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˜3.45 Ga meteorite fragments suggest the Earth is poorer in Fe and Ni and richer in Ti and V than the current model

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Previous researchers have estimated elemental abundances of the solar system and of the Earth mostly from the compositions of carbonaceous chondrites and other meteorites that have fallen recently on the Earth. The modern metal-rich meteorites are comprised of Fe-Ni alloys (Ni contents 5-20 wt%) with minor Co.

In the ABDP #1 drill core from Marble Bar, Western Australia, we have discovered numerous fragments (up to ˜2 mm in size and often >5 volume % of the rock) of metal-rich meteorites throughout a ˜40 m section of the ˜3.45 Ga Apex Basalt that overlies the thick (up to ˜200 m) Marble Bar Cher/Jasper (MBC) beds. The meteorite fragments occur together with impact spherules made of the melted volcanic rocks, angular fragments of the MBC, and the tsunami-disturbed MBC beds. The underlying MBC beds exhibit shocked- and brecciated textures and host numerous quartz veinlets that intruded along the impact-induced fractures. These features, and the areal extents of the Apex Basalt (˜3-4 km thick), suggest that the meteorite fragments are part of a large (˜10-20 km diameter?) bolide that created a large (˜150 km diameter?) impact crater on a deep (>2,000m) ocean floor, and that the Apex Basalt was the crater-fill basalt magma that was generated by the impact-induced, rapid decompression-melting of the mantle peridotite.

To our surprise, the meteorite fragments in the Apex Basalt have entirely different chemistries than the modern iron meteorites. They are mostly made of oxidized forms of Ti-Fe (Ti Fe) alloys with various amounts of Si, Al, V, Cr, and Cu as solid solutions; but Ni is very low (<0.1 wt%). Oxidation of the metal alloys probably occurred through reactions with the atmospheric O_2 in the "impact clouds". Thermodynamic data suggest that the original metal-alloys in our meteorites were formed in the core of a planet with more reducing conditions than the cores of the planets that formed the modern iron meteorites. Our findings suggest that: (1) The asteroids that formed the early Earth may have had very different compositions than the meteorites that have fallen recently on the Earth--consequently, the early-Earth materials may have come from different parts of the asteroid belt than the modern meteorites; (2) The age of the Earth may be older (or younger) than 4.54 Ga, an age which was determined using the modern meteorites; (3) Elemental abundances of the solar system and of the Earth are possibly much higher in Ti and V, and lower in Fe and Ni, than those estimated by previous researchers. This would explain why the previously-estimated solar abundances for Ti and V are much lower (whereas those for Fe and Ni are much higher) than those estimated using the Oddo Harkin's Rule of nucleosynthesis; and (4) The Earth's core is possibly made of Ti-Fe-Si-Al alloys, rather than of Fe-Ni alloys. This would explain why the density of the core is much lighter than the densities of Fe-Ni alloys. It would also explain why the Moon, which formed at ˜4.40 Ga, is characterized by Ti-rich basalts.

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