Lithos 252–253 (2016) 145–159

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

High-pressure metamorphic age and significance of eclogite-facies continental fragments associated with oceanic lithosphere in the Western Alps (Etirol-Levaz Slice, Valtournenche, Italy)

Kathrin Fassmer [a,*], Gerrit Obermüller [a], Thorsten J. Nagel [b], Frederik Kirst [a], Nikolaus Froitzheim [a], Sascha Sandmann [a], Irena Miladinova [a], Raúl O.C. Fonseca [a], Carsten Münker [c]

[a] University of Bonn, Steinmann Institut, Meckenheimer Allee 169, 53115 Bonn, Germany
[b] Institute for Geoscience, Aarhus Universitet, Høegh-Guldbergs Gade 2, 8000 Aarhus C, Denmark
[c] University of Cologne, Institut für Geologie und Mineralogie, Zülpicher Str. 49b, 50674 Köln, Germany

A R T I C L E   I N F O

Article history:
Received 31 March 2015
Accepted 24 February 2016
Available online 4 March 2016

Keywords:
Eclogite
Subduction
Western Alps
Zermatt-Saas Zone
Continental crust
Lu–Hf geochronology

A B S T R A C T

The Etirol-Levaz Slice in the Penninic Alps (Valtournenche, Italy) is a piece of eclogite-facies continental basement sandwiched between two oceanic units, the blueschist-facies Combin Zone in the hanging wall and the eclogite-facies Zermatt-Saas Zone in the footwall. It has been interpreted as an extensional allochthon from the continental margin of Adria, emplaced onto ultramafic and mafic basement of the future Zermatt-Saas Zone by Jurassic, rifting-related detachment faulting, and later subducted together with the future Zermatt-Saas Zone. Alternatively, the Etirol-Levaz Slice could be derived from a different paleogeographic domain and be separated from the Zermatt-Saas Zone by an Alpine shear zone.

We present Lu–Hf whole rock–garnet ages of two eclogite samples, one from the center of the unit and one from the border to the Zermatt-Saas Zone below. These data are accompanied by a new geological map of the Etirol-Levaz Slice and the surrounding area, as well as detailed petrology of these two samples. Assemblages, mineral compositions and garnet zoning in both samples indicate a clockwise PT-path and peak-metamorphic conditions of about 550–600 °C/20–25 kbar, similar to conditions proposed for the underlying Zermatt-Saas Zone. Prograde garnet ages of the two samples are 61.8 ± 1.8 Ma and 52.4 ± 2.1 Ma and reflect different timing of subduction. One of these is significantly older than published ages of eclogite-facies metamorphism in the Zermatt-Saas Zone and thus contradicts the hypothesis of Mesozoic emplacement. The occurrence of serpentinite and metagabbro bodies possibly derived from the Zermatt-Saas Zone inside the Etirol-Levaz Slice suggests that the latter is a tectonic composite. The basement slivers forming the Etirol-Levaz Slice and other continental fragments were subducted earlier than the Zermatt-Saas Zone, but nonetheless experienced similar pressure–temperature histories. Our results support the hypothesis that the Zermatt-Saas Zone and the overlying continental slivers do not represent a coherent paleogeographic unit but rather formed by successive, in-sequence subduction and accretion of different fragments.

1. Introduction

The Zermatt-Saas Zone in the Western Alps (Fig. 1) is a Mesozoic ophiolite unit that experienced (ultra)high-pressure metamorphic conditions. It serves as a classic reference unit for studying the orogenic history of ophiolites (Angiboust et al., 2009; Bearth, 1967; Bucher et al., 2005; Frezzotti et al., 2011; Groppo et al., 2009; Reinecke, 1998). A widely discussed problem in reconstructing subduction and exhumation is how coherently in space and time high-pressure units behave and answering this question has far-reaching implications for how subduction channels are organized. The Zermatt-Saas Zone has been interpreted either as a rather coherent piece of oceanic lithosphere (e.g. Angiboust et al., 2009) or more or less as a tectonic mélange (e.g. Negro et al., 2013). The unit consists of oceanic rocks, i.e. ultramafics, mafics, and metasediments, many of which display eclogite-facies assemblages including coesite and diamond within the Lago di Cignana subunit (Frezzotti et al., 2011; Reinecke, 1991, 1998). Several eclogite-facies slices of continental material, meters to kilometers in size, are present within and especially immediately at the top of the Zermatt-Saas Zone, all still within the ophiolitic nappe pile as the next higher unit, the blueschist-facies Combin Zone, is also derived from the Mesozoic oceanic domain. Inside and at the base of the Combin Zone there are Permo-Mesozoic continental metasediments of disputed paleogeographic origin called Frilihorn Nappe and Cimes-Blanches Nappe, respectively (Pleuger et al., 2007; Steck et al., 2015; Vannay

* Corresponding author. Tel.: +49 228 734988.
E-mail address: fassmer@uni-bonn.de (K. Fassmer).

