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Hf isotopic constraints for Austroalpine basement evolution of Eastern Alps: review and new data

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The Alps, as part of the Alpine-Mediterranean Mountain chain, are one of the classical localities for orogenic studies, where the Mesozoic-Cenozoic tectonic evolution is well known. Many classical models have been proposed to explain the tectonic evolution from Mesozoic rifting and breakup to Late Mesozoic-Cenozoic subduction, plate collision and exhumation. However, the pre-Mesozoic tectonic evolution of the pre-Alpine basement remains poorly known because of the lack of sufficient age data due to complex polyphase deformation and multiple metamorphic overprints. New data from mainly amphibolite-facies pre-Alpine basement of the Austroalpine mega-unit indicates that this basement is composed of a heterogeneous series of continental units, island arcs, ophiolites, subduction mélanges, accretionary wedges, and seamounts affected by different metamorphic grades. This study presents new results of LA-ICP-MS U-Pb zircon dating and MC-ICP-MS Lu-Hf isotopic tracing of zircons from three key areas of Austroalpine basement, including the: i) Wechsel Gneiss and Waldbach Complexes, and Wechsel Phyllite Unit, (ii) Saualpe-Koralpe-Pohorje, and (iii) Schladming areas. We determine the Wechsel Gneiss Complex to be a continental magmatic arc formed during 500–560 Ma in the proximity to a continental block with a 'memory' of Late Archean to Early Proterozoic continental crust. The Wechsel Gneiss Complex has Hf model ages of 2.1 to 2.2 Ga and 2.5 to 2.8 Ga that indicate a close relationship to northern Gondwana, with depleted mantle Hf model ages as old as 3.5 Ga. The Wechsel Phyllite Unit structurally overlying the Wechsel Gneiss Complex has partly different sources, including juvenile crust formed at ca. 530 Ma. In contrast, the Waldbach Complex constantly added new crustal material during 490–470 Ma period and bears considerably more positive εHf(t) values than the underlying Wechsel Gneiss Complex and gives relatively young, depleted mantle model ages of 700 to 500 Ma. The Waldbach Complex is, therefore, interpreted to be part of a magmatic arc that formed during closure of the Prototethys and was metamorphosed during Variscan orogenic events at ca. 350–330 Ma. The Schladming-Seckau and Wechsel Complexes represent a Cambro-Ordovician magmatic arc system formed by Prototethys subduction processes with the associated Late Neoproterozoic to Early Ordovician ophiolitic Speik complex having formed in its back-arc basin or as Prototethyan lithosphere. The Plankogel Complex and structurally overlying micaschist and amphibolite units represent accreted ocean, ocean island, and continent-derived materials, interpreted to be an accretionary complex formed during the Permo-Triassic closure of the Paleotethys. Many granites with Permian ages (e.g., porphyric granite called Grobgneiss and other granite gneisses and associated pegmatites) were likely formed in an extensional environment that culminated in the opening of the Middle-Late Triassic Meliata oceanic rift. These granites formed by partial remelting of crust with mainly Middle Proterozoic Hf model ages. Taken all these data together, we find that the Austroalpine basement is heterogeneously composed and includes complexes of different ages, different tectonic evolutionary histories and different remolten sources representing different locations before final accretion. The composite of pre-Alpine complexes in the Austroalpine mega-unit likely assembled not earlier than Late Permian or Early Triassic.