

SHORT COMMUNICATIONS

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A zoned perovskite-bearing chondrule from the Lancé meteorite

DURING the examination of a polished thin section of the carbonaceous chondrite Lancé an unusual chondrule was observed. It was thought to be spinel with a gehlenite rim, such as has been first figured by Fredriksson and Reid (1967) from the Sharps olivine-hypersthene chondrite, however, electron-microprobe study revealed an unexpected and previously unreported mineralogy and structure.

A general description of Lancé has been given by Michel-Lévy (1969). The chondrule in question is set in a fine-grained almost opaque groundmass, among the usual, mainly larger, olivine, pyroxene, and devitrified glass chondrules. It is almost circular in section with a diameter of 0.1 mm and can be seen under the microscope to contain two well-defined zones. The inner zone is isotropic with high relief. The outer zone is finely crystalline, shows some myrmekitic intergrowths, and seems to be composed mainly of a mineral or minerals of low to moderate birefringence and relief.

An electron microphoto and electron-microprobe scanning pictures for Ti, Ca, Al, and Mg (fig. 1) reveal that the core is composed of two distinct minerals having the composition of perovskite and spinel. The spinel forms the outer envelope of the core as well as being in the form of rounded fingers that interpenetrate the inner perovskite in a complex way.

Electron-probe microanalyses of the perovskite and spinel were made with the Cambridge Instruments Geoscan using a 15 kV accelerating voltage. Standards were wollastonite (Ca), topaz (Al), analysed olivine from St. John's Island (Mg and Fe), and pure Ti metal. The average element percentages were corrected using the method described and tested by Sweatman and Long (1969).

An average of twelve spot determinations on perovskite gave: TiO_2 55.8 %, Al_2O_3 1.52 %, FeO tr., MgO 0.87 %, CaO 40.2 %, sum 98.4 %. Rare earth elements were not found. An average of eight determinations on spinel gave: TiO_2 3.34 %, Al_2O_3 66.4 %, total Fe as FeO 1.35 %, MgO 25.8 %, CaO 0.04 %, sum 96.9 %. The perovskite analysis, after correction and on the assumption that the 1.25 % aluminium present was due to spinel, gave a formula, calculated on the basis of three oxygens, of $\text{Ca}_{1.01}\text{Mg}_{0.01}\text{Ti}_{0.99}\text{O}_{3.00}$. The spinel analysis, after correction on the assumption that the 0.04 % calcium present was due to perovskite, gave a formula, calculated on the basis of 32 oxygens, of $(\text{Mg}_{7.6}\text{Fe}_{0.2})(\text{Al}_{7.7}\text{Ti}_{0.2})_2\text{O}_{32}$.

The outer zone in thin section can be seen to consist of three vaguely defined sub-zones. This is also seen in the microprobe traces (fig. 2): Calcium reaches its peak in

