AN UNUSUAL BARRED OLIVINE CHONDRULE IN SPINEL TROCTOLITE 62295,

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Lunar rock 62295 contains a few percent lithic debris (1) and xenocrysts (2, 3) of controversial origin. Although the rock is small (251 g), rather gross differences exist between the various sections, particularly in the nature of these xenoliths or xenocrysts. Olivine (in part shocked?), plagioclase, spinel, and metal are among the possible xenocrysts. In addition, sharply euhedral, in part skeletal, phenocrysts (4) of normally zoned olivine (Fo 80-95) are present. We describe here a barred olivine chondrule (possibly a xenolith), with unusual zoning, that differs from all other xenoliths we have seen and presents unsolved problems as to its origin, as well as that of the host rock.

The chondrule is a single crystal of olivine (Fo 87-92), almost perfectly circular in section (623 x 660 μm), but with a jagged margin, that contains 30-40 bifurcating but subparallel stringers of plagioclase separating the olivine into a series of bars (Figs. 1 and 2). All the olivine goes to extinction essentially simultaneously (within 1°). Several adjoining plagioclase stringers behave similarly, as does some olivine (and plagioclase) in the host rock nearby (Fig. 2). At the edge of the chondrule a 20μm-band of olivine is essentially free of stringers. The texture and mineralogy of the host rock near the chondrule is the same as in the bulk rock. This and the crystallographic extensions from the chondrule suggest its presence during crystallization of the host.

Tiny particles (~1-2μm) of troilite plus nickel iron (~0.1% of chondrule) occur in the stringers. The stringers are small but about An_{90}. Many tiny silicate melt inclusions (glass plus ~10% vapor bubble) occur in the olivine. They are too small for analysis and comparison with the much larger melt inclusions in the phenocrysts of olivine in this same rock (4). The mode of the chondrule is olivine-91.2, plagioclase-8.8 wt.%. The olivine is not uniform in composition but is zoned from Fo_{87} to Fo_{92} in a peculiar manner, with iron-rich core and rim, and an iron-poor intermediate zone (Fig. 3). A representative analysis (pt. A, Fig. 1) shows SiO_2-40.3, Al_2O_3-0.05, FeO-8.93, MgO-50.4, CaO-0.09, MnO-0.09, and TiO_2, Cr_2O_3, and NiO all <0.05 (sum 99.86). Ca, Cr, and Al vary sympathetically with iron. The smaller compositional excursions on Fig. 3 may be spurious, but the gross zoning picture is certainly valid. If there is any compositional zoning within individual bars, it must be small. The small olivine crystal extensions out into the host rock are iron-rich, like the outer edge of the chondrule proper. The olivine of the chondrule is essentially similar to that present in the bulk of the rock in both major and minor elements (4). Several other olivine crystals in this rock, sharply euhedral or irregular, have roughly parallel lamellae. These, however, are thicker, much more widely spaced, and consist of glass with only 63%-86% normative plagioclase (4).

The origin of the chondrule presents several problems. The chondrule could represent crystallization of an impact-generated melt that was blasted out into space, crystallized, and fell back into a magma of 62295 composition. The melt inclusions indicate that the olivine grew from a melt, and plagio-

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clase-rich glass inclusions are found in the olivine of some meteoritic chondrites (5). The distribution of silicate melt inclusions and the barred structure suggest rapid feathery growth of olivine. Barred and feathery textures in synthetic chondrules (6) and in lunar and meteoritic chondrules (7) are generally considered to be a result of extremely rapid crystallization from strongly supercooled melts (8). The circular cross section suggests origin from the crystallization of a spherical droplet in free fall or zero gravity as is generally assumed for meteoritic chondrules (9). Somewhat similar barred chondrules of olivine and glass occur in the chondritic meteorites and in several lunar samples (7, 10, 11). However, the 91% olivine of the chondrule contrasts strongly with the ~25% olivine of the bulk rock, raising a problem of the origin of such a magnesian melt droplet.

If the chondrule grew in 62295 as a phenocryst, it is difficult to explain the circular shape and the lack of intermediate types between this and the euhedral olivine phenocrysts (4, Fig. 4). The circular outline and symmetry of the chondrule could be a fortuitous section through a corner of a unique rounded and zoned phenocryst.

If the chondrule is a meteoritic xenolith, its circular outline could be inherited (i.e., a true chondrule), or the result of dissolution (personal communication, E.C.T. Chao). In either case, its compositional similarity to the olivine of the surrounding rock is unusually fortuitous, unless 62295 itself is a fused meteorite of unusual composition.

