

Shock Effects and Thermal Metamorphism of Ordinary Chondrite Northwest Africa 722

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Northwest Africa 722 (NWA 722) is an ordinary chondrite characterized by an impact melt vein and a host domain with relict chondrules and matrix. In this study, mineral textures, major element compositions and noble gas compositions of NWA 722 (classified as L-impact melt, but see below) are analyzed and compared with three other ordinary chondrites, Valera (L5), Aba Panu (L3) and Bjurböle (L/LL4). The main goals of the project on NWA 722 are to determine: (1) the relative timing of impact vein formation vs. parent body metamorphism; (2) noble gas characteristics of the impact vein vs. host domain.

Polished thin sections of NWA 722, Valera, Aba Panu and Bjurböle were used for imaging of minerals and textures by microscope, scanning electron microscope (SEM), and electron probe micro-analyzer (EPMA). A Hitachi #3400 SEM and JEOL JXA-8900 EPMA at the Waseda University Earth Sciences Department (WU) were used for imaging. The WU EPMA was used for both elemental mapping and quantitative analyses. Samples of all four ordinary chondrites were analyzed for noble gases; for NWA 722, the host lithology and impact melt vein were sampled and analyzed separately. Elemental composition and isotope composition of noble gases were determined using a mass spectrometer (modified-VG3600) at the University of Tokyo Graduate School of Arts and Science.

The impact melt vein consists of fragmented olivine and pyroxene grains separated by thin seams of silicate glass. Rounded inclusions of Fe-Ni-metal mixed with troilite also occur in the vein. Near the vein margins, thin veinlets of Fe-Ni-metal and troilite extend into the host domain.

Quantitative EPMA analyses show that olivine grains from the impact melt vein and host lithology of NWA 722 have similar compositions near Fa_{18} . The Fa -content of NWA 722 olivine is similar to H-chondrites rather than L or LL chondrites (Weisberg et al., 2006). Nonetheless, the homogeneity of olivine compositions is similar to that of Bjurböle (L/LL4), suggesting that NWA 722 also is a type 4, indicating thermal metamorphism sufficient to cause equilibration in silicates, but not strong enough to recrystallize chondrule/matrix textures.

On the other hand, there is a significant Fe-Ni compositional difference between metal in the host and in the vein. Fe-Ni-rich metal grains from the host domain have compositions which correspond to either kamacite (low-Ni metal) or taenite (high-Ni metal), whereas Fe-Ni-metal compositions in the melt vein are intermediate between kamacite and taenite. The compositions of metal in the vein can be explained by quenching of the melt vein after thermal metamorphism on the parent body. Thus, shock injection of the vein occurred after thermal metamorphism. Textures suggest that the vein was emplaced as a viscous mixture of silicate grains and fluid in the vein interior, while more fluid sulfide and metallic liquids flowed near the vein margins.

Noble gas analyses of the four chondrites with different petrologic types show no correlation between petrologic type and concentration of heavy noble gases (including Q gases), suggesting that heavy gases are not lost during thermal metamorphism of ordinary chondrites. Furthermore, the host and vein of NWA 722 have similar ratios of trapped $^{36}Ar/^{132}Xe$ vs $^{84}Kr/^{132}Xe$, implying that the temperature in the vein material was not high enough to lose Q gases.

The cosmic ray exposure ages (T_{21}) of host and vein are 1.45 ± 0.090 Ma and 2.19 ± 0.099 Ma, respectively, showing that vein contains more cosmogenic ^{21}Ne . Considering that noble gases are incompatible, the melt vein could possess higher concentration of noble gases than the host if the melt vein quenched and noble gases did not escape from quenched glass. However, ratio of cosmogenic ^{21}Ne concentration to Q

gases in the melt vein is higher than the host, indicating that vein materials originated from the parent body surface where it had been enriched in cosmogenic noble gases.

Keywords: ordinary chondrite, impact melt vein, noble gas, chondrite metamorphism, cosmic ray exposure age