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Invited Review

Crustal modelling of the Ivrea–Verbano zone in northern Italy re-examined: Coseismic cataclasis versus extensional shear zones and sideways rotation

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ABSTRACT

New field and microstructural observations in the Ivrea–Verbano zone (IVZ), northern Italy, reveal extensive post-Hercynian cataclasis, indentation structures, microtectonic escape structures, microcataclastic injectites and occasional true pseudotachylytes. The deformation occurred in situ and was governed by pure shear. These observations are incompatible with prevailing crustal models of the IVZ. Most of these models assume the presence of lower-crustal, originally flat-lying extensional shear zones, sideways block rotation and exposure of the petrological Moho, although the original structural observations from the central IVZ suggested that the post-Hercynian deformation was cataclastic rather than shear-dominated. Other, already published information also contradicts the sideways rotation of a crustal block comprising the IVZ and the adjacent Serie dei Laghi (SdL) after the Early Permian, as assumed in the models. The IVZ and SdL have different detrital zircon populations and are separated by a steep shear zone and a transcurrent fault (not rotated listric faults as assumed in the models). Rotation is also prevented by a flat-lying zone of miarolitic cavities in the Early Permian Baveno granite and by contemporaneous, vertical basic dykes. The widespread in-situ cataclasis is interpreted as due to coseismic deformation by high-frequency seismic waves generated by earthquakes along the Insubric fault, and exerting oscillatory compression, dilation and torsion in a ≤10 km wide zone along the footwall of the Insubric line. The in-situ post-Hercynian cataclasis, absence of lower-crustal extensional shear zones and lack of sideways rotation of the IVZ and SdL call for a new and simpler crustal model of the region.

Contents

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1. Introduction

As noted by Windley and Garde (2009) there are only few places on Earth where the transition between the lower continental crust and the upper mantle can be directly observed. The Palaeozoic Ivrea–Verbano zone (IVZ) in the footwall of the Alpine Insubric line in northern Italy (Fig. 1) has long been considered to be one of these places (Fountain, 1976). Together with the adjacent Serie dei Laghi (SdL) it constitutes one of the most intensely studied crustal sections on Earth, and the literature is very extensive. The main purpose of the present study is to re-examine the original observations and assumptions that led to the interpretation of the IVZ and SdL as a coherent, sideways rotated crustal block exposing the petrological Moho, and to propose a different and simpler interpretation of the observations.

Most of the IVZ consists of a steeply dipping accretionary wedge of ductilely deformed, aluminous metasedimentary rocks (locally known as kinzigites and stronalites) and associated metavolcanic and metagabbroic rocks of volcanic and mantle provenance (Rivalenti et al., 1975; Sills and Tarney, 1984), as well as large tectonic lenses of peridotitic ultramafic rocks at Balmuccia and Finero close to the Insubric line (Garuti et al., 1980; Fig. 1). The intercalated sedimentary and mafic igneous rocks were deformed and metamorphosed during the Hercynian orogeny. The supracrustal pile dips moderately to steeply NW and displays a metamorphic gradient from amphibolite facies in the south-east to granulite facies in the north-west. The supracrustal rocks with their peridotite lenses were subsequently intruded at around 270 Ma by mantle-derived noritic to dioritic rocks known as the mafic complex (e.g., Peressini et al., 2007). To the south-east the IVZ abuts the Ediacaran/lower Cambrian metasedimentary rocks and Early Permian meta-igneous rocks of the SdL (Boriani et al., 1990). The IVZ and SdL are separated by a major, Early Permian, NE–SW-trending, dextral transpressional tectonic boundary zone known in the literature as the Cossato–Mergozzo–Brissago (CMB) line, see Section 3.5. This is cut by a slightly younger, likewise NW–SE-trending but sinistral transcurrent fault called the Pogallo line (Boriani and Sacchi, 1973), which has an offset of c. 12 km and is likely coeval with the intrusion of an Early Permian mafic dyke swarm and felsic differentiates along the CMB (Boriani and Giobbi, 2004).

The IVZ and the SdL were originally proposed to represent a coherent, sideways rotated crustal package that exposed the petrological Moho (Fountain, 1976). The proposed rotation of the presumed crustal block would have been clockwise on a horizontal axis pointing north-

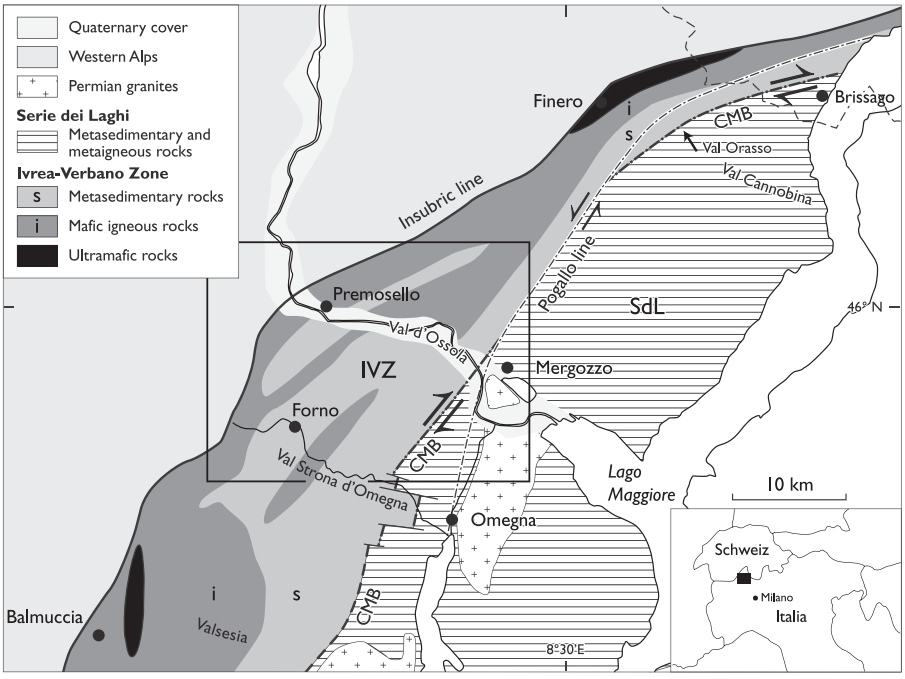

Fig. 1. Overview map of the Ivrea–Verbano zone (IVZ) and Serie dei Laghi (SdL) in the Southern Alps, northern Italy, with position of Fig. 2 (box).