Mineral H isotopes and water contents in UHP eclogite-gneiss contact from CCSD core samples

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By taking advantage of having depth profiles between contrasting lithologies from core samples of the Chinese Continental Scientific Drilling (CCSD) project, a combined study was accomplished by means of TC/EA-MS and FTIR methods to examine changes in mineral H isotope, total water and hydroxyl contents in garnet and omphacite across the contacts between ultrahigh-pressure (UHP) eclogite and gneiss in the Sulu orogen, east-central China. The results are used to decipher both origin and availability of metamorphic fluid during exhumation of deeply subducted continental crust. The samples of interest were from two continuous core segments from the CCSD main hole at depths of 734.21 to 737.16 m and 929.67 to 932.86 m, respectively. The results show δD values of −116 to −64‰ for garnet and −104 to −82‰ for omphacite, consistent with incorporation of meteoric water into protoliths of UHP metamorphic rocks by high-T alteration. Both equilibrium and disequilibrium H isotope fractionations were observed between garnet and omphacite, suggesting fluid-assisted H isotope exchange at local scales during amphibolite-facies retrogression.

While bulk water analysis gave total H_2O concentrations of 522 to 1584 ppm for garnet and 1170 to 20745 ppm for omphacite, structural hydroxyl analysis yielded H_2O contents of 80 to 413 ppm for garnet and 228 to 412 ppm for omphacite. It appears that significant amounts of molecular H_2O are present in the minerals, pointing to enhanced capacity of water storage in the UHP eclogite minerals. Hydrogen isotope variations in the transition between eclogite and gneiss show correlations with variations in their water contents. Petrographically, the degree of retrograde metamorphism generally increases with decreasing distance from the eclogite-gneiss boundary. Thus, retrograde metamorphism results in mineral reactions and H isotope variation. Because hydroxyl solubility in nominally anhydrous minerals decreases with dropping pressure, significant amounts of water are expected to be released from the minerals during decompression exhumation. Decompression exsolution of structural hydroxyl from 1 m^3 volume of eclogite composed of only garnet and omphacite results in release of a quantitative estimate of 3.07 to 3.44 kg water that can form 140 to 156 kg amphibole during exhumation. Therefore, it is concluded that fluid for retrogression of the eclogites away from the eclogite-gneiss boundary was derived from the decompression exsolution of structural hydroxyl and molecular H_2O in nominally anhydrous minerals. For the eclogites adjacent to gneiss, in contrast, the retrograde metamorphism was principally caused by aqueous fluid from the gneiss which is relatively rich in water.

New achievements in the study of the excess argon in HP-UHP metramorphic minerals

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Based on the study of the genesis, diffuse and transference of excess argon in the High and Ultrahigh-pressure metamorphic minerals using classical Ar-Ar and laser microprobe Ar-Ar dating method, the following conclusions can be drawn:

1. In the eclogites of different time(from the Caledonian to Indo-Sinian epoch) and different area in China, not only the phengites contain large amounts of excess argon, but the other trace potassium minerals, such as olivine, garnet and pyroxene, also contain excess argon and even the biotites in some eclogites also contain excess argon.

2. Four phengites for Ar-Ar dating are concentrated from the eclogites range from the margin to the center of the eclogite body on the top of the Qinglong Mountain in eastern China. The excess argon content of the four samples from the outer to the inner part of the rock body within 60cm is 73%, 74%, 76% and 78% respectively, which indicates that the excess argon in the phengites of the eclogites is distributed unevenly and show a little positive gradient. Therefore, the excess argon is basically believed to be inherited from its parent rock and not from its outside.

3. The phengites in the eclogite of Yuka area in the northern margin of the Qaidam Basin in western China, whose country rock is marble, do not contain excess argon, which indicates that the lithology of the country rock is a key factor to control the occurrence of the excess argon in eclogite.

4. The content of the excess argon in the phengites is found to be positively correlated with the ratio of its Na/(Na+K) and the correlation formula is:

$$y = -112.14+10710x-251844x^2+3\times106x^3-1\times107x^4$$
$$(R^2=0.997)$$

In which y is the content of the excess argon (%) and the x is the ratio of Na/(Na+K).

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