

have provided the source of chromium and the kamacite may have provided the source of nitrogen for this product.

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[Manuscript received 6 August 1980]

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MINERALOGICAL MAGAZINE, MARCH 1981, VOL. 44, PP. 109–11

Some observations on the mineralogy and genesis of chalcophanite

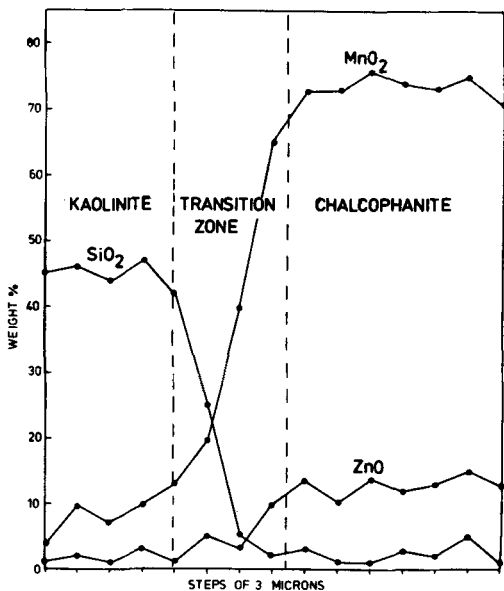
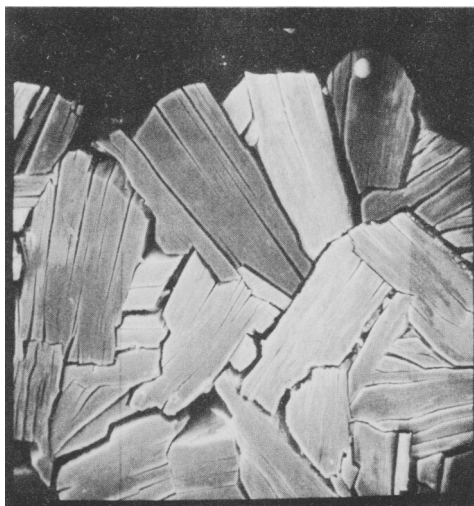
THE zinc-containing manganese oxide chalcophanite $\text{ZnMn}_3\text{O}_7 \cdot 3\text{H}_2\text{O}$ occurs in trace amounts in the manganese oxide ore deposits of Groote Eylandt (Ostwald, in press). The mineral was initially identified on the basis of its optical properties, association with known manganese oxide minerals, and its X-ray energy spectrum which showed strong peaks for Mn and Zn. Recently the writer identified a cavity filling of polycrystalline chalcophanite sufficiently large for investigations of chemical composition and X-ray powder data. The occurrence also showed features which suggest the mechanism of formation of the mineral in this particular occurrence.

Occurrence and mineralogy. The mineral occurs as cavity linings and botryoidal aggregates up to 0.5 mm in dimensions in a lateritized siliceous cryptomelane outcrop. The cavity containing the chalcophanite also originally contained a yellowish siliceous clay which has been largely removed by surface leaching. The chalcophanite occurs as masses of micron-sized crystallites with random optical orientation. In places this fine-grained chalcophanite has recrystallized to radiating tabular crystals up to 20 μm in length and 5 μm in width. These tabular crystals represent prisms flattened parallel to the basal plane, as evidenced by the presence of abundant (0001) cleavages (fig. 1). The mineral shows very well-defined bireflection in shades of grey and white. Anisotropism is also

extreme but without definite colours. Individual grains are too small and too full of cleavages for reflectivity and microhardness determinations.

Before the removal of the clay infilling, the chalcophanite occurred as a layer between siliceous cryptomelane ore and clay, with the growing faces of its crystallites projecting into the clay, and as aggregates within the clay. SEM-EDS examination indicated that this clay also contained traces of Zn and Mn, and EPMA determinations were carried out. Microanalyses on three areas of chalcophanite and average microanalysis of the clay are shown in Table I. Results of X-ray diffraction analysis on small samples of chalcophanite and clay removed from the polished sections are listed in Table II. These indicated that the clay mineral is essentially a 7 Å kandite-type clay. No other mineral phases were identified in the clay by X-ray diffraction. To determine the relationship, if any, between the chalcophanite and the zinc-containing manganeseiferous clay, EPMA line scans were made across the minerals. These showed that the recrystallized chalcophanite-clay junction was sharp and well defined but the junction between the dense finer-grained chalcophanite and clay was characterized in some places by a zone intermediate in chemical composition between chalcophanite and clay. This is illustrated in the EPMA line scans in fig. 2.

Detailed optical study of this region indicates that it has the general appearance of clay rather



FIGS. 1 and 2. FIG. 1 (top). Scanning electron micrograph of polished section of recrystallized chalcophanite showing abundant (0001) cleavages ($800\times$). FIG. 2 (bottom). Electron-probe microanalysis line scans across the transition layer between clay and chalcophanite.

than of chalcophanite, and it is here suggested that this transition zone is a clay partially altered to chalcophanite by some type of solid-state reaction.

