

Protolith and metamorphic ages of eclogites from the Eastern Alps: The Permian to Cretaceous Wilson cycle of the Austroalpine mega-unit

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The Austroalpine mega-unit contains the type locality for eclogites (Haüy, 1822) but their protolith ages are largely unknown except that of the Permian Bärenfelsen metagabbroic eclogite, for which three Sm-Nd ages between 275 ± 18 and 275 ± 18 Ma have been reported (Thöni and Jagoutz, 1992; Miller and Thöni, 1997). Therefore, we studied the abundant non-gabbroic eclogites from the Saualpe-Koralpe and Siegggraben Complexes, which are considered to represent a previously coherent subducted and then exhumed fragment of a continental rift, which led to the formation of the late Middle Triassic Meliata oceanic basin. A combined zircon U-Pb and Hf isotopic study, whole rock geochemistry of two complexes revealed a protolith age of 242.3 ± 2.6 Ma (Middle Triassic) in the Siegggraben Complex, and 283 ± 5 Ma, 255 ± 3 Ma (early and late Permian), 251 ± 3 Ma, and 241 ± 3 Ma (Early to Middle Triassic) in the Saualpe-Koralpe Complex. Magmatic zircons from the Siegggraben eclogites have $^{176}\text{Hf}/^{177}\text{Hf}$ ratios of 0.283067–0.283174, $\epsilon\text{Hf}(t)$ values of +15.7 to +19.4, and that from Saualpe-Koralpe eclogites have $^{176}\text{Hf}/^{177}\text{Hf}$ ratios of 0.282935–0.283090, $\epsilon\text{Hf}(t)$ values of +10 to +17.4 showing their juvenile mantle source rather than significant crustal assimilation. In both complexes N-MORB geochemical characteristics are established. Associated ultramafic rocks of the Siegggraben eclogites as part of oceanic or Permian subcontinental mantle lithosphere suggest a depleted mantle source and a deep subduction environment. Two zircon grains of the Siegggraben eclogites with low Th/U ratios yield ages of 113 ± 2 Ma and 86 ± 4 Ma and represent the approximate age of eclogite metamorphism during Cretaceous. A trondhjemite dike cutting the eclogite gives a crystallization age of 82.19 ± 0.4 Ma and was formed by partial melting of likely eclogite during decompression. The host metasedimentary rocks of the Siegggraben and Saualpe-Koralpe Complexes are interpreted as old continental crust close to the margin of the Meliata basin, which were affected by Permian migmatitic metamorphism. Metamorphic zircons of one eclogite from the Saualpe-Koralpe Complex give an age of 87–93 Ma (peak at 91 ± 1.2 Ma). The results of this study combined with previous results are used to present a new model for the tectonic evolution of the distal Austroalpine unit associated with the Meliata Ocean in the Wilson cycle: the Austroalpine Siegggraben and Saualpe-Koralpe Complexes represent a location on the distal thinned continental margin during Permian to Middle Triassic rifting. The mafic rocks are associated with numerous Permian and potentially Triassic acidic pegmatites, whereas the structurally separated thick Triassic sedimentary cover successions lack any magmatism, likely excluding the present-day eclogite-bearing units as Triassic basement of the sedimentary cover successions.

The now eclogite-bearing piece of continental crust adjacent to the Meliata oceanic lithosphere subducted during Early Cretaceous times to mantle depth. The subducted continental crust was then exhumed incorporating even ultramafic mantle rocks. During exhumation and decompression of mafic rocks, partial melting took place forming the trondhjemite dike in Late Cretaceous times.

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