of attracting the attention of geologists in other parts of the world to areas where the geological relations are similar to those here discussed, and inducing them to study their own examples in the same way as Professor O. T. Jones has so admirably done for the Lower Palaeozoic geosyncline of the British Isles. In most of the cases here described there are no fossils; whether this is a help or a hindrance in their study and in similar instances, is perhaps an open question.

Kyanite-Gedrite Parageneses.

By C. E. Tilley.

DISCUSSION of the genesis of kyanite-amphibole associations in amphibolites has so far been limited to assemblages involving common hornblende (1). Striking examples of an association of kyanite with rhombic amphibole (gedrite) now known from the Archaean gneisses of the White Sea area, Russia, visited by the Northern Excursion of the International Congress in 1937, probably provide one of the first records of this paragenesis in the literature.[1] The rocks of the region include coarse-grained garnet and kyanite rich gneisses associated with amphibolites in the Shueretsky district of Karelia, and have been described by Ignatiev (2).

Among the amphibole-bearing types—garnet-amphibolites (some with cummingtonite) and garnet-gedritites are not uncommon, and the whole suite, sediments as well as basic igneous rocks, are believed to have experienced two distinct periods of movement and metamorphism—Post-Svionian and Post-Bothnian. On the occasion of the International Excursion, gedritites containing large kyanite crystals attracted special attention on account of their unusual paragenesis. Though Ignatiev has published an analysis of a gedrite from the Terbeostrov (Shueretsky) gedritites it is desirable that an analysis of the amphibole should be available from a rock in which kyanite is intimately associated.

An analysis of a gedrite in this aluminous environment has therefore been carried out on material collected by the writer from Shueretsky. The rock type from which the mineral was isolated is composed of a coarse-grained aggregate of gedrite intimately mixed with kyanite and containing large but sporadic garnets. Kyanite also occurs in nests with quartz.

In slice the rocks are seen to contain, in addition to the above minerals, accessory biotite, apatite, magnetite, and a little plagioclase (andesine). Staurolite is normally absent but in some slices an occasional grain is found associated with kyanite or gedrite. The

[1] Des Cloizeaux (*Nouv. Rech.*, Paris, 1867, p. 32) mentions this association in a study of "Anthophyllite" from Cordier's collection.

dominant minerals of the slices are gedrite, kyanite, and quartz. The analysis is set down in Table I while in Table II comparable gedrite analyses are added. The high content of alumina of the Karelian gedrite is exceeded only in two analyses, those of the gedrites of North Carolina and of Fiskernäs. A previous analysis of a Terbeostrov gedrite cited by Ignatiev is also included.

These analyses provide a striking commentary on the influence of a highly aluminous environment (associates kyanite, garnet, sapphirine, spinel, and corundum) on the composition of rhombic amphiboles. The low content of silica shows that aluminium is partly replacing silicon in the (Si_4O_{11}) bands and partly magnesium in the crystal structure (cf. Table I).

Table I.

	1	Metal atoms to 24 (O, OH).				
SiO_2 .	44·09	6·301		8·00		
Al_2O_3 .	17·22	2·904	1·699 / 1·205			
Fe_2O_3 .	1·87	0·200				
TiO_2 .	0·31	0·033				
FeO .	15·02	1·796		6·88		
MgO .	17·12	3·646			7·30	
MnO .	0·14	0·016				
CaO .	0·51	0·078				0·42
Na_2O .	1·24	0·344				
K_2O .	tr					
H_2O +	2·03	1·936			1·94	
H_2O −	nil					
	99·55	Sp. Gr. 3·259 α 1·651 γ 1·672 ·+				
		Absorption α and β greenish yellow, γ greyish green.				

1. Gedrite from kyanite-garnet gedritite, Terbeostrov, Shueretsky, Karelia, U.S.S.R. Anal. H. C. G. Vincent.

In previous discussions of gedrite parageneses the apparent antipathetic character of gedrite (anthophyllite) and aluminium silicate minerals has been remarked.

In the anthophyllite-cordierite rocks of Orijärvi referred to by Eskola (3), sillimanite protected by cordierite was regarded as an "armoured relic", the relations being expressed by the equation:—

(*a*) anthophyllite (gedrite) + sillimanite + quartz $\rightleftarrows$ cordierite,

and I have previously referred in discussing the Lizard assemblages (4) to the possibility of a reversible relation expressed by the equation:—

(*b*) gedrite + andalusite ⇄ staurolite + cordierite,

with the implication that normally the right hand side of this equation is the stable assemblage.

In discussing the kyanite-staurolite and staurolite-gedrite gneisses of the Oslo district, Broch (5) has commented upon the absence of association of kyanite and gedrite in those rocks, and noted that staurolite may represent the intervening mineral. There, and in the assemblages of Terbeostrov now described, physical conditions of metamorphism doubtless account for the absence of cordierite.

