magnetic detector, and magnetic noise which induces both a detector and an EEG voltage. Curious phenomena were indeed occasionally seen, but these were eventually understood and avoided. For example, poor contacts between EEG leads and the scalp resulted in 60-hz pickup in the EEG line which influenced the triggers with eyes open, thereby selecting 60 hz magnetic subharmonics near 10 hz to stand out on the MEG.

Figure 3 shows the course B-vector distribution at an arbitrary phase of the alpha cycle, averaged over 2500 cycles. The distribution remains the same if the upper EEG lead is moved to another point, at about the same alpha-rhythm potential, say the right ear. No measurements have yet been made with the inion lead moved, but one would expect a different distribution. Such measurements with resulting magnetic distributions would probably reveal information about the internal alpha-rhythm sources, and would be a first step in evaluating the possible uses of the MEG.

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References and Notes

1. G. M. Baule and R. McFee, *Amer. Heart J.* **66**, 95 (1963).
2. D. Cohen, *Science* **156**, 653 (1967).
3. A paper with results of extensive magnetocardiographic mapping of ten human heart subjects has been submitted for publication.
4. For example, potential measurements on a spherical surface which contains a concentric, radially pulsating shell of charge cannot yield the instantaneous charge radius. In this case, magnetic measurements on the surface are always zero and of no help. A case illustrating magnetic use is an irregular, closed volume containing three irregular, successively enclosed regions. The inner region is conducting and contains currents and their sources; the middle region is insulating and nonreactive; and the outer region is conducting. The outer surface potential will be instantaneously constant and hence reveal nothing about the inner source distribution, but the surface magnetic measurements will show internal currents, hence some information about the source distribution.
5. G. Baule and R. McFee, *J. Appl. Phys.* **36**, 2066 (1965).
6. I assume the head to be approximated by an alternating electric dipole inside and parallel to the surface of a semi-infinite volume conductor of 1000 ohm-cm resistivity. The dipole makes an a-c distribution within the medium which produces an external alternating magnetic field, the maximum of which depends only on the maximum surface potential. I chose 30μv (pp) as that part of the voltage not due to a perpendicular dipole, which contributes zero external magnetic field.
7. D. Cohen, *J. Appl. Phys. Suppl.* **38**, 1296 (1967).
8. I thank Prof. H. Fernandez-Moran, Prof. F. Gibbs, and Prof. J. Hughes for their help and encouragement. Supported by the Research Corporation.

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Krinovite, $NaMg_2CrSi_3O_{10}$: A New Meteorite Mineral

Abstract. *An unusual new silicate, krinovite, has been discovered within graphite nodules in three iron meteorites. Its ratio of silicon to oxygen of 3 : 10 suggests a rare kind of silicate polymerization. The meteorite nodules in which it occurs exhibit a chemical fractionation that differs from that of both stone meteorites and terrestrial basalt.*

Krinovite (kreen′-off-ite), a mineral unknown in any terrestrial rock, occurs as minute subhedral grains (largest approximately 200 μ) disseminated within graphite nodules in the octahedrite iron meteorites Canyon Diablo (United States), Wichita County (United States), and Youndegin (Australia).

The composition (Table 1) was determined by electron microprobe methods (*1*), and the observed variations are given in the table. The simplified empirical formula is $NaMg_2CrSi_3O_{10}$. The 3 : 10 ratio of silicon to oxygen suggests a very unusual silicate polymerization into short chains, each consisting of three tetrahedral units in which two oxygens are shared. This type of polymerization has recently been encountered by Donnay and Allmann (*2*) in the rare terrestrial mineral ardennite, in which both Si_3O_{10} and single tetrahedral SiO_4 units occur. More recently Moore and Bennett (*3*) established the presence of these same polymerized units, partially aluminous, $(Al,Si)_2SiO_{10}$, in the structure of the rare mineral kornerupine. In this mineral the units occur with the double-linked tetrahedral pairs Si_2O_7. Krinovite may be the first example of a mineral with purely Si_3O_{10} units. On the other hand, it must be noted that the empirical formula could be written in other ways which suggest mixed polymerizations in well-known ratios: $NaMg_2Cr(SiO_4)(SiO_3)_2$ or $NaMg_2Cr(Si_2O_7)(SiO_3)$. By multiplying the "molecule" by integers 2, 3, and so forth, other combinations are possible.

Single-crystal measurements (Weissenberg camera) indicate monoclinic symmetry with $a = 19.48 \pm 0.04$ Å; b, 29.18 ± 0.06 Å; c, 10.25 ± 0.02 Å, and β, 103° ± 2° (*4*). The cell dimensions given here are observed in the single-crystal pattern; however, a space group could not be assigned because of twinning noted in the patterns. Hence, the true a and c axes may differ from those given. The cell chosen is, however, allowable and is the one consistent with morphological examination. The powder diffraction pattern (Table 2) was not indexed because of the large size of the cell which leads to too many ambiguities and multiple index assignments.

