Fig. 1   Left:; Isotopic composition of the CO_2 obtained by stepwise combustion of a bulk sample of the CM Cold Bokkeveld, plotted against temperature. Bottom: Yields of each step; the box in the top-right corner is an enlargement ($\times 10$) for high temperatures.

Halbout, J. *et al.*, 1985. Carbon isotopes in bulk carbonaceous chondrites. *Lunar Planet. Sci. Conf. XVI*, 314-315.

RELATIONSHIP BETWEEN PETROGRAPHY AND SILICON ISOTOPES IN AL-LENDE COARSE-GRAINED INCLUSIONS

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Silicon isotopic compositions of a suite of Allende inclusions, the F-series, lie on a mass fractionation line, ranging in $\delta^{30}Si$ from $+4.8$ to $-3.5\permil$ (Clayton *et al.*, 1985). These inclusions could not have formed by single-stage condensation from an isotopically homogeneous gas, as the observed range of $\delta^{30}Si$ is much greater than expected from Rayleigh fractionation during high-temperature condensation of only the first 5% of nebular silicon, $< 1\permil$ (Clayton *et al.*, 1985).

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We examined polished thin sections of all 15 F-series inclusions by optical and SEM petrography. Among them are two amoeboid olivine aggregates, two fine-grained inclusions and one coarse-grained, olivine-rich inclusion. Condensation of most of the silicates in the latter inclusions would not be expected at such high temperatures as those in coarse-grained, Ca-, Al-rich inclusions and could conceivably have occurred after condensation of many tens of % of silicon. Such inclusions might thus be expected to have $\delta^{30}Si$ values that are 2-3‰ more negative than those of coarse-grained inclusions, assuming Rayleigh fractionation. Although this is found, the remaining inclusions still occupy the entire observed range of $\delta^{30}Si$.

Variable amounts of fine-grained, secondary alteration products occur in the remaining inclusions. If SiO_2 added during alteration (MacPherson *et al.*, 1981) had a different Si isotopic composition from that of primary phases, formation of different amounts of alteration products in different inclusions might be a possible explanation of the large range of $\delta^{30}Si$ values (Molini-Velsko, 1983). To test this, we determined point-count modes of the ten remaining F-series inclusions and four other coarse-grained ones with known $\delta^{30}Si$. Combining these with energy dispersive analyses of primary and secondary phases, we determined P, the proportion of the total SiO_2 in each inclusion that is present in secondary phases.

Three Type B1 inclusions show a wide range of $\delta^{30}Si$, +4.8 to +1.7, despite little variation in P, .19 to .25. Similarly, two B2's vary from +4.1 to +.3 in $\delta^{30}Si$ but have the same P, .44. Two compact Type A's have $\delta^{30}Si$ of +2.8 and +2.3 and P of .38 and .32, resp. Three fluffy Type A's have much lower $\delta^{30}Si$, +.7, −.1 and −2.8, and much higher P, .78, .97 and .97, resp. Two unusual, spinel-rich, coarse-grained inclusions also have very low $\delta^{30}Si$, −1.8 and −3.5, and very high P, .92 and .99, resp.

For each inclusion type (B1, B2, fluffy A), the relatively large range in $\delta^{30}Si$ cannot be explained by Rayleigh fractionation during single-stage condensation from a homogeneous gas. No significant correlation is seen between $\delta^{30}Si$ and P within any inclusion type. If alteration products in all inclusions of a given type have the same ratio of indigenous to added Si, the large range of $\delta^{30}Si$ within each type cannot be explained by formation of different amounts of alteration products with isotopically-distinct Si. Type B inclusions as a group, however, are significantly higher in $\delta^{30}Si$ and much lower in P than fluffy Type A's or the spinel-rich inclusions, taken as groups. $\delta^{30}Si$ values for Type B's, fluffy Type A's; and spinel-rich inclusions studied here are +2.8 ± .6, −.76 ± .87, −2.7 ± .6, resp., and values of P are .31 ± .04, .91 ± .05, .96 ± .02, resp. We do not yet know if the much higher P for the latter two inclusion types is responsible for their having lower $\delta^{30}Si$ than Type B's or if $\delta^{30}Si$ differences reflect primary processes.

Clayton, R.N. *et al.*, 1985. *Protostars & Planets, II, in press.*
MacPherson, G.J. *et al.*, 1981. *Proc. 12th LPSC*, 1079.
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MAJOR, MINOR AND TRACE ELEMENT DISTRIBUTION IN MINERALS OF A COARSE GRAINED TYPE B INCLUSION FROM LEOVILLE

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Zoning patterns and, more generally, the fine-scale distribution of elements in minerals, are important clues to understand the mode of formation and history of planetary matter, and this is even more true of Ca-Al rich inclusions of carbonaceous chondrites, the origin of which is still a matter of considerable debate. So far, information on zoning patterns has