NATURE OF EARTH

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Introduction: The nature of planetary surfaces, e.g. Moon, Mars, Mercury, and Earth, attest to the importance of impact as a geological process in the context of solar system and planetary evolution. Understanding the origin of solid planets (core, mantle and crust) it is important to know relative abundances of refractory highly siderophile elements (Os, Ir, Ru, Rh) in silicate mantle and crust of planets. Osmium and Ir are abundant in most meteorites but depleted in crustal rocks (low target/meteorite ratios) and thus the most reliable elements for projectile identification. Chromium isotopic studies (excepting carbonaceous chondrites [1]), Os isotopic studies and estimates of Au/(Os, Ir, Ru, Rh) ratios are not helpful in identifying the meteoritic types of impactors on Earth.

Target rocks: However, target/meteorite ratios are high if target rocks consist of mantle rocks. In such cases Os, Ir, Ru, and Rh element contents are enriched in impactites due to relatively high abundances (ng/g level) in target rocks to make the identification of projectile types difficult (e.g., Gardnos impact structure, Norway [2]). Ruthenium/Ir is the most reliable key ratio that rules out Earth primitive upper mantle (PUM) derived refractory highly siderophile element components in impactites. Ruthenium/Ir of the Earth mantle is 2.0 ± 0.1 and thus signify-cantly above chondritic ratios varying from 1.4 to 1.6 [3,4].

Earth mantle: On Earth Rh/Ir, Ru/Ir, Pd/Ir, and Pt/Os derived from PUM match the ratios of group IV irons with fractionated trace element patterns. The question raise if HSE in mantle rocks are added to the accreting Earth by a late bombardment of pre-differentiated objects or the cores of these objects (magmatic iron meteorites as remnants of the first planetesimals) or some unsampled inner solar system materials from the Mercury-Venus formation region, not sampled through meteorite collections [5].

Earth crust: The PGE and Ni systematics of the upper continental crust (UCC) closely resembles group IIIAB iron meteorites with highly fractionated refractory trace element patterns, pallasites, and the evolved suite of Martian meteorites (representing Martian crust).

Projectiles of impact craters: To date, about 20 iron meteorites and about 20 chondrites have been identified as projectiles of 176 known small and large impact craters on Earth. The projectiles for 136 impact craters are still unknown. Melt rocks from many impact craters on Earth (e.g., Rochechouart [6], Sääksjärvi [7], Dellen, Mien, Boltysh) are depleted in Os relatively to Ir and Ru. Subchondritic Os/Ir (about 3 times lower than Os/Ir in the metal phase of non-magmatic irons), fractionated Ru/Ir and Rh/Os ratios are strong arguments to conclude that about 50% of the currently identified iron projectiles from terrestrial impact craters are related to magmatic irons.

References: [1] Koeberl et al. (2007) Earth and Planetary Science Letters 256, 534–546 [2] Goderis et al. (2009) Chemical Geology 258, 145-156. [3] Schmidt (2004) Meteorit. Planet. Sci. 39, 1995–2007. [4] Becker et al. (2006) Geochimica et Cosmochimica Acta 70, 4528–4550. [5] Schmidt (2009) Workshop on Planet Formation and Evolution: The Solar System and Extrasolar Planets, Tübingen, Germany. [6] Janssens et al. (1977) Journal of Geophysical Research 82:750-758. [7] Schmidt et al. (1997) Geochimica et Cosmochimica Acta 61, 2977–2987.