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Crustal evolution of western Europe: insights from detrital zircon U-Pb-Hf-O isotopes

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Western Europe is a collage of peri-Gondwana terranes that were initially formed along the north Gondwana margin during the Late Ediacaran Cadomian oroeny, after which they rifted from the supercontinent and assembled by a series of orogenic processes during the Phanerozoic. We studied detrital zircon U-Pb-Hf-O from black sand of the Rhone River delta (southern France) which drains significant parts of western Europe (1). Recent black sand is an extraordinary sampler of all major episodes of European magmatism with zircon U-Pb ages peaking at 0.55 Ga (Cadomian), 0.45 Ga (Cenerian) and 0.31 Ga (Variscan). Hafnium in detrital zircon defines a crustal evolutionary array with Hf-T_{DM} ages pointing to repeated reworking of a Mesoproterozoic (1.0-1.5 Ga) crustal reservoir. However, the majority of the zircon have elevated $\delta^{18}O$ indicating the involvement of a significant sedimentary component in the parental granitoids. A preponderance of the obtained Mesoproterozoic Hf-T_{DM} ages are thus mixed ages and do not designate the reworking of Mesoproterozoic crust. The Variscan and post-Variscan populations also include a distinguished proportion of detrital zircon with mantle-like $\delta^{18}O$ while retaining Mesoproterozoic Hf model ages. They are interpreted as indicating crystallization from juvenile melts whose Hf reflects source contamination.

As a whole, our detrital zircon U-Pb-Hf-O data do not support the widespread presence of a pre-Neoproterozoic crustal reservoir below peri-Gondwana terranes of western Europe. The prevalent oldest rocks in this region are Late Ediacaran-Cadomian clastic sediments, mostly derived from the erosion of Pan-African orogens with variable contributions from proximal Cadomian arcs. The apparent Mesoproterozoic Nd/Hf model ages of many European granitoids are likely inherited from the isotopic properties of the Cadomian and younger sediments that were involved in their generation. Since the widespread presence of an older continental basement is negated, peri-Gondwana Cadomian sedimentary basins that were reworked into present-day Europe were originally mostly floored by oceanic crust. Slivers of Mesoproterozoic and older rocks (such as the 2.03 Ga Icart gneiss) which are scattered in western Europe, likely wandered in the proto-Tethys and accreted to the Cadomian active margin in the late Neoproterozoic.

(1) Avigad, Abbo, Gerdes & Schmitt (2022) Gondwana Research 106, 379-396