Distribution of significant trace elements in Lower Cambrian carbonaceous black shale deposits from South China

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Carbonaceous black shales have a wide distribution on the surface and in subsurface Lower Cambrian sedimentary sequences of South China. The Lower Cambrian carbonaceous black shales in South China gained strong interest since four decades when the famous Ni-Mo polymetallic deposits were discovered and exploited. In this work the 54 samples of the variety of Lower Cambrian shale locations in South China are investigated focusing on their trace elemental geochemical characteristics.

Several trace elements including Co, V, Li, Ni, Rb, Zn, Pb, Ti, Mo, Sr, Cu and Cr of the black shales, indicate improved depositional environmental condititions during in the Lower Cambrian. Vanadium (V) attains an average concentration of 176 ppm and varies from 42ppm to 4137 ppm. The average Nickel (Ni) content in the studied samples is 147 ppm. The studied samples show Cobalt (Co) contents less than 10 ppm. Strontium (Sr) is abundant, ranging between 17 ppm and 1703 ppm with an average of 252ppm. The average Zinc (Zn) content is 84 ppm. The average Chromium (Cr) content of the studied samples is 108 ppm. Black shales are rich in Cu with a content of about 95 ppm. The studied shales in outcrops show significant enrichment in organic matters of the total organic carbon content (TOC) average up to 8.54%. All studied shales are overmature (R_o>2.65%) for hydrocarbon generation with a weak hydrocarbon potential of kerogen type I.

This study show that the trace elements as V, Co, Ni, Mo, Sr and Cu are a positive correlation with TOC. Additionally, Vanadium also shows a positive correlation with some of the other trace elements, such as Ni, and Cr (r=0.62 and 0.47). Vanadium is enriched in organic rich shales deposited under reducing conditions and might also be hosted by detrital silicate minerals. This indicates that vanadium is considered to be typically of organic matter association rather hosted by detrital silicate minerals. It has been suggested that some V, Co, Ni, Mo and Cu may be complexed within the kerogen molecule. The high concentrations of V, Co, Ni, Mo and Cu in the inorganic fraction may be the result of oxidation and weathering of the organic matter and the subsequent mobilization and concentration in host rocks.

Noble gas isotopic constraints on the origin of fluids in the Jinchuan Ni-Cu sulfide deposit, Western China

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He and Ar elemental and isotopic compositions of 23 olivine (Olv), orthopyroxene (Opx), clinopyroxene (Cpx) and sulfide separates in Jinchuan Cu-Ni sulfide-bearing ultramafic intrusions in northwest China have been determined to investigate the sources of fluids during the evolution of the intrusion and the associated sulfide ores.

$^3He/^4He$ ratios show higher values in sulfide (from 0.268 to 0.808 Ra with a mean of 0.456Ra), ($^3He/^4He$ of atmosphere is 1.399×10^{-6}), than those in silicate minerals (from 0.155 to 0.366 Ra with a mean of 0.239Ra). These ratios decrease from Olv (average 0.291Ra), Opx (0.215) to Cpx (0.174). $^3He/^4He$ ratios are positively correlated with ^4He contents in Olv and sulfide, but negatively correlated with ^4He contents in Opx and Cpx. The $^{40}Ar/^{36}Ar$ ratios in silicate minerals (average 18060) are higher than in sulfides (1062). These ratios increase from Olv (18357) and Opx (18497) to Cpx (22621). Positive correlation between $^{40}Ar/^{36}Ar$ and ^{40}Ar content is found in the silicate minerals but not in the sulfides. This complication suggests that radiogenic ^4He and ^{40}Ar are not important in olivine and sulfide, which helps to trace their origins.

The $^3He/^4He$ and $^{40}Ar/^{36}Ar$ ratios of the Jinchuan samples indicate mixing of noble gasses from mantle, crust and atmosphere in the Jinchuan system. Among them, the contribution from the continental crust is most significant. Higher $^3He/^4He$ ratios and lower $^{40}Ar/^{36}Ar$ ratios in the sulfides than in the silicate minerals from the Jinchuan intrusion suggest that the segregation of the sulfide melt occurs at an early stage during magmatic differentiation. Continental crustal volatiles have been continually added during magma formation and crystallization.

A two-stage model is proposed. Mixing of components from the mantle and continental crust took place at a magmatic stage. This was then followed by the addition of atmospheric components at a subsolidus stage.

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