Krinovite is deep emerald green. In sodium light $\alpha = 1.712 \pm 0.002$; β, 1.725 ± 0.002; γ, 1.760 ± 0.005; biaxial +; and $2V$, 61° ± 2°, measured, and 64°, calculated. The optic axial plane is parallel to b. Pleochroism is intense, $X(= b)$ is yellow-green; Y, blue-green; and Z, greenish black (sometimes an anomalous dark reddish brown). Dispersion of the refractive indices is strong, but no optic axis dispersion could be detected. No cleavage was observed. Most grains showed multiple twinning.

The hardness is between 5.5 and 7. Density was determined by the sink-or-float method as 3.38 g/cm^3; the calculated x-ray density is 3.44 g/cm^3 based on $Z = 32$.

Approximately 50 unsuccessful attempts were made to synthesize krinovite. Mixtures of Cr_2O_3, Na_2SiO_3, SiO_2, and MgO heated in air in platinum for several days to several weeks at 700° to 1400°C invariably resulted in considerable oxidation of chromium with the formation of some sodium chromate. In some cases magnesiochromite was formed. Ureyite, $NaCr(SiO_3)_2$ (*5*), was readily formed. Similar attempts in an argon atmosphere or in vacuum, in both platinum and graphite crucibles, resulted in the formation of gray-green enamels within which spinel and unidentifiable phases were dispersed. Attempts at 25 kb and 650° to 1400°C were unsuccessful.

Natural krinovite heated in air at 1000°C for 10 days lost its green color. Olivine was the only phase that could be identified among the decomposition products. Ureyite, similarly treated, was virtually unaffected. Natural krinovite was also heated in vacuum for 6 days at 1000°C and again lost its color. Decomposition products were magnesiochromite, cristobalite, and unidentifiable phases. We must conclude that temperatures in the whole range examined (650° to 1400°C) are probably too high for the stable, or metastable, formation of krinovite.

The dominant associated minerals in both Canyon Diablo and Wichita

Table 1. Electron microprobe analysis * of krinovite, determined on specimens from the Canyon Diablo meteorite.

Oxide	Percentage (by weight)
SiO_2	48.1 ± 0.7
TiO_2	0.5 ± 0.1
Al_2O_3	0.6 ± 0.1
Cr_2O_3	19.1 ± 0.5
FeO	1.8 ± 0.04
MnO	0.1 ± 0.007
MgO	19.7 ± 0.4
CaO	0.1 ± 0.01
Na_2O	9.1 ± 0.5
K_2O	0.0
Total	99.1

* Analysis by E. Olsen and I. S. McCallum.

County meteorites are graphite, roedderite, high albite, and the amphibole richterite. This occurrence of richterite in Canyon Diablo marks the second known occurrence of amphibole in a meteorite (*6*). In addition, our specimen of Canyon Diablo contains ureyite and chromite (*7*). Wichita County has forsterite (Fo 99) but no ureyite or chromite. The associated minerals in Youndegin have not yet been thoroughly examined.

It is clear from the empirical formula that the simplest mineral reaction that forms krinovite is (volumes in cubic centimeters per mole):

$$\underset{\text{ureyite}}{NaCrSi_2O_6} + \underset{\text{forsterite}}{Mg_2SiO_4} = \underset{\text{krinovite}}{NaMg_2CrSi_3O_{10}}$$

$$63.02 \qquad 43.78 \qquad 110.30$$

$$\Delta V = +3.50 \text{ cm}^3\text{/mole (at } T = 298°\text{K)}$$

If one assumes that the sign of ΔV (change in volume) remains the same at higher temperatures, krinovite appears to be a low-pressure phase relative to ureyite plus forsterite (*8*). In this regard it is interesting that in two of the assemblages the association is krinovite plus ureyite (Canyon Diablo), or krinovite plus forsterite (Wichita County). If krinovite results from this reaction, differences in bulk composition would be expected to deplete one of the reactants, but not necessarily both. In the occurrences of ureyite (*5*, *7*) no forsterite was reported, but in one case pyroxenes and quartz were found, which suggests that the bulk composition was too siliceous for krinovite to form. With free silica, krinovite might be unstable relative to pyroxenes:

$$\underset{\text{krinovite}}{NaMg_2CrSi_3O_{10}} + \underset{\text{silica}}{SiO_2} =$$

$$\underset{\text{ureyite}}{NaCrSi_2O_6} + \underset{\text{pyroxene}}{2MgSiO_3}$$

