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Trace-Element Mobility in Eclogite-Facies Subducted Crust: Garnet, Zircon, and Rutile Petrochronology of As Sifah, Oman

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Trace element flux in subduction zones is strongly affected by the chemistry and availability of an accompanying fluid, in addition to mineral partitioning behavior. These factors may be exacerbated in certain lithologies, suggesting a role for lithology-specific rock permeability, fluid fugacity, and/or trace-element partitioning during subduction. To assess lithological controls on elemental transport in subducted mafic crust and sediment, we obtained dates (Sm-Nd, Lu-Hf, and U-Pb) and major- and trace-element concentrations for garnet, zircon, and rutile in end-member mafic and metapelitic rocks from the ultrahigh-pressure As Sifah unit of Oman. The three phases record similar isotopic dates among all lithologies, but trace-element records for each phase are distinct for each rock type. For example, i) mafic rocks show expected garnet/zircon rare-earth element (REE) partitioning, but metapelitic garnet and zircon do not, and ii) mafic rutiles record lower intergranular solubilities for high-field-strength elements (HFSEs) than pelitic rutiles. Together, these data suggest that REE and HFSE equilibrium length-scales varied significantly between adjacent lithologies, implicating crucial differences in fluid flux during subduction. Further, Lu-Hf isotopic data are scattered and non-isochronous for all rocks – even in metapelites that exhibit cm- to outcrop-scale HFSE equilibrium length-scales – suggesting that achievement of elemental equilibrium does not imply isotopic equilibrium, even at the same scale. Our approach illustrates the power of multi-phase petrochronology in determining the behavior of distinct trace-element groups during metamorphism.