Noble Gases Isotopic Compositions and Their Genesis: Implications for the Polymetallic Crusts and Nodules from the South China Sea

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The noble gases have some unique advantages that can be useful in marine research. Their nuclide abundances and isotopic ratios of the polymetallic crusts and nodules from the South China Sea were analyzed, and results were as follows: (1) when using the high-temperature bulk melting method, the isotopic compositions for noble gases mainly occur in the crystal lattice of iron/manganese minerals and part of the terrigenous detrital minerals, and the He and Ar isotope systems have good stability during the ore-forming process, basically displaying the original characteristics of the sources; (2) variations of He and Ar nuclide abundance in the polymetallic crusts and nodules are less than 1 order of magnitude in the abundances of ^{4}He, ^{3}He and $^{40}Ar(cm^{3}\cdot STP\cdot g^{-1})$, which are in the range 0.311×10^{-7}~ 3.610×10^{-7}(n = 7, the same below), 2.684×10^{-14}~ 10.913×10^{-14}, and 0.390×10^{-6}~ 1.495×10^{-6}, respectively. The polymetallic crusts and nodules from the South China Sea have lower ^{3}He abundances, and the $^{3}He/^{4}He$ ratios (R/R_A) range from 0.191 to 1.079, significantly lower than the values of MORB which represent the upper mantle source and OIB of the lower mantle source, higher than crustal rocks. The $^{40}Ar/^{36}Ar$ ratios range from 329.000 to 873.900, significantly higher than the atmospheric values, and are closer to OIB of the lower mantle source compared with MORB of the upper mantle source and crustal rocks which have a high content of radioactive origin Ar^{*}; (3) the He sources of the polymetallic crusts and nodules from the South China Sea are mainly from the lower mantle and continental crust, whereas the Ar sources are mainly from the mixture of mantle, seawater, and the terrigenous detrital source; (4) the isotopic characteristics of He and Ar in the polymetallic crusts and nodules may reflect the noble gases component of OIB that represents the lower mantle source, and provides evidence of the magma activity characteristics of the seamounts in the South China Sea, where the magma has OIB properties; (5) the statistical results show some differences in the composition of noble gases between the deep-sea nodules and the seamount ferromanganese crusts due to the difference in the growing environments, noble gas sources, and the genetic mechanism. The growth and ore-forming process are impacted by the marginal sea environment and the material supply conditions, the noble gases in the polymetallic crusts, and nodules from the South China Sea are similar to the seamount ferromanganese crusts and show the characteristics of hydrogenous origin, although they have significantly different deep-sea nodules.