Nucleogenic xenon in polycrystalline diamonds from Jwaneng, Botswana?

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As part of a wider investigation into the evolution of the noble gases through time, during the year we undertook noble gas analyses of well-characterised polycrystalline diamonds from the Jwaneng kimberlite pipe, Botswana. These samples yielded complex, multiple noble gas components (crustal, atmospheric and in-situ radiogenic/fissiogenic), which were successfully deconvoluted by combining vacuum crushing and step-heating experiments and examining a full suite of noble gas isotope and elemental abundances.

From these diamond samples we found xenon isotope anomalies, relative to atmospheric. The ^{129}Xe isotope anomalies observed in the samples are comparable to those in mantle-derived samples, including MORBs, Loihi dunites and Icelandic picritic glasses. Excess ^{129}Xe observed in mantle-derived samples is generally attributed to radioactive decay of an extinct nuclide ^{129}I (half life of 16 Ma), once present in the Earth. However, a similar excess in ^{129}Xe, accompanied by excess $^{131\text{-}136}$Xe (as observed in the Jwaneng diamonds), has recently been reported for continental metamorphic rocks (gneiss and amphibolites), and in Archean cherts in the metasedimentary sequences of Pilbara Craton, Western Australia. It is postulated that the excess ^{129}Xe in these rocks was in fact due to nucleogenic production from tellurium $^{128}\text{Te}(n,\gamma)^{129}\text{Te}\xrightarrow[69\text{m}]{\beta^-}{}^{129}\text{I}\xrightarrow[16\text{Ma}]{\beta^-}{}^{129}\text{Xe}$ in the crust. The observation of crustal-like noble gases (e.g., radiogenic helium and argon, nucleogenic neon) and the apparent absence of mantle noble gases (e.g., primordial ^{3}He and solar-like neon) in the Jwaneng diamonds are somewhat analogous to the compositions reported for the metamorphic rocks. Therefore, one interpretation is that the ^{129}Xe excesses observed in the Jwaneng diamonds represent crustal nucleogenic xenon, rather than mantle xenon. It is also important to point out that the ^{131}Xe excesses in the Jwaneng diamonds are systematically higher than those observed in MORBs, possibly also reflecting the nucleogenic production of ^{131}Xe from tellurium $^{130}\text{Te}(n,\gamma)^{131}\text{Te}\xrightarrow[25\text{m}]{\beta^-}{}^{131}\text{I}\xrightarrow[8\text{d}]{\beta^-}{}^{131}\text{Xe}$. In addition, the $(^{129}\text{Xe}/^{131}\text{Xe})_{excess}$ ratios in the Jwaneng diamonds are consistent with the range of nucleogenic ^{129}Xe/^{131}Xe ratios produced from tellurium by neutron capture, thus supporting a nucleogenic origin for the excess ^{129}Xe. It must be stressed, however, that it would require reasonably high neutron fluxes and tellurium concentrations in the crust to provide the level of ^{129}Xe and ^{131}Xe excesses observed in the Jwaneng diamonds. Thus, although a crustal nucleogenic origin for excess ^{129}Xe in the Jwaneng diamonds requires verification, particularly in relation to the absolute production of nucleogenic xenon in the crust, we tentatively suggest that the Jwaneng diamonds do not contain detectable amounts of mantle xenon. This argument is consistent with the observation of crustal neon in the diamonds. These crustal noble gases observed in the diamonds could have been introduced into the diamond stability field of the sub-continental mantle by subduction-related processes. It is critically important to test this hypothesis through further investigations of eclogitic diamonds from various localities. Such studies will clarify whether crustal noble gas inventories can be retained during subduction of crustal material into the mantle lithosphere.

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