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Pressure-Induced Argon Insertion into a Small Pore Zeolite; Implication to the "Missing Xenon" Problem

이용재(Yong Jae Lee)
연세대학교 지구시스템과학과(*yongjaelee@yonsei.ac.kr*)

The noble gases He, Ar, Ne, Kr and Xe are currently understood to originate from accreting planetessimals, which are the Earth's primordial building blocks. They are initially dissolved in silicate melts at high pressures in the Earth's mantle and ascend to the surface, where they are released into the atmosphere. Noble gases with their very stable electronic configuration are widely seen as non-reactive elements. However, the amount of Xe present in the atmospheres of the Earth and Mars is depleted by about a factor of 20 relative to the other noble gases. This is referred to as the "missing Xe problem" and one hypothesis suggests that Xe under certain conditions becomes soluble and/or forms compounds with minerals. It has been established that Xe can form water clathrates at ambient and high pressure conditions and be contained in the nanometer size pores of certain zeolites. Work by Sanloup et al suggests the formation of Xe silicates at high pressures and temperatures based on laser-heated samples of Xe and beta-cristobalite contained in diamond-anvil cells. In more recent work evidence was put forward that Xe can be substituted into the silicon sites of the quartz structure. In argon compared to the heavier noble gases the valence electrons are not screened very well by core electrons and only one compound (HArF) has been experimentally established using infrared spectroscopy. In the following we report on a related phenomenon, the pressure-induced insertion of the noble gas argon into the framework structure of natrolite - a small pore zeolite - under moderate geophysical pressure- and temperature conditions. This work thus provides another piece of evidence that Ar should be seen as "moderately to extremely compatible in its behavior towards dominant minerals in the upper mantle" as pointed out recently by Watson et al.