Perryite in the Kota-Kota and South Oman enstatite chondrites

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Summary. Electron-microprobe scanning pictures and quantitative analyses of the nickel silicide perryite in the Kota-Kota and South Oman enstatite chondrites are given. Comparative data for the narrow perryite lamellae in the Horse Creek iron meteorite are included. Perryite in these meteorites lies within the limits 75–81 % Ni, 3–7 % Fe, 12–15 % Si, 2–5 % P.

Ramdohr and Kullerud (1962) observed in certain stony meteorites a new mineral, provisionally termed the Henderson phase, in recognition of its previous (unpublished) discovery by E. P. Henderson in the Horse Creek iron meteorite. The composition $(Ni,Fe)_2Si$ was proposed initially, but Ramdohr (1963) later modified this to the more general $(Ni,Fe)_xSi_y$, and later still (Ramdohr, 1964) suggested $(Ni,Fe)_2(Si,P)$ on the basis of the similarity of the octahedral cleavage of synthetic Ni_2Si and 'Henderson phase', the likelihood of the substitution of Fe for Ni in the presence of the Fe-rich phases kamacite and troilite, and the exsolution of schreibersite observed in some cases. Fredriksson and Wickman (1963) described this mineral in Horse Creek and found that it contains about 75 % Ni and 15 % Si, with some P and Fe. Fredriksson and Henderson (1965) later gave it an improved microprobe analysis: 81 % Ni, 3 % Fe, 12 % Si, 5 % P, for the material found in Horse Creek, and proposed the name perryite. The introduction of this new mineral name has been criticized by Fleischer (1967) as lacking adequate supporting data, but as there is no doubt that a mineral of this approximate composition exists, and since the name perryite has become established in the literature, it is retained here.

The Kota-Kota enstatite chondrite, in addition to the common opaque minerals troilite, kamacite, and schreibersite, contains perryite, comprising an estimated 10 to 15 % of the opaque content of the meteorite. The perryite is typically intergrown with troilite in the manner shown in fig. 1, in which the scanning pictures demonstrate its high Ni and Si

