplectites.

Eight samples of the granodiorite and three enclaves have been analysed by means of ICP-OES and ICP-MS for major and trace elements . Mineral assemblage and major element chemistry of the host rock indicate a granodioritic composition; a per-aluminous character (A/CNK=1.1-1.3) is also clear. Alkali content is high, and K_2O is in the range of high K calc-alkaline series, as well as the FeO^*/MgO values. HFSE and some LILE are relatively low. REE chondrite-normalised arrays show slightly fractionated LREE, nearly horizontal HREE patterns and a Eu anomaly.

The MME is more mafic and alumina-rich than the enclosing granodiorite (A/CNK=1.4). K/Na and ΣREE are lower; Fe_2O_3tot, MgO, LILE and U are higher, whereas Σ (alkalis) and Mg_v display comparable values. REE pattern resembles those of the host rock, with a still lower HREE fractionation. High Ga content in MME could be explained by Bt and Kfs fractionation from the granodioritic melt (Ewart & Griffin 1994). MME does not strictly represent a liquid, but a crystal mush which segregated from the granodioritic melt; also, element inter-diffusion probably took place between the host magma and the enclave. The small size of the enclave prevented any chemical/mineralogical zoning. Compositional and mineralogical similarity between MME and host rock phases is a feature which supports an almost synchronous crystallization under similar physical conditions.

MX and SE have similar composition; low SiO_2 and extremely high Al_2O_3 point towards a pelitic protolith; high P_2O_5, LILE, Zr content are also distinctive. Nb/Ta and Zr/Hf ratios significantly differ from those of the enclosing granodiorite; ΣREE is higher and the normalised patterns are nearly parallel. The Hc+Sil assemblage found in MX is typical of high-T re-equilibration of metapelites. Moreover, the frequent patchy texture suggests their incongruent partial melting, with growth of either cordierite or garnet as products. However, the Yb/Sr ratio, sensitive to partial melting (Tindle & Pearce, 1983), is not significantly higher than the host . Isotopic, trace element and REE data rule out the possibility that the metamorphic xenoliths represent restites of an important crustal source for the granodioritic melt.

Enclaves and granodiorite Rb/Sr whole rock analyses revealed that the former did not isotopically equilibrate with the host, despite their small size. An Ordovician emplacement age is inferred by U/Pb single grain conventional dating on clear, euhedral zircons, which yielded concordant ages of 463+4 Ma. Turbid crystals were found to be discordant, but reliable discordias can not be drawn due to statistically poor constraints. The recalculated $(^{87}Sr/^{86}Sr)_{463}$ of the granodiorite is unreasonably low, testifying a post-emplacement reopening of the Rb/Sr system.

Taking into account some discriminant diagrams for granitoid rocks (Pearce et al., 1984; Harris et al., 1986), the trace element signatures of the "Venice granodiorite" suggest a late to post-orogenic environment; however, its emplacement along an active margin cannot be excluded on the basis of these diagrams only.

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