RE-INVESTIGATION OF SPECIFIC IMPACTOR COMPOSITIONS FROM TERRESTRIAL IMPACT CRATERS BY THE DIAGNOSTIC ELEMENT RATIOS RU/RH AND IR/RH

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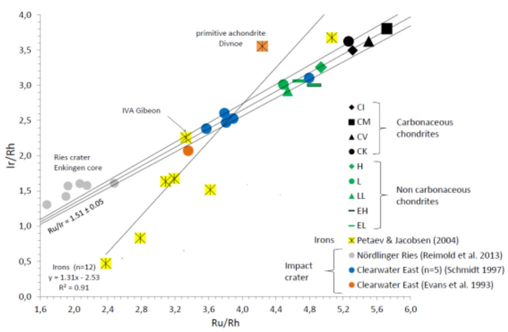
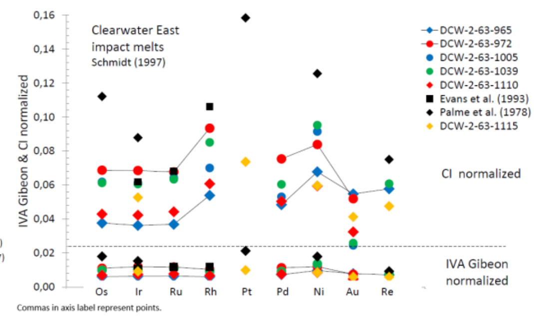
Introduction: Studying the nature of impactors is crucial to understand the characteristics and origin of the material delivered to planets. To date, there are 190 confirmed impact structures on Earth. Utility elements to identify specific impactor compositions in melts from impact craters are refractory elements Os, Ru, Ir, Rh (PGE) and Ni. PGE are abundant in most meteorites but depleted in crustal rocks. For Ir and Os, there is a difference of four orders of magnitude, and Rh three orders of magnitude between their meteoritic and crustal abundances. Cr for example is only 30times more abundant in meteorites compared to Earth's upper crust. The determination of PGE in melt samples is a difficult challenge because of low contents in the pg/g to ng/g range. There are still few data on Rh in impact melt samples, mainly because of difficulties with analysis. Mass element ratios on Ru/Rh and Ir/Rh from iron meteorites show that re-investigation on specific impactor compositions shed light in controversial identifications.

Clearwater East, Brent, Wanapitei Impact Craters, Canada: Clearwater East has highest PGE contents in melt samples from any terrestrial impact crater. Since the earlier studies by Palme and co-workers 1978 a chondrite has been suggested as impactor based on PGE, Ni, Cr [1-6] and Cr isotopes [7]. However, LA-ICP-MS data on PGE including Ni from iron meteorites [8] allows comparing these data with ICP-MS [4] and neutron activation data from Clearwater East melt samples [5]. Surprisingly, element ratios of iron meteorite IVA Gibeon (see figures) agree with Clearwater East samples. The authors [1-6] reached their conclusions without the benefit of Rh from iron meteorites. Up to ~1.2 wt.% of a IVA Gibeon-like component could be contained in the melt samples. However, a member of an unidentified chondrite group as projectile type, which is not known from meteorite collections, could also be possible (Palme 2019, pers. communication) - similar problem with excess mantle PGE. Possibly ε^{100}Ru data could solve the mystery in the future. For Brent and Wanapitei craters [4], iron bolides (e.g., IA, IVA, IIC) were identified by Ru/Rh and Ir/Rh ratios.





Rochechouart, France: Rochechouart samples [9] and melt rocks from Apollo 16 landing site[10] match Ru/Rh and Ir/Rh from IA, IIC and IVA irons. An ordinary chondrite is favoured by [7] based on Cr isotopic composition.

Hiawatha, Greenland: A "highly fractionated iron asteroid" has been suggested for the 31-kilometer-wide, circular bedrock depression beneath Hiawatha Glacier in northwest Greenland [11]. Diagnostic element ratios of a mixture of upper crust and an iron meteorite would not match element ratios determined in glaciofluvial sediments.

Popigai, Siberia: [12] reported "…Ru/Rh vs. Pt/Pd or Ru/Rh vs. Pd/Ir, the Popigai impactor is clearly identified as an ordinary chondrite and most likely L-chondrite". However, EL chondrites or even iron meteorites match diagnostic Ru/Rh and Ir/Rh ratios from the late Eocene Popigai impact structure.

Conclusion: Most diagnostic element ratios for specific impactor compositions are Ir/Rh, Ru/Rh and Os/Ir [13]. High quality data especially of Rh might answer fundamental questions of cosmochemistry [14] and contribute to our understanding of processes involved in the formation and unique composition of planetary bodies.

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