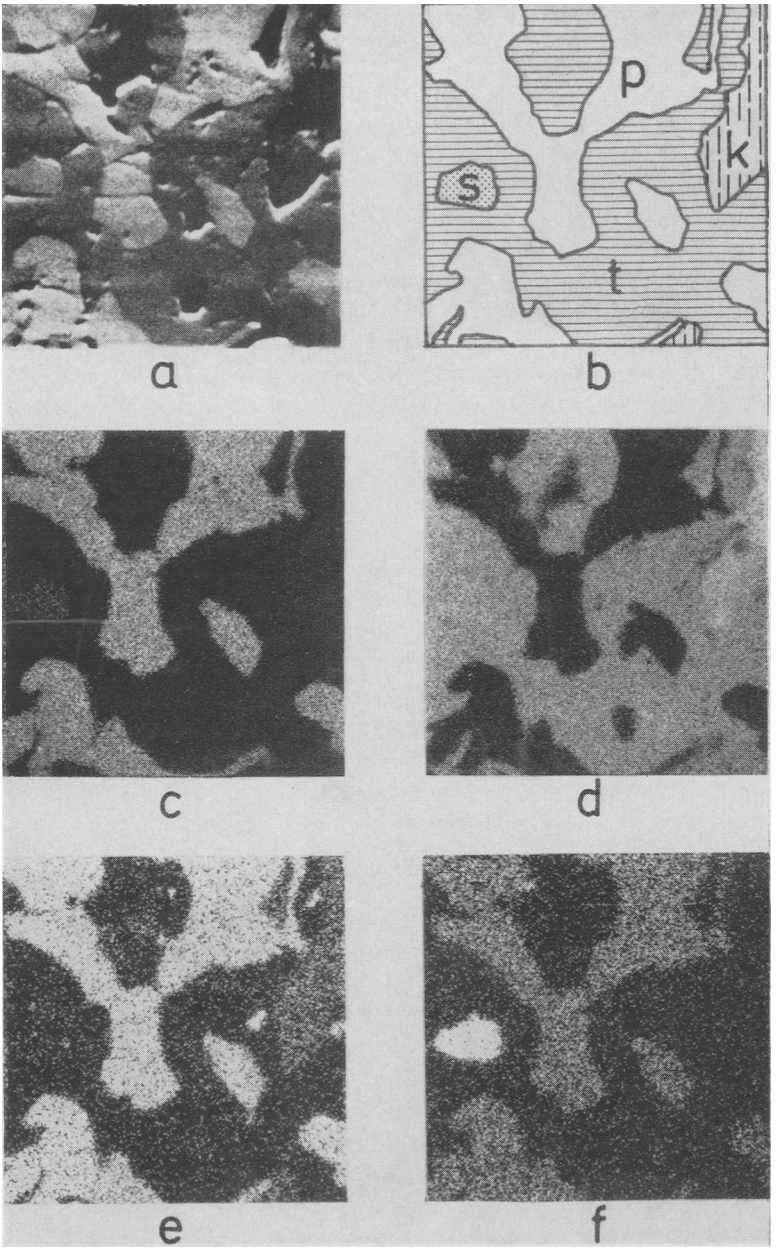

FIG. 1. Scanning pictures of perryite in Kota-Kota (magnification $\times 350$), showing (*a*) backscattered electron image, and X-ray images of (*c*) Ni, (*d*) Fe, (*e*) Si, and (*f*) P. Phases present are perryite (p), troilite (t), kamacite (k), and schreibersite (s).

content. The Fe content is low compared with the surrounding troilite, but the presence of P can be seen.

The grain size in Kota-Kota is large enough for accurate quantitative microprobe analysis, whereas the very narrow perryite lamellae in Horse Creek are difficult to resolve completely. The average composition of perryite in Kota-Kota was found to be 81·0 % Ni, 4·0 % Fe, 12·4 % Si, 3·5 % P. The analysis was performed with a Cambridge Instrument Co. Geoscan electron microprobe, using as standards pure Ni, Fe, and Si, and schreibersite for P. The usual corrections were applied. The specimen analysed was B.M. 1905,355, slide no. 24. The above composition is very close to that given by Fredriksson and Henderson for Horse Creek. The kamacite in Kota-Kota was found to contain 2·6 % Si and 3·0 % Ni. This is a much lower Ni content than that of kamacite in other enstatite chondrites so far investigated, and is probably related to the unusually high abundance of perryite in this meteorite.

The South Oman enstatite chondrite also contains perryite, but its abundance is much less than in Kota-Kota. The grain size is smaller, but grains large enough for quantitative microprobe analysis are present. In this meteorite, perryite occurs as small laths, usually associated with kamacite. Scanning pictures of the grain selected for analysis are shown in fig. 2. The composition of this grain was found to be 75·5 % Ni, 6·3 % Fe, 15·0 % Si, 2·4 % P. The specimen analysed was B.M. 1966,1, slide no. 174 (material supplied by Dr. S. O. Agrell of Cambridge University, by exchange). The coexisting kamacite contains 3·9 % Si and 6·7 % Ni. This Si content is the highest yet observed in kamacite in enstatite chondrites; the Ni content is normal.

The Horse Creek iron meteorite consists mainly of kamacite, with numerous thin, oriented lamellae of perryite. An attempt was made to obtain a quantitative microprobe analysis of this perryite. Apart from the resolution of the electron probe, a further problem in analysing these lamellae is the strong fluorescence excitation of Fe in the surrounding kamacite by Ni-Kα radiation from the perryite. Using a method described by Reed and Long (1963), it is estimated that this effect gives rise to an apparent Fe concentration of about 5 %, which was subtracted from the measured Fe content of the perryite. This calculation is rather approximate, so the accuracy of the resulting Fe concentration is not high. Analysis of perryite at points where it could be resolved gave the approximate composition: 79 % Ni, 4 % Fe, 12 % Si, 4 % P, which is close to that given by Fredricksson and Henderson. The kamacite was found to contain 2·4 % Si and 4·1 % Ni.

