volume of gas-pressurized CO_2-bubbles (9-10 vol%), in simple shear using a HT-HP Paterson-type rock deformation apparatus. Strain rates ranging between $1\cdot10^{-5}$ s^{-1} and $4\cdot10^{-3}$ s^{-1} were applied at temperatures between 823 and 1023 K (subsolidus conditions) and constant confining pressure of 200 MPa (8 km depth). The results suggest that three-phase suspensions are characterized by strain rate-dependent rheology (non-Newtonian behavior). Two kinds of non-Newtonian behaviors were observed: shear thinning (decrease of viscosity with increasing strain rate) and shear thickening (increase of viscosity with increasing strain rate). The first effect dominantly occurs because of crystal size reduction and shear localization, enhanced by the presence of gas bubbles in the weak shear bands. However, when the solid crystal framework induces an internal flow blockage due to crystal interlock, the second effect becomes dominant. Comparing our results with previous ones for the rheology of crystal-bearing systems (Caricchi et al., 2007), the presence of limited amount of gas bubbles (12 vol% maximum) favors an evident decrease in viscosity; e.g., at about 70 vol% crystals a decrease of about 4 orders of magnitude in relative viscosity is caused by adding only 9 vol% bubbles. These experiments suggest that magma rheology is strongly controlled by the simultaneous presence of bubbles and crystals in the melt phase and their interactions during deformation. The localization in strain favors granite mobilization in the crust and the occurrence of large eruptions; in contrast, the crystal interlocking halts the batholith in the crust.

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4.8

The tonalitic lamellae along the Giudicarie fault system: a multidisciplinary study

Pomella Hannah[1], Klötzli Urs[2], Scholger Robert[3], Stipp Michael[4] & Fügenschuh Bernhard[5]

[1] *alpS GmbH. Grabenweg 68, A-6020 Innsbruck (Pomella@alps-gmbh.com)*
[2] *Department of Lithospheric Research. Althanstraße 14, A-1090 Vienna*
[3] *Chair of Geophysics, University of Leoben. Peter-Tunner-Str. 25, A-8700 Leoben*
[4] *Leibniz-Institute of Marine Sciences, IFM-GEOMAR. Wischhofstr. 1-3, D-24148 Kiel*
[5] *Institute of Geology and Paleontology. Innrain 52, A- 6020 Innsbruck*

Numerous large and small magmatic bodies are exposed along the Periadriatic line (PAL) or close to it (e.g. Becke 1903; Rosenberg 2004). This study concentrates on small intrusions along two important faults of the Giudicarie fault system (GFS), the Northern Giudicarie (NGF) and the Meran-Mauls fault (MMF), summarised under the term tonalitic lamellae (Dal Piaz 1926).

Magnetic fabric analyses in combination with structural field data indicate dextral strike slip deformation along the NE-SW striking northern part of the GFS, the Meran-Mauls fault, overprinted by younger top-SE thrusting (Pomella et al. 2010). The regional stressfield was constantly oriented approximately NNW-SSE during Tertiary times. The distinctive change in deformation along the MMF from dextral strike slip to top-SE thrusting may be caused by a rotation or bending of the fault after the intrusion of the tonalites and the formation of their horizontal magnetic foliation.

U/Pb data on zircon (Pomella et al. 2010) show that some of the lamellae are of Oligocene (Rupelian), others of Late Eocene (Priabonian,) age. An amphibole-gabbro lens occurring on the Meran-Mauls fault provides a Middle Eocene (Bartonian) age. Among the major Periadriatic plutons, only the southern units of the Adamello batholith also intruded in the Eocene which suggests a strong correlation between the tonalitic lamellae and the Adamello batholith.

New zircon fission track data (Pomella 2010) show a corridor of young, Miocene zircon fission track ages from the tonalitic intrusions along the Northern Giudicarie fault. This corridor connects Early Miocene (17-23 Ma) Zircon fission track ages of the NE-Adamello with the Miocene (23-9 Ma) zircon fission track ages of the Meran-Mauls basement and the Tauern window. To the SE the narrow corridor is bounded by Southalpine sediments characterized by only partially reset zircon fission track ages and towards NW by Oligocene zircon fission track cooling ages found in the Austroalpine units.

This multidisciplinary study provides evidence for a polyphase deformation along the Giudicarie fault system:

Oligocene (Fig. 1(a)): Intrusion of the northeastern units of the Adamello batholith adjacent to the straight, dextral strike-slip PAL. Late Oligocene / earliest Miocene (Fig. 1(b)): The NNW-ward movement of the Southalpine indenter leads to a bending of the fault, material from the northeastern part of the Adamello batholith is squeezed to the NE along the bent part of the fault. Early Miocene (Fig. 1(C)): The brittle Passeier fault, Northern and Southern Giudicarie fault dissect the bent part of the PAL. Along the northern part of the bend (MMF) a nearly continuous tonalitic body persists, whereas along the NGF only small boudinaged bodies rotated during brittle faulting are present

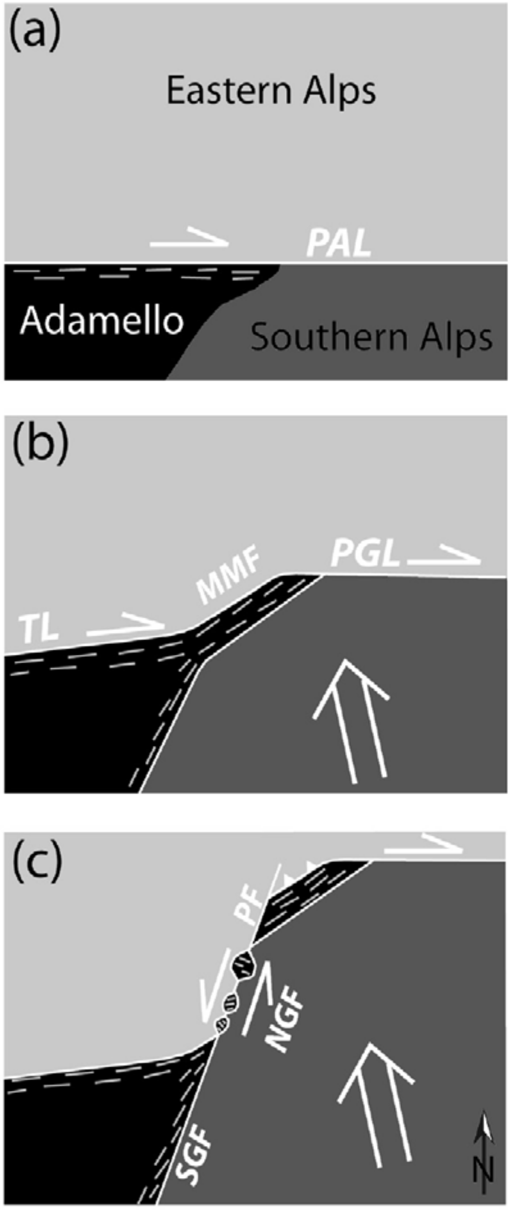

Figure 1. Schematic illustration of the emplacement of the tonalitic lamellae along the Giudicarie fault system (Pomella et al. 2010). PAL = Periadriatic line, MMF = Meran-Mauls fault, TL = Tonale line, PGL = Pustertal Gailtal line, NGF = Northern Giudicarie fault, SGF = Southern Giudicarie fault, PF = Passeier fault.

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