BULK FLUORINE AND CHLORINE CONTENTS OF CHONDRITIC METEORITES.

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Introduction: An understanding of bulk halogen abundances of chondrites is of fundamental importance to interpreting geochemical behavior within the mantles of asteroids and the terrestrial planets. Fluorine and chlorine are of particular importance because they are present in high enough abundance to have a significant effect on properties such as melt and fluid chemistry in planetary interiors. Variability in bulk halogen contents among chondrite groups means that the choice of chondritic material used to model the geochemical evolution of a planetesimal or planet can be critical. While chlorine abundances in chondrites are fairly well constrained, fluorine abundances are poorly constrained for most chondrite groups [1-3]. Here, we assess the available chondrite abundance values for these elements, and offer a reappraisal of bulk F abundances in ordinary, and potentially enstatite, chondrites.

Bulk chondrite F and Cl data from the literature: Chlorine abundances have been reported for many different chondrites, in studies using several different analytical techniques. Values obtained from different methods are mostly in the range of hundreds of ppm [1-3]. Figure 1 shows bulk chondrite F and Cl data, for chondrite falls, from studies in which both elements were measured in the same chondrite (see [3]). Mean chlorine abundances vary widely among chondrite groups, up to ~700 ppm in CI chondrites. In contrast, measurements of fluorine abundances are limited and studies using different techniques are not in agreement. This makes it difficult to interpret the variability in bulk fluorine contents among different chondrite groups. In particular, much of the fluorine data are from [4] who obtained high F values, 100-300 ppm. [5] argued that these data are incorrect. Compilations such as those of [1,2] have applied an inconsistent approach towards selecting fluorine abundances for different chondrite groups. For C chondrites, high-F values are not included in the recommended values for each group, and F/Cl ratios are similar to CI-chondrite and solar ratios (Fig. 1). However, for O and E chondrites, both [1] and [2] include some of the high-F data in their recommended values (Fig. 1).

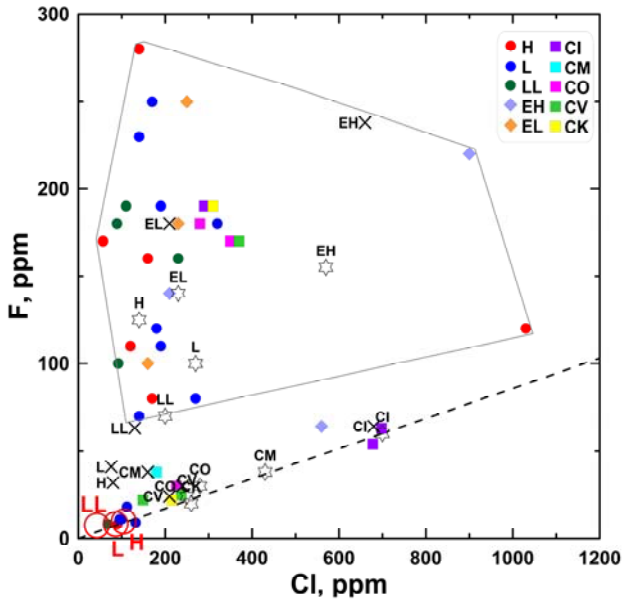

Figure 1: F and Cl contents in chondrite falls, from studies where both elements were measured [3]. Bulk chondrite values are shown as open stars [1] and crosses [2]. Area outlined by grey line shows measurements with high F [4]. Large red circles are values calculated from apatite modal abundances and compositions in OC [6-8].

Reappraisal of bulk chondrite F abundances in O and E chondrites: Chlorine is a major element in sodalite in CV chondrites, apatite in ordinary chondrites and chondrule glass as well as djerfisherite in enstatite chondrites [e.g. 3]. For OCs, bulk chlorine contents are consistent with chlorine abundances determined from modal abundances and compositions of apatite [6-8], which supports the recommended bulk compositions of [1,2]. For OCs, F is typically a minor element in apatite, present at sufficient levels (0.5-1 wt%) to measure by EPMA and SIMS [6-8]. Bulk F contents determined from modal abundances and compositions of apatite give significantly lower bulk F values than values given by [1,2]. Calculated values are consistent with a CI-chondrite F/Cl ratio and measurements by [5] (Fig. 1). We suggest that the correct bulk F contents of OCs are around 10 ppm [5,6-8]. We further suggest that bulk F values for E chondrites given by compilations such as [1,2] are also too high because they rely heavily on the high-F data. More accurate values may be closer to a CI ratio of F/Cl, i.e. in the range of 20 and 50 ppm for EL and EH groups respectively, assuming the measured Cl contents are accurate.

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