Constraining noble gas solubilities in the Earth's mantle

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Noble gases (NGs) are important geochemical markers for determining the volatile origins and their redistribution processes since Earth accretion. In order to reconstruct such processes, NG solubility and partitioning data between mineral and melts are required at Earth's mantle conditions. However, such information is difficult to obtain from field studies due to the potential atmospheric NG contamination, the few available deep Earth samples and the potential re-distribution of NGs during obduction.

In this contribution, we present an original approach to predict and constrain solubility behaviors of NGs at Earth's mantle conditions. Our previous experimental studies of the thermo-elastic properties of heavy NGs (Ar, Kr, Xe) revealed extremely high compressibilities and high thermal expansivities of these elements [1-5]. We indeed observed a reduction of the atomic volume of NGs by 40% at transition zone depth. We propose that this may considerably affect the NG partitioning behaviors with increasing depth. In order to assess the influence of mechanical property changes on NG solubilities, we have extended the classical lattice strain approach, which is widely used to predict trace element partitioning between mineral and melt, by taking into consideration the mechanical properties of NGs and the one of the host phase. Using this approach, we have obtained solubilities that are in good agreement with those determined experimentally in lower mantle mineral phases [6]. In this contribution, we discuss the advantages and limitations of this approach and its application to upper mantle minerals, hydrous minerals and melts.

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