Genesis. These investigations have shown that there is an intimate relation between chalcophanite and a clay as demonstrated by the presence of a transition zone between these minerals with intermediate levels of Mn, Zn, and Si. If the transition zone is interpreted as a solid-state reaction zone

TABLE I. *Electron-probe microanalysis of chalcophanite and clay (wt %)*

	Chalcophanite			Clay
	Area 1	Area 2	Area 3	
MnO ₂	73.50	76.09	72.38	0.48
ZnO	15.20	15.61	13.23	0.37
SiO ₂	0.04	0.02	0.08	45.46
Al ₂ O ₃	0.04	0.04	0.12	38.37
FeO	0.23	0.22	0.19	0.15
NiO	0.01	nd	nd	nd
CaO	0.02	0.04	nd	nd
CoO	0.01	0.01	0.03	0.02
Total	89.05	92.03	86.03	84.85

nd = not detected

then the chalcophanite may be considered as a metasomatic replacement of the clay structure. More particularly, the chalcophanite may be a topotactic transformation (in the sense of Dasgupta, 1974) of the clay mineral. Evidence for this is: the occurrence of a very rare manganese mineral (chalcophanite) within an older, widespread clay-manganese oxide horizon; the presence of a transition layer between clay and fine-grained chalcophanite; the fact that both the kandite group clays and chalcophanite are layer lattice minerals with major crystal spacings at about 3.5 Å and 7 Å.

These facts suggest that the fine-grained chalcophanite developed by reaction of a 7 Å clay mineral containing traces of Zn scavenged from a marine environment and Mn ions derived from adjacent cryptomelane. The prominent structural unit d_{100} at 7.10 Å of the clay was replaced by a structural unit of layered MnO₆ octahedra with similar spacings as a result of a low-temperature topotactic transformation. At the same time Zn present at

TABLE II. *X-ray diffraction of chalcophanite and clay*

Chalcophanite		Clay	
I	d (Å)	I	d (Å)
100	7.05	100	7.10
50	4.10	90	3.58
60	3.51	80	2.37
50	2.60	90	1.49
50	2.23	80	1.28
30	1.90	90	1.13
40	1.62		

trace levels in the clay concentrated for crystal chemical reasons within the chalcophanite. Subsequent crystallization produced coarser tabular crystals.

These deductions suggest that the nature of clay minerals in sediments may influence or even control the development of later manganese oxide minerals in a way which has been hitherto little imagined.

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[*Manuscript received 2 July 1980*]

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MINERALOGICAL MAGAZINE, MARCH 1981, VOL. 44, P. 111

Pargasite-rich rock from the Eastern Ghats, India

A UNIQUE occurrence of pargasite-rich rock containing 60% pargasite, 39% fassaite, and 1% spinel occurs 2.4 km north of Aganampudi village (Long. 83° 8' 12" E; Lat. 17° 34' 40" N) in Visakhapatnam District, Andhra Pradesh, within the 'Charnockite region' of the Eastern Ghats of the Precambrian of India (Fermor, 1936). It occurs as a conformable body in Khondalites. The sharp contacts and inward coarsening of grain size suggest an igneous origin.

The chemical analyses of pargasite and fassaite are given in Table I along with number of metal ions. The Mg/(Mg + Fe²⁺) ratio (0.752) and Si (6.17) indicate that the analysed amphibole is a pargasite according to Leake (1978).

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[*Manuscript received 1 September 1980*]

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TABLE I. *Chemical analysis of pargasite and fassaite*

	Number of ions on the basis of 24(O,OH,F) 6(O)			
	1	2	1	2
SiO ₁	42.05	46.52	Si	6.170 1.742
Al ₂ O ₃	15.86	10.07	Al	1.830 0.258
Fe ₂ O ₃	2.36	2.22	Σ	8.000 2.000
FeO	8.35	5.26	Al	0.912 0.187
MnO	0.21	0.31	Ti	0.084 0.009
MgO	14.18	11.45	Fe ³⁺	0.264 0.063
CaO	10.98	22.58	Fe ²⁺	1.023 0.164
Na ₂ O	2.52	0.27	Mn	0.026 0.010
K ₂ O	0.83	0.15	Mg	3.098 0.637
Cr ₂ O ₃	0.12	0.06	Cr	0.017 0.002
TiO ₂	0.76	0.32	Σ	5.424
H ₂ O ⁺	1.28	0.28	Ca	1.728 0.905
H ₂ O ⁻	0.12	0.12	Na	0.714 0.020
F	0.08	—	K	0.159 0.007
O ≡ F	0.035	—	Σ	2.601 2.004
			OH	1.251
			F	0.035
			Σ	1.286
Total	99.665	99.61		

The pargasite and fassaite have 2V, 88° and 56-60° and Y:Z 20-24° and 38-42° respectively.

1. Pargasite from amphibole-rich rock, Aganampudi.
2. Fassaite from amphibole-rich rock, Aganampudi.

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