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Zircon U-Pb, Hf isotope and trace element geochemistry: source of the Himalayan UHP eclogites

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To understand the magmatic source and the metamorphic evolution of Himalayan ultrahigh-pressure rocks in the Kaghan Valley of Pakistan, we conducted an integrated study of U?Pb age-dating, Hf isotope and trace element geochemistry on zircons. Zircons Laser Ablation-Inductively Coupled Plasma-Mass Spectrometer (LA-ICP-MS) U?Pb age between 143 and 277Ma was obtained from zircons in High-pressure (Group I eclogites) with a concordant age of 255 $\pm$ 9 Ma (MSWD = 0.87, 95% conf., and probability = 0.56). Identical age values were obtained from the core portions of zircons in felsic gneisses. The rims of the oscillatory zoned zircons in felsic gneisses yielded 47 Ma. In contrast, zircons in ultrahigh-pressure (Group II) eclogites yielded U?Pb concordant age of 48 $\pm$ 4 Ma (MSWD = 1.4, 95% conf., and probability = 0.18).

LA-ICP-MS trace element compositions from the same spots on zircons analyzed for U?Pb age show two contrasting compositional groups. Zircons in felsic gneisses are trace-element enriched at the core domains and have higher Th/U ratios ($>$0.5) indicating their magmatic origin. Zircons in Group I eclogites are also trace element enriched and have higher Th/U ratios ($>$0.5) indicating typical magmatic protolith signatures. In contrast, zircons in Group II eclogites have significantly lower contents of trace elements, lower Th/U ratios ($<$0.5) and are typical of metamorphic origin. The identical age values and trace element compositions of zircons in felsic gneisses and eclogites suggest their crystallization from a same magma source which potentially produced both mafic and felsic rocks intermittently. The rim portions in zircons from felsic gneisses grew during the Himalayan UHP metamorphism. Zircons found in UHP eclogites, with no age data representing the protolith event, were recrystallized from the formerly formed zircons during the Himalayan UHP eclogite facies metamorphism. The Hf isotope data of zircons, obtained from the same age spots, support our interpretation. The relatively narrow range in the ?Hf, mostly positive, values (9.5 to -3.1 in zircons of Group I eclogites; +10.8 to -0.9 in zircons of Group II eclogites; and +15.6 to -2.6 in zircons of felsic gneisses), suggest their formation from a juvenile enriched mantle source.

Keywords: Himalaya, Zircon U-Pb age, Hf isotope, trace element, eclogites, Kaghan