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Discovery of in situ super-reducing, ultrahigh-pressure phases in the Luobusa ophiolitic chromitites, Tibet: New insights into the deep upper mantle and mantle transition zone

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Abstract

Previous research on super-reducing ultrahigh-pressure (SuR UHP) phases from the Tibetan ophiolitic chromitites were mainly conducted on isolated grains extracted from extremely large samples. This approach has been questioned because of possible contamination. To elucidate the occurrence and origin of these SuR UHP minerals, we studied 33 thin sections and rock chips of three ophiolitic chromitites from the Yarlung Zangbo suture zone. Here we report and analyze unambiguously in situ SuR UHP assemblages from the ophiolitic chromitites by electron probe micro-analyzer, scanning microscope and Laser Raman spectroscope. The SuR UHP and associated phases include: (1) blue moissanite as inclusions in olivine ($Fo_{96–98}$), and in olivine domains between disseminated chromite grains; (2) multiple inclusions of moissanite + wüstite + native Fe in olivine; (3) FeNi and FeCr alloys in olivine and chromite; and (4) native Fe and Si in chromite. Crustal asphaltum and h-BN also occur as inclusions in chromite. Our documented in situ SuR UHP phases, combined with the previously inferred existence of ringwoodite + stishovite, all indicate that these assemblages formed under a highly reducing environment (oxygen fugacities several orders of magnitude lower than that of the iron-wüstite buffer) in the mantle transition zone (MTZ) and in the deep upper mantle. Diamond + moissanite with distinct ^{13}C-depleted compositions from chromitites have a metasedimentary carbon source. Associations with existing crustal minerals in chromitites demonstrate that carbon-bearing metasedimentary rocks were recycled into the mantle through subduction, and locally modified its composition. Finally we propose a three-stage model to explain the formation of SuR UHP phase-bearing chromitite. Discoveries of SuR UHP phases in Luobusa and other ophiolitic podiform chromitites from the polar Ural Mountains and from Myanmar imply existence of a new type of ophiolitic chromitite. Such occurrences provide an additional window to explore the physical-chemical conditions of the MTZ, mantle dynamics, and the profound recycling of crustal materials.

Keywords: Ophiolitic chromitite, in situ, super-reducing UHP phases, deep upper mantle, mantle transition zone, Tibet, moissanite, wüstite, Invited Centennial article