

Highly siderophile element evidence for early Solar System processes in ordinary chondrite components

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The highly siderophile elements (HSE=Re, Os, Ir, Ru, Pt and Pd) are all strongly partitioned into metal relative to silicate during melting, but may be fractionated from each other during melting of Fe-Ni metal. The volatilities of the HSE encompass the condensation temperatures of the earliest solids that formed in the Solar System (i.e., Al, Ti and Ca oxides, magnesian silicates and metal). Our objective is to use high precision and high sensitivity isotope dilution mass spectrometric analyses of the HSE to constrain the origins of some of the diverse components in two ordinary chondrites, Dhajala (H3.8) and Ochansk (H4).

Metal from both Dhajala and Ochansk contains about 80% of the HSE present in the bulk samples, with unfractionated HSE abundances, but wide variations in contents. These features likely resulted from the presence of HSE-rich carrier phases that may dominate the HSE budget in the metal. These suggested carrier phases formed in a reducing environment in which Pd was more refractory than Fe, and were incorporated into early-formed metal grains.

Nonmagnetic components from Dhajala and Ochansk consist of chondrules and matrix from which metal had been removed in the lab. The metal-free fractions have uniform but fractionated HSE whose abundances are >40 times those expected from metal-silicate equilibrium, with large depletions in Pd and lesser depletions in Re, Ru and Pt, relative to Os and Ir. Their compositions are consistent with microphases of either highly refractory condensates (similar to those in CAIs) or residues of high degrees of metal melting (as during chondrule formation) that were well-dispersed throughout the chondrules and matrix. The low Re/Os ratios suggest these microphases formed in a more oxidizing environment than the unfractionated HSE carriers in the metal.

These ordinary chondrites thus contain two distinct HSE-bearing components that formed separately and out of equilibrium with each other. Early sorting of these HSE carriers prior to chondrite accretion may provide an explanation for the disparate HSE ratios and ¹⁸⁷Os/¹⁸⁸Os ratios measured among the chondrite classes.

Rapid progression of kyanite-sillimanite type metamorphism in the Unazuki area, southwest Japan

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Geochronological constraints from metamorphic rocks provide important information for understanding crustal evolution as well as metamorphic processes. The Unazuki region, southwest Japan, which is one of crucial sites for deciphering the Permo-Triassic orogeny in East Asia, has experienced the kyanite-sillimanite type metamorphism characterized by a clockwise P-T path. Radiometric ages of the Unazuki schists, previously determined by Rb-Sr and K-Ar methods, are scattered from 248 Ma to 175 Ma primarily because of multi-phase metamorphism and deformation. In this study, *in situ* zircon U-Pb geochronology was applied to the schist and granite samples to discuss the timing and the duration of kyanite-sillimanite type, regional metamorphism.

Protoliths of the Unazuki schists are sedimentary and felsic volcanic rocks of late Carboniferous to early Permian age, based on the fossil evidence [1]. U-Pb data of quartzofeldspathic schist derived from felsic volcanics yield an eruption age of 258 ± 2 Ma, indicating that regional metamorphism occurred after 258 Ma. On the other hand, U-Pb age of a granite intruding the schist is 253 ± 1 Ma. The granite contains some xenoliths of the Unazuki schist, in which staurolite is replaced by andalusite and cordierite due to thermal flux from granitic magma [2]. Therefore, regional metamorphism occurred between 258 and 253 Ma, suggesting a rapid metamorphic progression. Further work is needed to confirm this rapidity of crustal-thickening process.

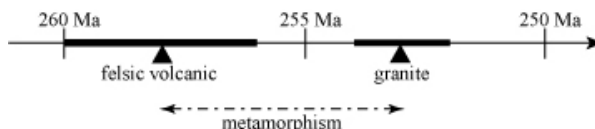


Figure: Age constraints from the Unazuki region.

[1] Hiroi (1978) *J. Geol. Soc. Japan* **84**, 521-530.

[2] Kitamura & Hiroi (1982) *Contrib. Mineral. Petrol.* **80**, 110-116.