The unusual zoning poses problems for all three possible modes of origin. We are unaware of any report of such zoning in chondrules of lunar or meteoritic origin. Furthermore, the crystals in meteoritic barred chondrules are usually assumed to have grown from a nucleus on the outer surface of the droplet, which would not yield the observed concentric zoning. Iron-rich rims are found on some meteoritic olivine crystals and chondrules, possibly in part from equilibration with the matrix (12), and some barred chondrules even have rims of metallic iron, but none have iron-rich rims <u>and</u> cores.

It is possible to set up ad hoc explanations of the observed zoning by recourse to rapidly changing f_{O_2} and/or temperature of crystallization (e.g., resulting from heat of crystallization released during rapid crystallization of strongly supercooled drops, 6), or by taking cognizance of two distinctly different environments implicit in the proposed modes of origin, i.e., free fall in space followed by re-equilibration in 62295 magma for the meteoritic and droplet modes, or deep and shallow crystallization for a phenocryst mode of origin. The importance of this chondrule is the occurrence of such structures in a lunar igneous rock and the light that this might shed on the whole enigma of the origin of meteoritic chondrules.

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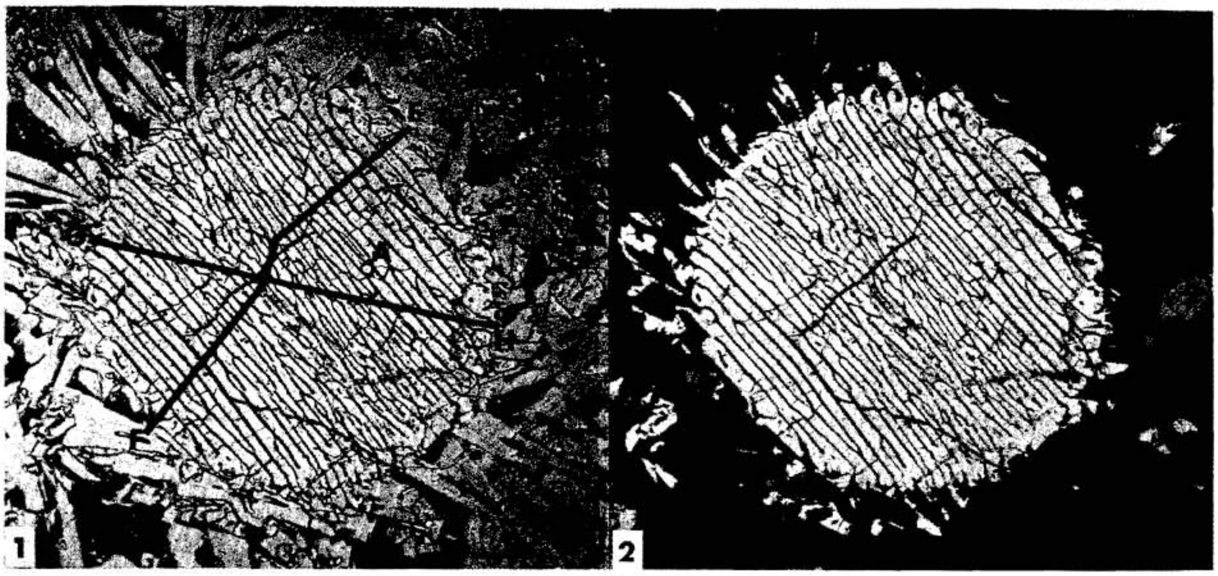

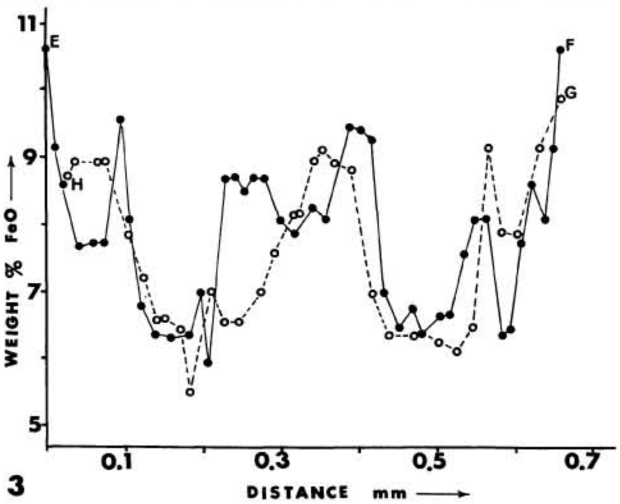

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Figs. 1,2. Chondrule in 62295, in transmitted plain light (Fig. 1) and with crossed polarizers (Fig. 2). Bar = 100 μm. Electron microprobe analysis point A and step scan traverses E-F and G-H are shown on Fig. 1. (Offsets on E-F were made to avoid pits and cracks).
Fig. 3. Electron microprobe step scans made on centers of individual olivine bars along two traverses shown on Fig. 1.