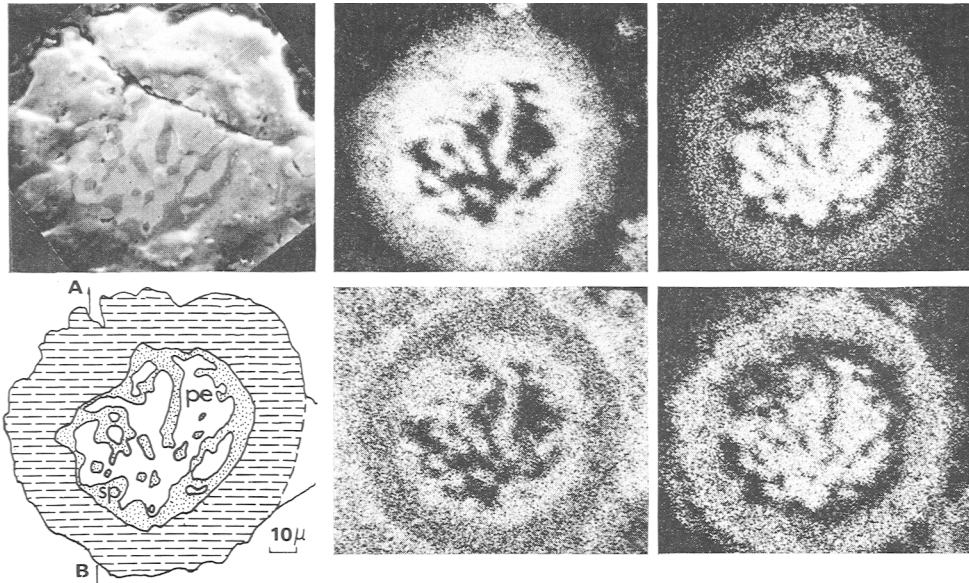


FIG. 1. Stereoscan picture of chondrule (top left), together with (bottom left) diagrammatic representation of phases present (pe — perovskite, sp — spinel). X-ray scanning pictures for Al (top centre), Mg (bottom centre), Ti (top right), and Ca (bottom right).

the centre of the zone and titanium in the inner part of the zone, while aluminium builds up towards the inner part of the zone. Electron-probe microanalysis did not give consistent counts throughout the outer zone, suggesting that the zone was polymineralic; however, an average of eight spot analyses obtained from the centre of the zone, which incidentally took the best polish, gave: SiO_2 38.6%, TiO_2 8.45%, Al_2O_3 16.0%, MgO 11.0%, CaO 23.8%, sum 97.9%. This analysis could be interpreted in a variety of ways, as a highly unusual fassaïtic diopside or as a mixture of diopside and anorthite or melilite or both with corundum and a titanium mineral, or as a number of less likely mixtures. It is, however, of particular interest that when the analysis is plotted on the 10% MgO plane of the system $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ (Prince, 1954) it falls between two close low-temperature piercing points: diopside-anorthite-melilite and spinel-anorthite-melilite. The possibility that the outer zone represents devitrified glass is thus to some extent supported.

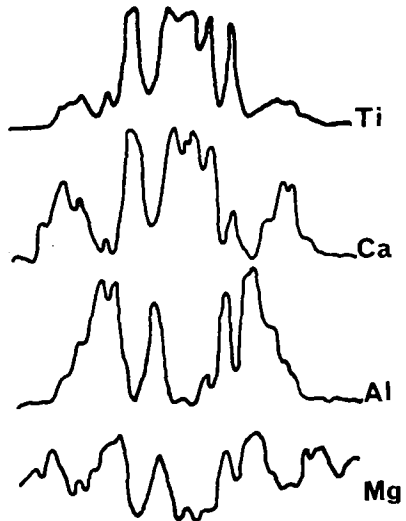


FIG. 2. Elemental scanning traces along line A-B of fig. 1.

It is tempting to speculate on the possible origin of such a structure, but in view of the complexity of the history of carbonaceous chondrites it is probably also of little value. What may be worth remembering is that the mineralogy has similarities to that of certain achondrite fragments recorded in Leoville by Keil, Huss, and Wiik (1969), and the zoning is reminiscent of gehlenite-spinel zones found round calcium-rich achondrite fragments in Vigarano (Michel-Lévy, 1968).

*Department of Mineralogy
British Museum (Natural History)
Cromwell Road, London, S.W. 7*

MICHAEL J. FROST
R. F. SYMES

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Chemical composition of the upper mantle

HARRIS, Reay, and White (1967) attempted to establish a quantitative chemical composition of the upper mantle, using published analyses of olivine nodules from basalts, garnet-peridotite nodules from kimberlites, and samples of tectonically emplaced ultramafic masses. Independent estimates of undepleted mantle composition derived from each group of rocks were shown to approach a common value. The number of reliable analyses available to Harris *et al.* was insufficient for making any definite conclusion regarding the possible heterogeneity of the upper mantle. The present contribution is an interim report on an analytical programme attempting to make good this deficiency. It is the direct continuation of the earlier authors' work.

One hundred and fifty spinel-lherzolite xenoliths from the basaltic volcanics of five widely spaced localities in the Massif Central, France, forty from the basaltic maar volcano, Dreiser Weiher, in the Eifel, Germany (Frechen, 1963), and fifteen peridotite xenoliths from the Bultfontein kimberlite pipe, South Africa, have been chemically analysed. The South African samples were made available by Dr. J. B. Dawson, University of St. Andrews, to whom we are most grateful. Each sample has been analysed for SiO₂, Al₂O₃, Cr₂O₃, total iron, NiO, MnO, MgO, and CaO by X-ray