

THE IIAB IRON METEORITES: FORMATION AND RELATION TO OTHER METEORITE GROUPS.

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Introduction: The IIAB iron meteorites are one of the largest iron meteorite groups that formed by fractional crystallization [1]. Iron meteorites formed over a range of oxygen fugacities (fO_2) [2], most formed relatively reduced at $\sim IW-4$ to -2.5 (IABs), where IW = iron-wüstite buffer, to relatively oxidized at $IW-1$ (IVBs) [2,3]. While the IIABs contain reduced mineral phases (daubréelite [1]), the fO_2 for IIABs is poorly constrained. The fO_2 of iron meteorites may have become more reducing during cooling, with oxidized phases (i.e., chromite) forming at higher temperatures and daubréelite forming at lower temperatures [4]. The O- and Cr-isotope compositions of silicates and chromite in meteorites, including iron meteorites, can determine potential genetic links to other meteorites and constrain if a meteorite is from the non-carbonaceous (NC) or carbonaceous (CC) group [e.g., 5–8]. Iron meteorite groups have been identified as being in the NC or CC group using Mo [9] and Ni [10] isotope compositions of their metallic component. Numerous iron meteorites contain minor amounts of silicates and oxides [e.g., 11], but most have not been analyzed for their Cr or Ti isotope compositions, with some exceptions (e.g., IIIABs [6,7], a IIG, and a IIAB [7]). We analyzed the compositions of silicates and chromite in six IIAB iron meteorites to investigate the relationship between IIABs and known meteorite groups, the fO_2 of IIABs, and the origin of chromite in the IIABs.

Samples and Analytical Procedures: We identified chromite in six IIABs: Coahuila, Gressk, Kopjes Vlei, Old Woman, Sandia Mountains, and Sikhote-Alin. Electron microprobe analyses (EPMA) were conducted at the Smithsonian Institution, University of Arizona, and Arizona State University (ASU). Chromite grains were mechanically extracted from Coahuila, Sandia Mountains, and Sikhote-Alin. Chromite was analyzed for bulk O-isotopes via laser fluorination at the Open University [e.g., 12] and bulk Cr-isotopes via inductively coupled plasma mass spectrometry at ASU [e.g., 8]. Daubréelite was extracted from North Chile for analysis. Bulk extraction for O-isotope analyses via laser fluorination was not possible for Gressk, Kopjes Vlei, and Old Woman. Instead, *in situ* O-isotope analyses via secondary ion mass spectrometry of chromite in Kopjes Vlei and Old Woman were determined at the University of Hawai'i (UH) to constrain their O-isotope compositions; *in situ* analyses of chromite in Sandia Mountains and Sikhote-Alin were also obtained for comparison to bulk O-isotope analyses. Chromite in Sikhote-Alin was found in association with olivine and pyroxene, which was also analyzed via EPMA and for *in situ* O-isotope compositions at UH. The equilibration temperature and fO_2 for olivine-spinel in Sikhote-Alin was determined following [3].

Results and Discussion: The bulk chromite O-isotope (mean $\Delta^{17}O \sim -1.1 \pm 0.1\text{‰}$ [$\pm 2\sigma$]) and Cr-isotope (mean $\varepsilon^{54}Cr \sim -0.97 \pm 0.22$ [$\pm 2\sigma$]) compositions obtained here indicate IIABs are NCs that overlap with the ureilite and acapulcoite/lodranite field. This is consistent with the recent work of [7], and with the assignment of the IIABs to the NCs [9,10]. The $\varepsilon^{54}Cr$ composition of North Chile daubréelite is similar to that of IIAB chromite. The *in situ* chromite $\Delta^{17}O$ ‰ compositions are indistinguishable from those of bulk chromite, supporting the robustness of $\Delta^{17}O$ ‰ data from both techniques. In Sikhote-Alin, the *in situ* $\Delta^{17}O$ ‰ composition of olivine is consistent with chromite, indicating they are cogenetic. Chromite is only surrounded by Fe,Ni metal in Kopjes Vlei, Old Woman, and Sandia Mountains, but is also associated with sulfides in Coahuila, Gressk, and Sikhote-Alin. Chromite in Gressk is associated with troilite and daubréelite, and in Sikhote-Alin it is associated with troilite, schreibersite, silica, kosmochlor, pyroxene, and olivine. Olivine (Fa₆) and low-Ca pyroxene (Fs₉₋₁₄) in Sikhote-Alin are most like acapulcoites (data from [3,13]). The Fe/(Fe+Mg) ratio (range 1–0.62) of chromite in each IIAB is correlated with their bulk Au content [1], a proxy for crystallization sequence [1,4], indicating that crystallization order influenced chromite compositions. Sikhote-Alin was the last IIAB studied here to crystallize, and it has the lowest chromite Fe/(Fe+Mg) ratio. The fO_2 of Sikhote-Alin is calculated here to be $IW-2.7$, similar to IABs [2] and acapulcoites [3], indicating the IIABs are more reduced than the IVBs. The origin and fO_2 history of IIABs is complex and will be discussed in detail.

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