# Tracing volatile accretion to Earth using Cr isotopes

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It is well known that Earth is volatile depleted relative to chondrites [1]. One possible explanation is that Earth lost its volatiles during accretion. However, the terrestrial composition lies on the carbonaceous chondrite (CC) volatile depletion trend [2]. This suggests that Earth inherited its volatile depletion from precursor material, which had already lost moderately and highly volatile elements in the solar nebula prior to planet formation. However, it is debated when, or if, volatile elements were added back to Earth. The terrestrial elemental and radiogenic isotope compositions can be broadly reproduced by assuming the dominant early material lies on the CC volatile depletion trend, but is more depleted than CV chondrites. This was followed by more volatile-rich material, likely originating from outside the snow line, approximated by CI chondrites [e.g. 3]. This is consistent with dynamical models [4]. Interestingly, recent studies have suggested that the last material added to Earth – the late veneer – had its source in the inner solar system and included enstatite chondrite (EC) type material [5, 6].

In this study, we use the Mn-Cr system to further constrain the timing and mechanism of terrestrial volatile delivery. Manganese-53 decays to $^{53}$Cr with a half-life of 3.7 Ma implying that changes in the Mn/Cr ratio of materials during the first ~18 Ma of the solar system can be dated. Also, Mn is more volatile than Cr and thus the $^{53}$Cr/$^{52}$Cr ratio of material reflects volatile enrichment integrated over the first few Ma years of the solar system.

We present new, ultra-high precision, $\varepsilon^{53}$Cr data for Archean and modern samples. Preliminary results show that on average terrestrial materials must have been volatile depleted early rather than during accretion. We find that the Cr isotope compositions of the Archean and modern mantles are incompatible with addition of relatively volatile enriched material (e.g. Mars or EC type) during the moon forming impact. We will present terrestrial accretion models, which account for Earth's Cr isotope composition during accretion and constraints from other elements (e.g. Pd-Ag and Hf-W).

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