Orogen-parallel extension in the central Alps, Graubünden region, Switzerland

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Introduction

Work in the Swiss Alps over the past two decades (Mancktelow, 1992; Nievergelt et al., 1996; Meyre et al., 1998; Wey and Froitzheim, 2001; Wawrzyniec et al., 2001) has shown that there have been several periods of orogen-parallel extension in the central Alps both during and after main-phase ("Neoalpine") deformation. Principal periods of extension include 38-30 Ma along the Turba mylonite zone-Gurgaletsch shear zone (TMZ-GSZ) in eastern Switzerland and ~17-3 Ma along the Simplon Line in western Switzerland. Both of these zones occur in Penninic rocks. No one has identified extensional zones that mirror the TMZ-GSZ in western Switzerland or the Simplon line in eastern Switzerland. Likewise, it is unknown how much extension has been accommodated in other levels of the structural stack, including along the base of the main Austroalpine overthrust (hauptverschiebung).

This project seeks to answer several questions with regard to extension in the central Alps: 1. Has extension occurred at the base of the Austroalpine-Penninic contact and that observed deeper in the structural stack (within the Pennine Zone proper, i.e., the TMZ-GSZ and the Simplon line)? 2. Can we further elucidate the structural and paleogeographic position of equivalual, intermediate nappes such as the Corvatsch teildecke, the Margna-Sella nappe, and the Platta ophiolite, whose position, whether Austroalpine or Penninic, has long been argued (c.f., Triumy, 1980)? 3. Lastly, can we correlate structural and paleogeographic zones in Penninic, with those in the Austroalpine, to determine when they were juxtaposed? 4. Lastly, can we correlate structural and paleogeographic zones in Penninic, with those in the Austroalpine, to determine when they were juxtaposed?

Methodology

We seek to answer the above questions using a combination of a) field work that involves structural measurements and kinematic analysis of important deformation fabrics (foliation, mineral lineations, fold axes, etc.) and b) noble gas thermochronometry on He- and Ar-producing minerals (i.e., apatite, zircon, white mica, biotite), and c) paleomagnetism.

Five weeks of field work have been completed in 2011 and 2013 during which structural measurements were made and samples for thermochronometry were collected. Additional fieldwork is anticipated for 2014. The thermochronometry is currently underway. U/Th-He measurements on apatite and zircon are being done in the Farley lab at Caltech. Ar/Ar measurements on He- and Ar-producing minerals (i.e., apatite, zircon, white mica, biotite) and c) paleomagnetism.

The He work is currently underway in the Farley lab at Caltech. The Ar work will be done in conjunction with Gordon Lister and Marnie Forster at the Australian National University.

A compilation of existing thermochronometric data (Fig. 2) shows that the Austroalpine domain has been "cold" (~200°C) since the JuraCretaceous, whereas Penninic rocks have cooled below 200°C more recently. During the Late Oligocene, while the thermal discontinuity between the two zones is dramatic, the defining thermal boundary has not been identified, and it may lie at the Austroalpine overthrust or lower in the structural section, i.e., at the Turba mylonite zone-Gurgaletsch shear zone. These data also show that some of the intermediate nappes (i.e., Margna-Sella) have cooled since the late Cretaceous and were probably already attached to the underside of the Austroalpine sheet prior to main "Neoalpine" deformation.

No one has identified significant thermal gradients and kinematic analysis in the field and in thin section (Fig. 4) show dominant movement in the Margna-Sella and Corvatsch nappes to the NE, E, and ESE, approximately orthogonal to the expected northerly transport direction of the Apulian 'inserter'. In general, the timing of the eastward extension is not well constrained, but the Turba mylonite zone, which puts Platta ophiolite down onto Bündnerschiefer oceanic sediments, is cut by the 30-32 Ma Bregen pluton thereby providing an upper limit for the age.

Thermochronologic ages (Hunziker et al., 1997; Vernon et al., 2008; this study) are plotted against elevation (Fig. 5A) and nominal closure temperature (Fig. 5B). Both plots show that the Austroalpine hangingwall cooled independently of the Penninic footwall until roughly 40-30 Ma, at which time they were juxtaposed and cooled together. Penninic footwall rocks cooled at a rapid rate, ~10-12°C/Ma, during exhumation from ~10-25 km depth, likely along one or more normal faults.

Progress Report

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