Geophysical Research Abstracts, Vol. 7, 11051, 2005
SRef-ID: 1607-7962/gra/EGU05-A-11051

Relationships between late-Variscan strike-slip faults and the emplacement of intrusive magmas in the South Alpine and in the Upper-Austroalpine basement of Central Alps

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ROSENBERG (2004), presented A well-documented account of the literature dealing with the relationships between faults and plutons and provided a model based on the Tertiary magmatism in the Alps. The model can also be applied to the late-Variscan intrusive bodies.

In the western Southern Alps the contact between Ivrea-Verbano Zone (IVZ) and Serie dei Laghi (SdL) occurs through an important sub vertical tectonic lineament (CMBL) characterised by the simultaneous occurrence of: high-T mylonites, basic-to acidic dikes and stocks (the «Appinite Suite»), migmatites and granitic plutons.

The fault has been interpreted as a tilted low-angle normal fault (HANDY M.R., 1987; MULCH et al., 2002). Different views, based on field observations and on petrological evidence were expressed by BORIANI et al. (1990 and by BORIANI and GIOBBI MANCINI (2004). The CMBL is a late-Variscan oblique strike-slip fault, which puts in contact a hot lower crust (IVZ) with a cooler intermediate-upper crust (SdL). The fault guided the ascent and the emplacement of the Early Permian intrusive rocks. These rocks form two main groups: 1) Small bodies of mafic- to- acidic rocks (the «Appinite Suite»), which occur along the CMBL in both IVZ and SdL; 2) Large cross-cutting granitic plutons only in SdL.

The “Appinite suite” is intruded in a belt along the CMBL. Pseudo-brecciate structures are often present. A “granitic” matrix cements fragments of mafic rocks. Since

the mafic rocks are sometimes slightly foliated, this character has been interpreted by as indicative of a syn-mylonitic intrusion. Nevertheless the pattern of the dikes suggests that they were intruded essentially after the mylonitization in a Tran tensional, rather then in transpressional regime. The age determinations on these post-mylonitic dykes, using various approaches and radiometric methods, point to an age interval spanning from 271 to 285 Ma (KÖPPEL and GRÜNENFELDER, 1978-79; BORIANI and VILLA, 1997; MULCH ET *A*L., 2002).

The migmatites are developed in the SdL rocks in a belt about 2 km wide S of the CMBL. Their origin has been attributed to the heat provided by the "appinite" intrusion and by juxtaposition of the "hot" IVZ to the cooler SdL (BORIANI and GIOBBI MANCINI, 2004).

The granitic plutons, the so-called "Graniti dei Laghi", produced narrow contact aureoles (BORIANI ET AL., 1988), which overprint the non-pervasive greenschist facies Variscan retrograde phase. Two Rb-Sr whole rock isochrones of about 277 Ma, as well as biotite ages of about 280 Ma, point to an intrusion age of around 280 Ma. The upper layer of the Mottarone - Baveno pluton consists of the pink granite «Granito Rosa di Baveno». Since it is miarolithic, it was emplaced at shallow depth, and therefore it was likely sub-horizontal at the time of its emplacement; now it dips ESE of about 15˚. Therefore the whole sequence cannot have been rotated of more than 15-20˚ after the Early Permian.

VANNUCCI et al. (1989), BORIANI et al. (1992), PINARELLI et al. (2002), PINARELLI et al. (1993) and BORIANI et al. (1995) performed a thorough geochemical investigation on the origin of the magma of granites and appinites. Their Pb, Sr and Nd systematics was studied. In the most recent model of PINARELLI et al. (2002), based on Pb, Nd and Sr isotope distribution, the primary magma of "Appinites" and granites had the composition of the most mafic gabbro-noritic appinite. It was derived from an enriched mantle source, contaminated during an early Variscan subduction. The primary magma underwent an AFC process that lead to the formation of the different kinds of Appinites and of their felsic differentiates. Later on the mafic magma further evolved via AFC, producing the large granitic plutons.

Preliminary studies on the Southern Steep Belt of the Upper Austroalpine Units (Tonale and Punta di Pietra Rossa) in Valtellina show more or less the same situation, although partly obliterated by the Alpine tectono-metamorphic overprint (VENZO et al., 1971; SCHMID et al., 1996). The Tonale Unit consists of high-amphibolite facies (pre-Alpine metamorphism) metapelites with intercalations of amphibolite and marble. These rocks suffered dehydration melting involving muscovite with production of leucosomes, often with pegmatitic texture. During cooling and part of the muscovite

recrystallized, giving rise to the characteristic “cross” muscovite lamellae. The Tonale Unit rocks are very similar to those of the southern part of the Kinzigitic Unit of the Ivrea-Verbano Zone, with which the Tonale Unit is in geometric continuity through the Insubric Line in the Locarno-Bellinzona area.

The Punta di Pietra Rossa Unit (Campo – Languard Nappe) mostly consists of fine-grained paragneiss with lenses of Ordovician metagranites showing a pre-Alpine metamorphic imprint of the lower amphibolite facies. The intrusion age of the orthogneiss protolith has been recently dated by the SHRIMP method on zircons by BERGOMI and BORIANI (2004) at about 460 Ma. The contact with the Tonale Unit is always underlined by a mylonitic belt showing an amphibolite facies character, often overprinted by further mylonitization in the greenschist facies conditions.

East of Tirano the tectonic contact between the two units is defined by the Pejo and Mortirolo Lines, whilst in the lower Valtellina it is difficult to identify, for the simple reason that the original shear zone is folded, with sub-vertical axial plane, on sub-horizontal axes striking ENE. For this reason the two units appear interfingered on the geological map of the Rethic slope of Valtellina.

The Punta di Pietra Rossa Unit, and not the Tonale Unit, contains lenses of a metagranite (-granodiorite), the so-called “Mt Rolla” granite gneiss. The intrusion age of this metagranite has been recently dated by the SHRIMP method on zircons by BERGOMI and BORIANI (2004) at about 306 Ma. Beautiful contact aureoles on both Punta di Pietra Rossa para- and orthogneisses are often exposed. A row of other metagranites occurs along the Mortirolo Line in the Punta di Pietra Rossa Unit.

There are many analogies between the shear zone separating the Tonale and Punta di Pietra Rossa Units and the CMBL in the South-Alpine basement. In both cases they separate Variscan high grade rocks from lower grade rocks, and in both cases they are characterized by the presence of a row of late-Variscan granites intruded in the lower grade unit.

Therefore, also in the late-Variscan case the link between faults, especially strike-slip faults, and intrusion of granitoid magma is confirmed. Strike-slip faults appear to be the most suitable tectonic discontinuities for allowing the ascent and favouring the emplacement of granitic bodies because their activity is characterized by trans-tensional episodes that can trigger melting at the mantle and crustal level and provide room for the ascent of the magma. It really looks difficult to envisage the ascent of a magma of an intermediate composition through a shear zone in a trans-pressional regime without an important solid-liquid fractionation.

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