The Chemical Composition of the Allende Meteorite: Primary Nebular Variations and Secondary Alteration

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Carbonaceous chondrites are the most primitive objects in the solar system. Yet, many of them have been modified by secondary alteration on a parent planet. In order to better understand the extent of the primary nebular inhomogeneities and the effect of secondary alteration we have begun a systematic study of the chemical homogeneity of the CV-chondrite Allende. We determined the chemical composition of 39 bulk samples from a single 4 mm thick piece of Allende, covering an area of 22.5 cm^2 and with a mass of 30 grams. The slice was cut into 39 equally sized pieces with an average sample weight of 600 mg. This mass corresponds to a cube of 6 mm length. Each individual sample was powdered. Aliquots of 120 mg were taken for XRF analyses. Analytical procedures were similar to those applied by Wolf and Palme (2001).

One sample was dominated by a CAI and another by a dark inclusion. Both were excluded from further considerations. The average major element composition is very similar to that obtained in earlier studies by Klerner and Palme (1999). Si- and Mg-contents were 16.01 % and 14.94 % with standard deviations of 0.94 % and 1.35 %, barely above analytical uncertainty. Concentrations of Al 1.59 (s.d. 17%) and Ca 1.71 % (s.d. 9 %) are somewhat more variable. The concentration of Fe (total) is with 23.65 % and a standard deviation of 2.6% very constant, despite large variations in the FeO-contents of individual components (chondrules, matrix).

The small standard deviations for Mg, Si and Fe in our study and the excellent agreement with results from earlier studies reflect the very homogenous composition of bulk Allende even on a mm to cm-scale. On a scale of about 5 mm, Allende is essentially isochemical, except for the presence of very large chondrules, cm-sized Ca, Al-rich inclusions (CAIs) and dark inclusions (DI) would cause larger deviations. These objects are rare and they are not end-members of a continuous size distribution, they are clearly exotic. We conclude that large cm-sized CAIs contribute less than 10 % to the bulk Al content of Allende. If smaller CAIs are responsible for the range in Al-contents, about 3 % of CAIs would be required, in agreement with new estimates for CAIs in CV-chondrites (2.98 % by area) by Hezel et al. (2008).

References:

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