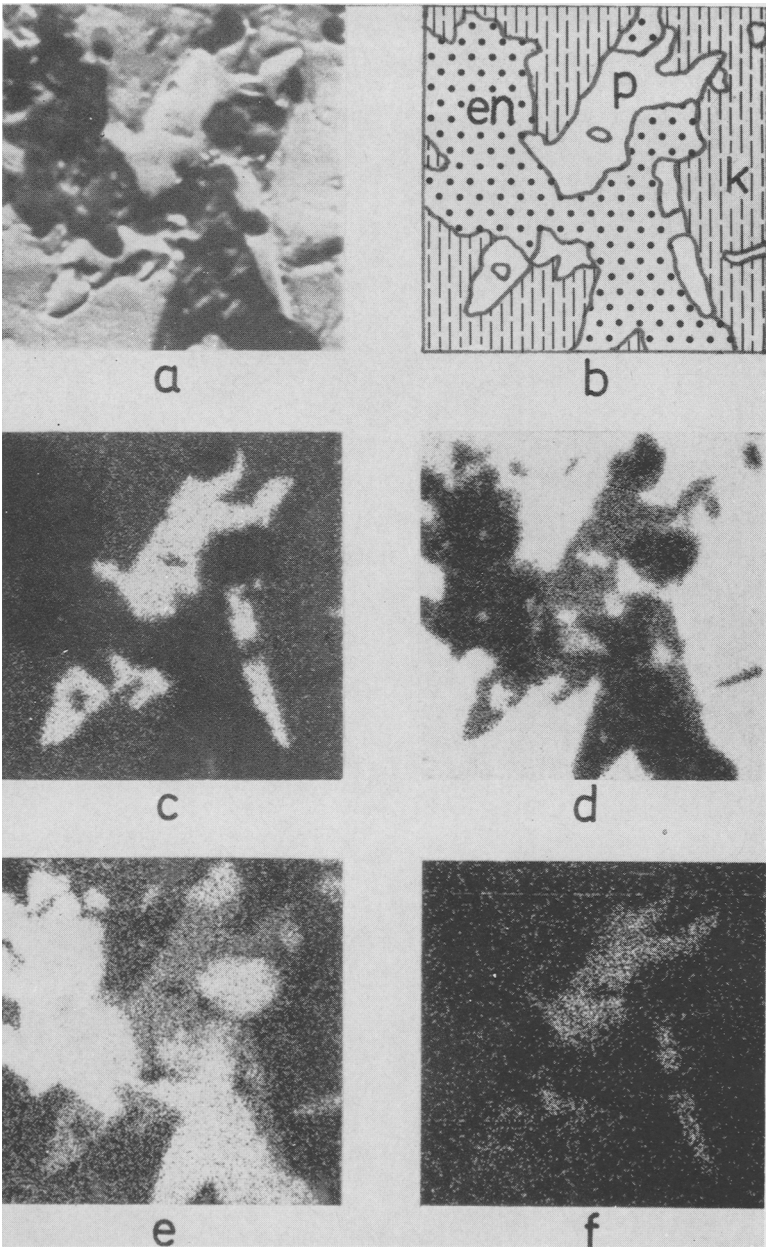

FIG. 2. Scanning pictures of perryite in South Oman (magnification × 500), showing (*a*) backscattered electron image, and X-ray images of (*c*) Ni, (*d*) Fe, (*e*) Si, and (*f*) P. Phases present are perryite (p), kamacite (k), and enstatite (en).

Conclusions. The analyses of perryite given above lie within the limits 75 to 81 % Ni, 3 to 7 % Fe, 12 to 15 % Si, 2 to 5 % P. The data for Kota-Kota and South Oman are more reliable than those for the narrow lamellae in Horse Creek. Ramdohr (1964) states that the powder pattern of perryite is very similar to that of α-iron (kamacite) except for differences in the relative intensities of the lines, which suggests that perryite may have a b.c.c. structure, with the Si and P occupying interstitial positions. On the basis of two Fe and Ni atoms per unit cell, the structural formulae calculated from the microprobe data are: $(Ni_{1.90}Fe_{0.10})(Si_{0.61}P_{0.16})$ for Kota-Kota, and $(Ni_{1.84}Fe_{0.16})(Si_{0.76}P_{0.11})$ for South Oman. These results confirm the deficiency in Si+P noted by Ramdohr (1964), compared with ideal $(Ni,Fe)_2(Si,P)$.

An X-ray diffraction investigation of perryite from Kota-Kota by Dr. R. J. Davis is in progress.

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