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Jadeite-gneiss from the Eclogite Zone, Tauern Window, Eastern Alps, Austria: Metamorphic, geochemical and zircon record of a sedimentary protolith

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Abstract

In the Eclogite Zone of the Tauern Window, a layer of strongly retrogressed leucocratic jadeite-bearing gneiss is intercalated between mafic kyanite-eclogites. The jadeite-gneiss consists of garnet + quartz + paragonite ± phengite ± zoisite + zircon + rutile + apatite + pyrite. Kyanite, jadeite or omphacite are exclusively present as inclusions in garnet. Retrogressive hydration during exhumation led to a breakdown of matrix jadeite to form pseudomorphs of calcic amphibole + albite. Peak metamorphic conditions derived from the primary gneiss assemblage are 2.0–2.4 GPa at approximately 640 °C. Major, trace element and isotopic compositions of the jadeite-gneiss are consistent with a siliciclastic sedimentary protolith. Zircon morphology and zonation patterns reveal a complex history. The presence of fracture-truncated zircons suggests a detrital origin, whereas most internal structures and Th/U ratios are characteristic of zircons from magmatic rocks. In situ LA-ICP-MS and SHRIMP U–Pb geochronology and zircon geochemisty provide evidence of at least three magmatic events in the provenance area. These were dated at 466 ± 2 Ma, 437 ± 2 Ma and 288 ± 9 Ma. Older ages ranging from 503 to 691 Ma are preserved in the cores of some zircon grains, suggesting derivation from peri-Gondwanan sources. Surprisingly, no firm evidence of the Tertiary high-pressure metamorphic event and subsequent retrograde overprint was seen in any of the studied zircons. However, some zircons show resorbed surfaces suggesting corrosion by a superficial fluid phase undersaturated in zirconium and one extensively altered porous zircon yielded highly discordant $^{206}Pb/^{238}U$ ages in the range 325–109 Ma documenting partial recrystallization by dissolution–reprecipitation of a highly reactive grain.

Keywords: Tauern window; Eastern Alps; High-pressure metasediment; U–Pb dating; Zircon

1. Introduction

The Alpine orogen is a continental collision belt resulting from the closure of the Neotethys ocean by south-directed subduction and collision of the European and Apulian plates in the Cretaceous and Tertiary (e.g. Stampfli et al., 1998). During the Alpine orogeny, high-pressure metamorphism affected rocks from different palaeogeographic domains, such as the Apulian continental crust, the Piemont–Ligurian oceanic lithosphere and metasediments, the Briançonnais and the European

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continental margin. In the Western and Central Alps the timing of this complex geodynamic evolution is well constrained by SHRIMP data for zircons: high-pressure metamorphism of the subducted continental Sesia–Lanzo Zone occurred at approximately 65 Ma, followed by subduction and high-pressure/ultrahigh-pressure metamorphism of the oceanic crust of the Piemont–Ligurian ocean at approximately 44 Ma and of the Adula–Cima Lunga nappe system and the Internal Massifs 33–35 Ma ago (e.g. Rubatto et al., 1998, 1999; Gebauer, 1999; Lapen et al., 2003; Rubatto and Hermann, 2003; Federico et al., 2005). In the Eastern Alps, high-pressure metamorphism during Alpine compression has been dated for the Koralpe–Saualpe–Pohorje region in the eastern parts of the Austroalpine basement: Sm–Nd garnet and U–Pb zircon ages from eclogite assemblages cluster at 90±2 Ma (Thöni, 2002; Miller et al., 2005), documenting subduction of the southeastern Austroalpine units in the course of the complex collision of the Apulian microplate and Europe. In the Eclogite Zone of the Tauern Window, peak pressures were reached shortly before 45 Ma, based on $^{39}Ar/^{40}Ar$ geochronology (Ratschbacher et al., 2004) whereas Glodny et al. (2005) suggest an Oligocene age (31.5±0.7 Ma), based on multimineral Rb/Sr internal isochrons.

In the Tauern Eclogite Zone, Alpine high-pressure metamorphism is documented in metabasic eclogites and metasediments. In this paper we present petrological and geochemical data on quartz-rich zircon-bearing gneisses that are interlayered with kyanite-eclogites at the Steinsteg locality in order to document the impact of high-pressure metamorphism on one of the rare meta-acidic lithologies, and to evaluate the nature of the protolith. Since the jadeite-gneiss turned out to be a metasediment we also studied the detrital zircon population in order to constrain provenance and the age of the sediment source.

2. Regional geology

The Tauern Window exposes Penninic units of continental and oceanic affinities in the footwall of the Austroalpine nappe system (Fig. 1). The stacking of this nappe sequence and metamorphism occurred in response to the closure of the Neotethys and continent–continent collision in late Cretaceous–Tertiary time. In the central Tauern Window the Eclogite Zone is

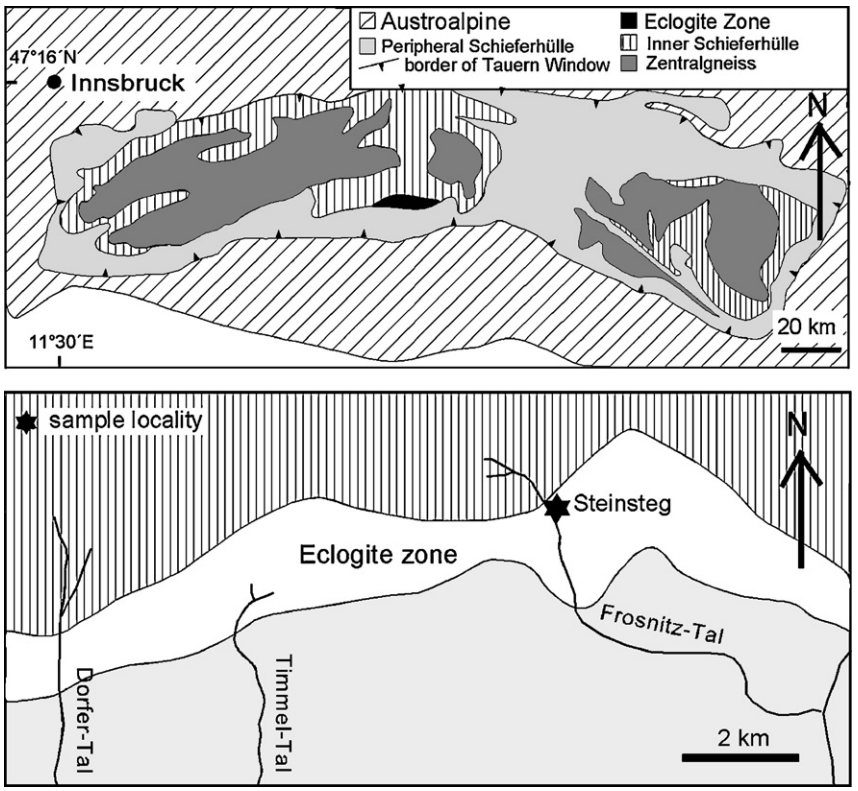

Fig. 1. Simplified tectonic map showing the Tauern Window, the Eclogite Zone and the Steinsteg sampling locality.