The Chelyabinsk fall highly siderophile element abundance and $^{187}Os/^{188}Os$ composition and comparison with ordinary and carbonaceous chondrites

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Introduction: The Chelyabinsk asteroidal airburst on February 15, 2013 has garnered significant attention, with the meteorites that fell being equilibrated LL4-5 ordinary chondrite material (e.g., [1, 2]). Here we report new ^{187}Re-^{187}Os and highly siderophile element (HSE: Os, Ir, Ru, Pt, Pd, Re) abundances, along with complementary major- and trace-element abundance data, for ordinary chondrites Chelyabinsk, Kunashak (L6 fall, Russia, June 11, 1949), Richardton (H5 fall, Dakota, 1918) and Peace River (L6 fall, Alberta, March 31, 1963) and compare them with carbonaceous chondrite falls Allende (CV3, Mexico, February 9, 1969) and Murchison (CM2, Australia, September 28, 1969).

Methods: Samples were analyzed at the *Scripps Isotope Geochemistry Laboratory* for major, trace and HSE abundances and $^{187}Os/^{188}Os$ using methods outlined previously (c.f., [3]).

Results: The new HSE abundance and $^{187}Os/^{188}Os$ ratios for two different portions of Allende and Murchison, respectively are consistent with previous results [4, 5]. Chelyabinsk has HSE abundances similar to CI-chondrite Orgueil, while HSE abundances between the ordinary and carbonaceous chondrites vary by a factor of two and partially reflect heterogeneity in the small sample aliquants (mass = 20-101 mg). Relative HSE abundances vary between chondrite samples, with Chelyabinsk (LL4-5) having higher Pd/Ir ratios than Peace River, Kunashak (L6) or Richardton (H5). The measured $^{187}Os/^{188}Os$ composition of two fragments of Chelyabinsk, one with (0.1284) and the other without fusion crust (0.1253) are distinguishable and are consistent with measured $^{187}Os/^{188}Os$ ratios for the other ordinary chondrites (0.1257-0.1284). Re/Os ratios for Murchison and Allende are approximately 5% lower than for the ordinary chondrites, with the exception of one Murchison fragment, which has unsupported Re (Re/Os >2, but measured $^{187}Os/^{188}Os$ of 0.1248), indicating recent terrestrial contamination. With the exception of this Murchison sample, the measured chondrites lie along the 4.558 Ga IIIA Iron isochron, with limited scatter.

Discussion: Chelyabinsk shares many similarities with other equilibrated low iron ordinary chondrites (e.g., Semarkona, Benguerir) which tend to have lower Pd and absolute HSE concentrations than less equilibrated, high iron ordinary chondrites (e.g., Richardton). Metamorphism does not appear to have affected the ^{187}Re-^{187}Os systematics of Chelyabinsk which is consistent with limited disturbance since formation. Collectively, the new data for ordinary and carbonaceous chondrites reflect distinct conditions of formation for major chondrite classes and the role of metal/sulphide separation during early Solar System formation.

References: [1] Liu, Y. et al. 2013. *Meteoritics and Planetary Science*, **48** (S1), A225-A225. [2] Taylor, L.A. et al. 2014. *Lunar and Planetary Institute Science Conference Abstracts*, **45**, 2346. [3] Day, J.M.D. et al. (2012) *Nature Geoscience*, **5**, 614-617. [4] Horan, M.F. et al. 2003. *Chemical Geology*, **196**, 5-20. [5] Fischer-Godde M. et al. 2010. *Geochimica et Cosmochimica Acta*, **74**, 356-379.