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BUTLER, MISSOURI—AN UNUSUAL IRON METEORITE

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Butler, Missouri - An Unusual Iron Meteorite

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Abstract

The Butler iron meteorite has been found to have, with respect to the iron meteorites, an unusually high Co content (1.4 wt%), unusually high Ge contents in the kamacite and the taenite phases, and an unusually low cooling rate ($0.5^{\circ}C/10^{6}$ years). It is suggested that Butler formed in a different environment from that of the rest of the iron meteorites.

Author

As shown by Wasson (1), the Butler iron meteorite has an unusually high Ge content, 1996 ppm. This high Ge content as well as the high Ge/Ni ratio makes Butler an exception to two geochemical generalizations regarding iron meteorites (1). This exception implies that Butler may be unusual in other ways. The purpose of this note is to report the measurements of major element distributions and of the cooling rate of this meteorite, further showing its unusual characteristics.

The structure of the Butler meteorite, which has 16 wt% Ni (1), is transitional between a fine octahedrite and an ataxite. A photomicrograph of the meteorite is shown in Figure 1. The large kamacite plates make up the well-defined Widmanstatten pattern typical of the octahedrites. The interior areas between the kamacite plates of the major pattern are regions of transformed taenite (plessite) which contain a micro-Widmanstatten pattern sometimes found in the ataxites. This micro-pattern formed late in the meteorite's cooling history.

Analysis of the metallic phases of the meteorite with the electron microprobe showed that only Fe, Ni, Co and Ge are present in excess of .15 wt%. The Fe and Ni concentration gradients were typical of those found in iron meteorites. The Ni content varied from 16 to 45 wt% in taenite and from 6 to 6.5 wt% in kamacite except near the kamacite-taenite boundaries where it was less than 6 wt%. The Co content was, however, unusual. According to Krinov (2), the average Co content in fine octahedrites is .61 wt%. The total variation in Co

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The distribution of Ge in the meteoritic phases was measured with the electron microprobe using a procedure described by Goldstein and Wood (4). Ge concentrates only in kamacite and taenite. The kamacite bands which make up the typical Widmanstatten pattern of the meteorite contain 1700 + 50 ppm Ge. The kamacite areas in plessite, less than 50 microns in width, contain 1550 ± 50 ppm. Typical Ge and Ni concentration gradients in kamacite and taenite are shown in Figure 2. The Ge follows the Ni, and the maximum Ge content in taenite is over 4000 ppm (.4 wt%). The distribution of Ge with respect to Ni and kamacite band size is typical of that found for meteorites with overall Ge greater than 20 ppm (5). However, the absolute Ge contents of the metallic phases is much greater than in any other iron meteorite.

The cooling rate for the temperature range in which the Widmanstatten pattern developed (700-300°C) was also determined. This was accomplished by comparing the measured concentration gradients in several kamacite-taenite areas with gradients calculated by a theoretical growth analysis for the Widmanstatten pattern (6). The calculated gradients vary with the cooling rate assumed. The cooling rate is determined when a fit is obtained between the measured and calculated gradients.

The cooling rate determined for Butler is $0.5^{\circ}/10^{6}$ years with an estimated precision of ± 30%. This cooling rate is lower by a factor of 2 than any cooling rate determined for iron meteorites in the study of 27 iron and stony iron meteorites by Goldstein and Short (6). Thus the cooling history for Butler appears to be unique.

Butler is indeed an unusual meteorite. It not only contains more Ge and Co than any other iron meteorite, but also cooled more slowly than any other iron meteorite measured to date. It is probable that Butler formed in a different environment from that of the rest of the iron meteorites (7).

References and Notes

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7. I wish to thank P. Soules for his assistance with the photomicrograph of Butler.

Illustrations

Figure 1. Photomicrograph of the Butler iron meteorite.

Figure 2. Distribution of Ni as represented by (·) and Ge as represented by (ö) in the Butler iron meteorite.

BUTLER METEORITE 16.0 Wt% Ni, 1996 ppm Ge