http://dx.doi.org/10.1016/j.lithos.2016.02.019
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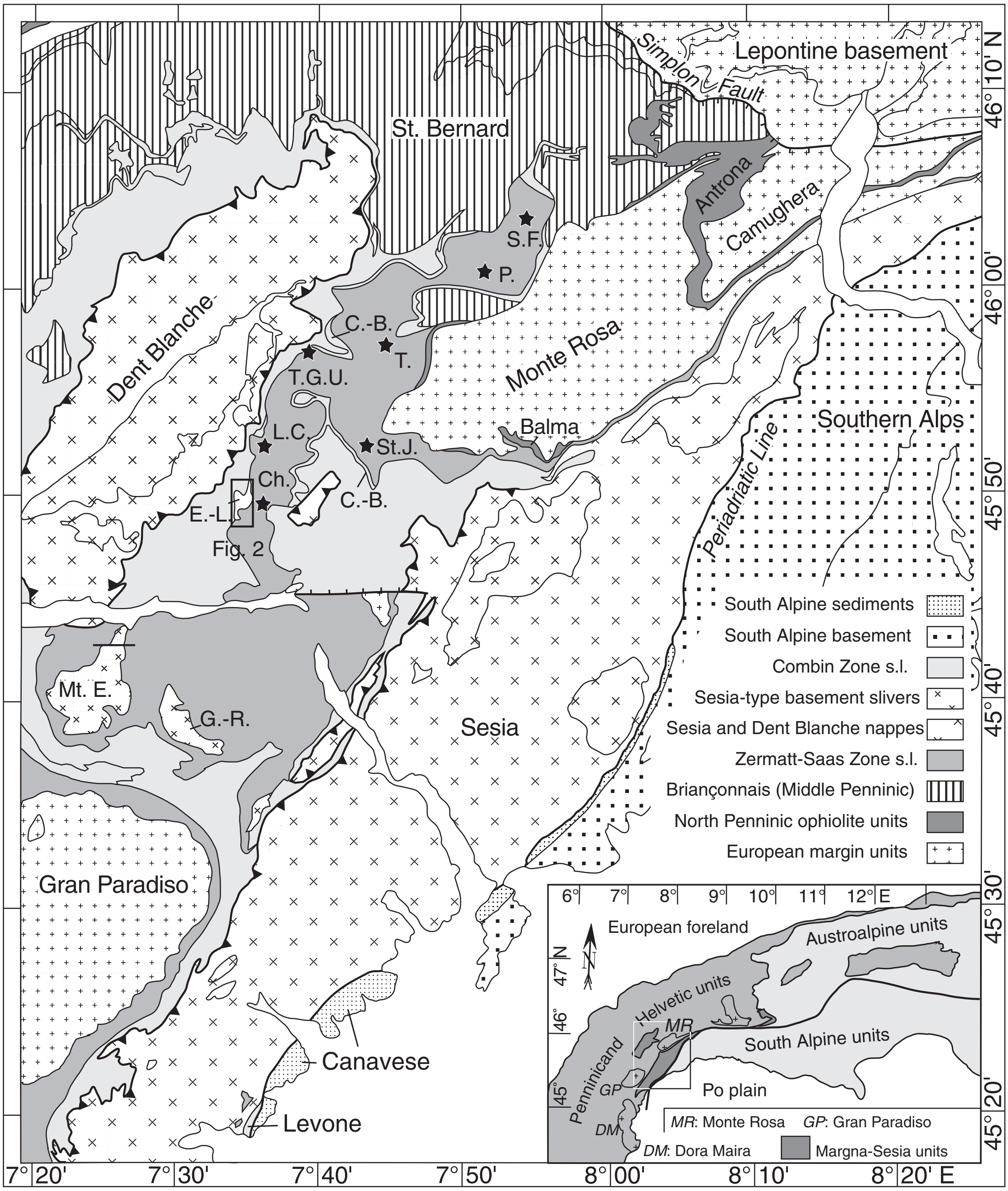

Fig. 1. Tectonic overview map of the Penninic Alps, modified after Steck et al. (1999) and Bigi et al. (1990). C.B.: Cimes-Blanches Nappe; Ch.: Chamois; E.-L.: Etirol-Levaz Slice; G.-R.: Glacier Rafray sliver; Mt. E.: Mont Emilius klippe; L.C.: Lago di Cignana; P.: Pfulwe; S.F.: Saas Fee; St.J.: St. Jacques; T.: Triftji; T.G.U.: Theodul Glacier Unit.
After Pleuger et al. (2007).

and Allemann, 1990). In schemes viewing the Zermatt-Saas Zone as a coherent ophiolite, the high-pressure metamorphic continental slivers are not easy to account for. Together with the results of geological mapping and petrological data, we present Lu–Hf garnet ages of two eclogite samples from the Etirol-Levaz Slice, which is one of these slivers on top of the Zermatt-Saas Zone. It has recently been interpreted as a single extensional allochthon that stranded on oceanic lithosphere in the course of Jurassic rifting (Beltrando et al., 2010a; Dal Piaz et al., 2001). This scheme would not require a significant Alpine shear zone between the Etirol-Levaz Slice and the Zermatt-Saas Zone, giving support to the concept of a coherent high-pressure unit. In contrast, our results show that not only peak-pressure conditions in the Etirol-Levaz Slice are older than in the Zermatt-Saas high-pressure rocks, but also that the Etirol-Levaz Slice itself is amalgamated from at least two eclogite-facies subunits with different subduction histories.

2. Regional geological setting

The Penninic domain in the Western and Central Alps consists of an intensely folded pile of nappes, which are of oceanic and continental origin and experienced different metamorphic histories (Fig. 1). The comprised oceanic lithosphere had formed since Middle Jurassic times between continental Europe in the north and continental Adria in the south (e.g. Stampfli et al., 2002). From early Late Cretaceous times onward, the Penninic domain was subducted southeastward beneath continental lithosphere of the Adriatic plate (e.g. Duchêne et al., 1997;