Cr isotope anomalies, their origins and implications

L. QIN[1]*, J. XIA[1], C. M. O'D ALEXANDER[2], L. R. NITTLER[2], R. W. CARLSON[2] AND J. WANG[2]

[1]CAS Key Laboratory of crust-mantle materials and Environment University of Science and Technology of China, 96 Jinzhai RD., Hefei, Anhui, 230026, China (lpqin@ustc.edu.cn)

[2]DTM, Carnegie Institution of Washington, 5241 Broad Branch Road, Washington, DC 20015, USA

With the emergence of high-precision isotopic data, isotopic anomalies have been reported for an increasing number of elements in bulk meteorites. Many of the isotopic anomalies are attributed to preservation of nucleosynthetic signatures. Studies of nucleosynthetic anomalies at the bulk meteorite scale can provide information not only on the stellar environment of solar system formation, but also on subsequent mixing processes in the proto-planetary disk. One of the consequences of the existence of nucleosynthetic anomalies is that they may hamper the use of several short-lived radioactive chronometers (e.g.^{146}Sm-^{142}Nd, ^{53}Mn-^{53}Cr), as these rely on the assumption that the solar system has homogeneous isotopic compositions for the daughter elements and for the abundance of the parent isotopes.

The well resolved difference in the ^{54}Cr anomaly among different chemical groups of meteorites has been extended to other neutron-rich nuclides of iron group elements, such as ^{50}Ti and ^{62}Ni. The extremely ^{54}Cr-rich nano-oxides isolated from Orgueil (CI) strongly indicate a Type II SNa origin. Thus, the variability in bulk ^{54}Cr/^{52}Cr between meteorite classes may reflect a heterogeneous distribution of the ^{54}Cr carrier in the solar nebula following a late supernova injection event. Because the ^{54}Cr-rich phases do not show a resolvable ^{53}Cr anomaly, the existence of such phases will not affect the use of the ^{53}Mn-^{53}Cr short-lived chronometer. A recent study found a large variation in Cr mass fractionation among meteorites from different chemical groups. Such fractionation could potentially affect the interpretation of the ^{54}Cr variability because the mass-dependent fractionation in nature is linear, but the use of the exponential law to correct for instrumental mass fractionation will cause residual mass fractionation effects on both ^{53}Cr/^{52}Cr and ^{54}Cr/^{52}Cr. This would also affect the interpretation of the bulk chondrite Mn-Cr isochron.