In the case of the Wichita County meteorite, sufficient excavation into the main graphite nodule has taken place to enable us to make some very rough visual estimates of the relative volumes occupied by each silicate phase. From these some bulk elemental abundances can be computed. Magnesium is about the same as in ordinary chondrite meteorites and in the solar atmosphere, but is about 4 times higher than terrestrial basalt. Sodium, chromium, and potassium are enriched by 4, 5, and 20 times, respectively, over the chondrites and the sun's atmosphere, and by 2, 20, and 2 times, respectively, over terrestrial basalt. On the other hand, calcium and aluminum are depleted by 2 and 5 times, respectively, relative to chondrites and the sun's atmosphere and are depleted by 28 and 12 times below terrestrial basalt. Even allowing for the large errors in these estimates, it is clear that these small isolated silicate systems within these iron meteorites represent an unusual fractionation of elements which is different from both ordinary chondrite meteorites and the lower crust of the earth.

Krinovite was named by us for E. L. Krinov, noted Russian investigator of meteorites and Scientific Secretary of the Committee on Meteorites of the Academy of Sciences of the U.S.S.R. (*9*, *10*).

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Table 2. X-ray powder diffraction pattern of krinovite.* Camera diameter, 114.59 mm; nickel filtered; copper radiation. b, Broad.

d (Å)	Intensity (visual)	d (Å)	Intensity (visual)
7.92	60	2.281	20
7.27	50	2.186	20
6.25	40	2.165	10
4.75	30	2.080	70
4.62	10	2.049	60
4.130	50	1.969	50
3.949	10	1.927	10
3.713	10	1.920	10
3.639	60	1.886	20
3.412	40	1.873	20
3.104	60	1.779	10
2.934	10	1.702	40 b
2.893	80	1.657	30
2.804	30	1.642	10
2.754	30	1.598	50
2.713	30	1.570	20
2.655	90	1.530	30
2.528	20	1.484	40
2.501	100	1.470	50
2.429	30	1.456	50
2.379	40	1.448	50
2.300	20		

* There were 12 additional spacings to 0.8337.

References and Notes

1. Microprobe data corrected by the methods of J. V. Smith [*J. Geol.* **73**, 830 (1965)] with a combination of natural and synthetic standards: natural albite, olivine, chromite, rutile, microcline, and synthetic anorthite and tephroite. The standards are all from the microprobe laboratory in the Dept. of Geophysical Sciences, Univ. of Chicago. The samples of krinovite analyzed were all separated grains mounted in carbon-coated epoxy within brass mounts. Normal operating conditions were 15 kv; sample current, 0.01 μa; counting times, 10 seconds; and 1 to 2 μ beam.
2. G. Donnay and R. Allmann, *Carnegie Inst. Wash. Year Book* **66**, 485 (1968).
3. P. Moore and J. Bennett, *Science* **159**, 524 (1968).
4. Cell dimensions were obtained by rotation on all three axes in order to obtain consistency. Twinning was quite prominent; however, examination of several crystals led to identical cell dimensions.
5. C. Frondel and C. Klein, Jr., *Science* **149**, 742 (1965).
6. E. Olsen, *ibid.* **156**, 61 (1967).
7. Ureyite in Canyon Diablo also has been noted by U. Marvin [*Trans. Amer. Geophys. Union* **48**, 167 (1967)].
8. Mole volume data for ureyite and forsterite were taken from R. Robie, P. Bethke, K. Beardsley [*U.S. Geol. Surv. Bull. No. 1248* (1967)]. Mole volume of krinovite was calculated.
9. Name approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association.
10. The meteorites used are from the collection of the Field Museum: Canyon Diablo (catalog No. Me 1249); Wichita County (No. Me 885); Youndegin (No. Me 877).
11. Work performed, in part, under the auspices of AEC. We thank S. Siegel, J. Whitaker, and B. Tani for the single-crystal x-ray work, and F. Gallagher for performing the high-pressure experiments (all are from Argonne National Laboratory). E.O. was supported by NSF grant GA-307, and this support is gratefully acknowledged.

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Visual Pigment Renewal in the Mature Frog Retina

Abstract. *It has been demonstrated by autoradiography that radioactive amino acids serve as precursors for proteins which are subsequently incorporated into retinal rod outer segment discs in mature animals. By the isolation and purification of visual pigment from retinas of adult frogs after injection of tritiated leucine and phenylalanine, it has been shown that at least part of this labeled protein consists of visual pigment (rhodopsin).*

From autoradiographic studies, Young (*1*, *2*) has suggested that the outer segments of retinal rods are constantly being renewed. In rod photoreceptors of adult rats, mice, and frogs injected with radioactive amino acids, protein synthesis predominates in the ergastoplasm of the inner segment. A major portion of the newly formed, radioactive protein then migrates to the outer segment, where it is incorporated into the basal discs of that structure.