Hence, dehrnite is a carbonate-fluorapatite containing no appreciable sodium or potassium.

An examination of the apatite mineral labelled *englishite-analysed* and seven topotype 'lewistonites' indicates that they, too, are carbonate-apatite containing no appreciable sodium or potassium. The compositional range for these specimens (Table I), coupled with the herein demonstrated inaccuracy of the dehrnite analyses done at the same time and presumably using the same methodology, and the unlikeliness of an apatite with 3·71 % K_2O or 4·34% Na_2O, indicates the extremely strong assumption that lewistonite, like dehrnite, is an invalid species. It is with sincere regret that the work of Larsen and Shannon, who did so much to increase our awareness of the mineralogy of the Utah variscite deposits, is partially discredited.

IMA Commission on New Minerals and Mineral Names—decisions. The foregoing data were presented to the IMA Commission in 1977. It was the decision of the members to accept the specimen (no. H-95495) labelled *englishite-analysed* as the type lewistonite. The Commission members further voted (18-0) to accept the herein given proposal and to formally discredit both lewistonite and dehrnite.

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Hydrothermal nickelian mackinawite in nickel mineralization at Wadi Qatan, Saudi Arabia

NICKELIAN mackinawite is a common alteration product in nickel sulphide ores (Uytenbogaardt and Burke, 1971), but its association with alabandine is unusual. This communication reports the occurrence of nickelian mackinawite associated with pentlandite and alabandine and discusses a possible mechanism for its formation.

At Wadi Qatan, a lens of fine-grained, pyrrhotine-pentlandite and pyrite-pentlandite mineralization lies conformably within a sequence of metamorphosed basaltic and andesitic rocks, intruded by granite and diorite. Field and textural evidence indicate that the pyrrhotine is probably derived from pre-existing pyrite by contact metamorphism, and that much of the pyrrhotine so formed has been locally re-pyritized (Blain, 1978). The resultant assemblages consist of pyrite or pyrrhotine with pentlandite and minor amounts of chalcopyrite, cubanite, alabandine, and molybdenite. Nickelian mackinawite, as an alteration product, has two modes of occurrence: pentlandite → nickelian mackinawite + carbonate, and alabandine → nickelian mackinawite + carbonate. All stages of alteration from incipient (fig. 1*a*) to partial (fig. 1*c*) and total (fig. 1*b*) replacement are present. The nickelian mackinawite, derived from both pentlandite and alabandine, consists of a delicately interwoven, fibrous mat of crystals. It is generally porous in appearance, indicating a volume reduction in the reaction. The associated carbonate minerals form in discrete clusters and are generally less abundant than the mackinawite. In places, the alteration is associated spatially with cross-cutting veinlets of pyrite. The association, mode of occurrence, and textures suggest that the alteration is hydrothermal.

TABLE I. *Electron probe micro-analysis results*

	Pentlandite		Alabandine		Nickelian mackinawite after pentlandite	
Fe	33·36	33·50	5·55	5·06	41·32	42·09
Mn	<0·01	<0·01	58·60	57·60	0·05	0·34
Ni	30·63	31·26	0·22	0·08	19·70	19·86
S	32·31	33·20	36·97	37·30	35·24	33·48
Others	n.d.	n.d.	0·13	0·01	n.d.	n.d.
Total	96·30	97·96	101·47	100·05	96·31	95·77

	Nickelian mackinawite after alabandine				Carbonate phase*	
Fe	40·61	50·09	43·15	43·87	27·34	25·27
Mn	0·69	0·38	0·32	0·30	14·49	16·55
Ni	19·05	12·26	17·21	16·55	1·95	0·88
S	35·36	35·92	36·24	36·14	2·26	0·98
Others	0·13	n.d.	n.d.	n.d.	0·41	0·35
Total	95·84	98·65	96·92	96·86	46·45	44·03

n.d.—not determined.

* Note that these analyses are very approximate because the data were corrected as for sulphides. All analyses were performed at the Division of Mineralogy of the Commonwealth Scientific and Industrial Research Organization in Western Australia.

