Hf isotopic constraints for the Austroalpine basement evolution of the 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. However, the pre-Alpine basement remains poorly known because of the lack of sufficient age data, complex polyphase deformation and polymetamorphism. New data from the mainly amphibolite-facies pre-Alpine basement of the Austroalpine mega-unit indicate its heterogeneous composition by continental units, island arcs, ophiolites, subduction mélanges, accretionary wedges, and seamounts affected by different metamorphic grades. We present 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 the Austroalpine basement, including the: i) the Wechsel Gneiss and Waldbach Complexes, and the 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 proximal to a continental block with a 'memory' of late Archean to early Proterozoic continental crust. Hf model ages of 2.1 Ga to 2.2 Ga and 2.5 Ga to 2.8 Ga that indicate a close relationship to the 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 ~530 Ma. In contrast, the Waldbach Complex constantly added new crustal material during the 490–470 Ma period and bears considerably positive εHf(t) values with young, depleted mantle model ages of 700 to 500 Ma. The Waldbach Complex is, therefore, interpreted to be part of a magmatic arc formed during closure of the Prototethys and metamorphosed during Variscan orogenic events at ~350–330 Ma. The Schladming-Seckau and Wechsel Complexes represent a Cambro–Ordovician magmatic arc system formed by Prototethys subduction processes with the associated upper Neoproterozoic to Lower Ordovician ophiolitic Speik Complex having formed in its back-arc basin or as Prototethyan lithosphere. The Plankogel Complex and structurally overlying mica-schist 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 Paleotethys. Many granites with Permian ages (*e.g.*, the porphyric Grobgneiss and other granite gneisses, and associated pegmatites) were likely formed in an extensional environment culminating with the opening of the Middle–Late Triassic Meliata oceanic rift. These granites are formed by partial remelting of a 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 the final accretion. The composite of the pre-Alpine complexes in the Austroalpine mega-unit is likely assembled not earlier than late Permian or Early Triassic. Tectonically, the Hf composition in Eastern Alps produce a fanning isotopic array, the lowest εHf values increase from –38 at ~550 Ma to –10 at 200 Ma, and the highest εHf values increase from +5 to values of the contemporary depleted mantle (~+16) over the same time interval, indicate an external orogenic system.

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