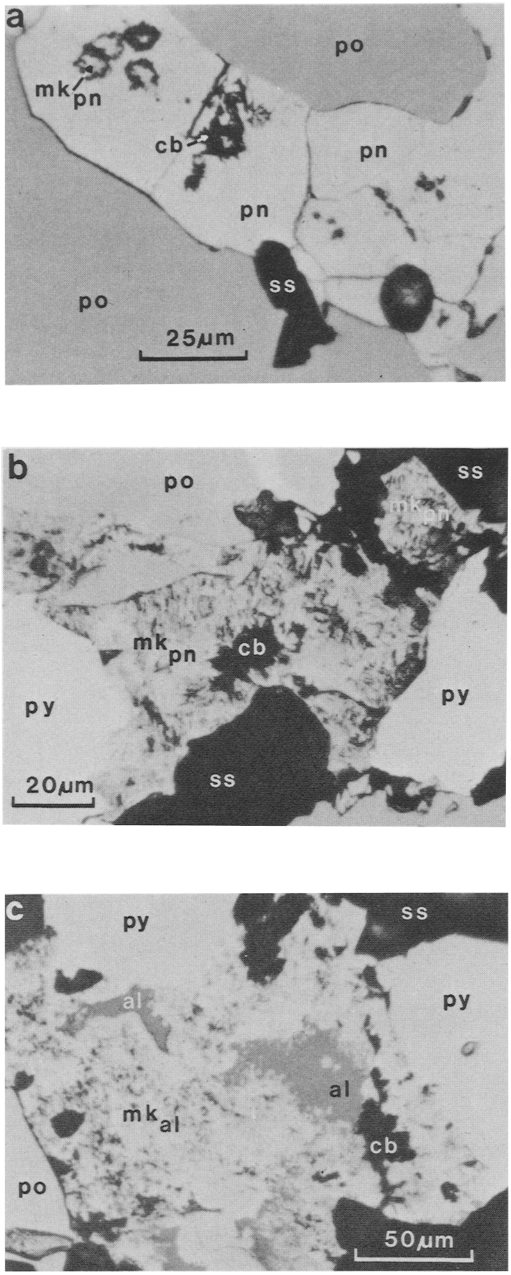

FIG. 1. Photomicrographs illustrating the alteration of pentlandite (*a*, *b*) and alabandine (*c*) to nickelian mackinawite and carbonate. The mineral abbreviations used are pn—pentlandite, po—pyrrhotine, py—pyrite, al—alabandine, mk—nickelian mackinawite, cb—carbonate phase, ss—silicate minerals; the subscript denotes the replaced mineral. All photographs are taken in plane polarized reflected light under oil immersion.

Electron probe micro-analysis data on the alteration indicate the following approximate compositions: pentlandite ($Fe_{4\cdot8}Ni_{4\cdot2}S_8$), alabandine (MnS), nickelian mackinawite ($Fe_{0\cdot7}Ni_{0\cdot3}S$), and carbonate phase (estimated $Fe_{0\cdot6}Mn_{0\cdot4}CO_3$). Assuming that the hydrothermal alteration takes place at constant sulphur, the general reactions involved may be expressed as:

$$\underset{\text{pentlandite } (257\cdot2/8\,=\,32\cdot15\ \text{Å}^3)}{0\cdot125Fe_{4\cdot8}Ni_{4\cdot2}S_8} + 0\cdot1Fe^{2+} \rightarrow \underset{\text{nickelian mackinawite } (33\cdot67\ \text{Å}^3)}{Fe_{0\cdot7}Ni_{0\cdot3}S} + 0\cdot225Ni^{2+}$$

$$\underset{\text{alabandine } (35\cdot63\ \text{Å}^3)}{MnS} + 0\cdot7Fe^{2+} + 0\cdot3Ni^{2+} \rightarrow \underset{\text{nickelian mackinawite } (33\cdot67\ \text{Å}^3)}{Fe_{0\cdot7}Ni_{0\cdot3}S} + Mn^{2+}$$

$$0\cdot6Fe^{2+} + 0\cdot4Mn^{2+} + 2HCO_3 \rightarrow \underset{\text{rhodochrosite-siderite } (49\cdot80\ \text{Å}^3)}{Fe_{0\cdot6}Mn_{0\cdot4}CO_3} + CO_2 + H_2O$$

The slight increase in molecular volume (bracketed) for the first reaction is inconsistent with the textural evidence of volume reduction and so it is quite possible that the actual reaction might also involve removal of some of the sulphur from the site of alteration. Nevertheless, the general pattern of elemental gain or loss during alteration is probably portrayed reasonably well by the equations. A feature common to all equations is that the alteration requires an over-all addition of iron. The metals released (nickel and manganese), however, appear to be accommodated in the alteration assemblage. Nickel released by the alteration of pentlandite is probably consumed by the formation of nickelian mackinawite from alabandine. Manganese released from the alteration of alabandine is probably consumed by the precipitation of the carbonate phase. The volumetric proportions of the alteration products empirically suggest that the expelled nickel and manganese are mainly redistributed locally without net removal from the system. It seems likely therefore that alteration is induced by high iron activity but postulation of a mechanism for concentrating iron under these conditions remains a problem.

The unusual mode of occurrence of the pyrite and pyrrhotine in this deposit could perhaps be significant. There is good evidence to suggest that the pyrrhotine monosulphide was derived from pre-existing pyrite by contact metamorphism. Much of the pyrrhotine so formed is thought to have been subsequently re-pyritized. Where areas of pyrrhotine are pervasively replaced by pyrite, the overall sulphide fabrics are identical. There is certainly no evidence for an expansion of the rock mass. In this respect, it is interesting to note that the formation of pyrite from pyrrhotine at constant volume theoretically requires the release of some iron:

$$\underset{\text{pyrrhotine } (1{\cdot}36\times 29{\cdot}25\ \text{Å}^3 = 39{\cdot}78\ \text{Å}^3)}{1{\cdot}36\mathrm{Fe}_{0{\cdot}88}\mathrm{S}} + 0{\cdot}64\mathrm{S} \rightarrow \underset{\text{pyrite } (39{\cdot}75\ \text{Å}^3)}{\mathrm{FeS}_2} + 0{\cdot}2\mathrm{Fe}$$

The relatively common association of pyrite with the alteration, especially in the specific case of cross-cutting veinlets, leads to the speculation that the concentration of iron required for this alteration process may result from the pyritization of pyrrhotine.

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Microprobe analyses of cadmium-rich tetrahedrites from Tyndrum, Perthshire, Scotland

CADMIUM-RICH tetrahedrites were analysed in a sample from the Tyndrum mining district, Scotland. It is the first occurrence of this variety of the mineral.

The mineralization at Tyndrum occurs in north-east–south-west trending fractures associated with the Tyndrum-Glen-Fyne fault. The mineral assemblage is mainly galena and sphalerite in quartz gangue with minor chalcopyrite, pyrite, baryte, and pyrargyrite. Tetrahedrite inclusions were observed in many galena samples from the area, but were most abundant in fine-grained massive galena from the 'Hard Vein' of the main mine where the largest inclusions attained a size of 100 microns. Inclusions from various samples were analysed.

The analyses were performed on a Cambridge Microscan 5 microprobe at the Grant Institute of Geology, Edinburgh. The general formula of the tetrahedrite–tennantite series is $(\mathrm{Cu, Ag})_{10}(\mathrm{Zn, Fe})_2(\mathrm{Sb, As})_4\mathrm{S}_{13}$, but Hg and Bi and, very rarely, Pb and Te have been recorded as major elements in the mineral. The inclusions were analysed for fifteen elements: Cu, Ag, Au, Ni, Co, Mn, Zn, Fe, Cd, and Bi using pure metal standards; Pb, Hg, and S using galena, cinnabar, and pyrite; and Sb and As using GaSb and GaAs. Te was also checked and found to be absent. Some difficulty was encountered in