TABLE II.

	1	2	3	4	5
SiO_2 .	44·09	44·22	46·18	43·58	46·50
Al_2O_3 .	17·22	23·79	21·78	17·07	15·48
Fe_2O_3 .	1·87	0·20	0·44	—	0·89
FeO .	15·02	9·21	2·77	15·96	16·01
MnO .	0 14	0·16	—	—	nil
MgO .	17·12	20·69	25·05	18·30	17·62
CaO .	0·51	0·62	—	0·75	0·81
Na_2O .	1·24	—	2·30	—	0·77
K_2O .	tr	—	—	—	0·12
H_2O + .	2·03	1·42	1·37	3·92[1]	1·19[1]
H_2O − .	nil	—	—	—	—
TiO_2 .	0·31	—	—	—	0·89
	99·55	100·31	99·89	99·58	100·28

1. Gedrite from kyanite-garnet-gedritite, Terbeostrov. Anal. H. C. G. Vincent.
2. Gedrite from garnet-hypersthene gedrite rock, Mason's Mt., Franklin, N. Carolina. E. P. Henderson, *Amer. Min.*, 1931, vol. xvi, 563.
3. Gedrite from sapphirine-bearing rock, Fiskernäs, Greenland. N. V. Ussing, *Zeits. für Kryst.*, 1889, vol. xv, 609.
4. Gedrite, Gèdres, associated minerals include spinel and corundum. A. Des Cloizeaux, *Man. Miner.*, 1, 1862, 542.
5. Gedrite, Terbeostrov, Shueretsky, White Sea. N. A. Ignatiev, (2), 73.

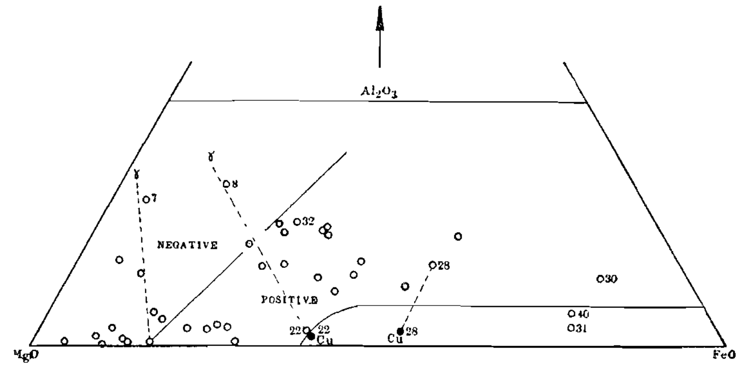
In the preceding assemblages (*a*), (*b*), the cordierite solid solutions (Mg → Fe) were considered as the intervening phase. In a magnesia-rich assemblage, staurolite, presumably by reason of its essential ferrous character, cannot play the same rôle. It would be of interest to ascertain whether the development of gedrite-kyanite assemblages is thus to be linked to a magnesia-rich environment. This point should be a matter of inquiry in further examples investigated, for it is clear that accurate analyses of the constituent phases form a pre-requisite for a fuller understanding of a varied mineral paragenesis.

[1] Loss on ignition.

THE COMPOSITION FIELD OF ANTHOPHYLLITE AND GEDRITE.

In figure 1 the compositions of analysed anthophyllites and gedrites are expressed in terms of the system $FeO-MgO-Al_2O_3$. The line drawn through the ternary field separates anthophyllites and gedrites of optically positive and negative character. Gedrites are usually referred to in textbooks as negative but the majority of analysed examples are actually positive—only those rich in magnesia like the gedrite of Fiskernäs being negative.

From the data available no satisfactory system of isofracts can as yet be drawn within the figure, but the general course of the γ values is suggested by the broken lines inserted in the left-hand part of the figure.



TEXT-FIG. 1.—Composition field of anthophyllite-gedrite series in the system $FeO-MgO-Al_2O_3$. Points numbered represent analyses of minerals referred to in the text, (7) Fiskernäs, (8) N. Carolina, (22) Ryfylke (anthophyllite and cummingtonite), (28) Isopää (anthophyllite and cummingtonite), (30) Gèdres, (31) Mesabi, (32) Terbeostrov (Table I), (40) Penge, Transvaal. The broken lines γ refer to approximate γ isofracts (1·64 and 1·66).

Very few reliable data on iron-rich members (ferroanthophyllite or ferrogedrite) exist. In the figure the points 30, 31, and 40 represent analyses of material reported to be rhombic amphiboles. Of these (30 Gèdres, 31 Mesabi, 40 Penge, Transvaal), the last, an " amosite " appears the most satisfactorily determined. It is certainly a remarkable fact that the extreme iron-rich amphiboles are for the most part monoclinic grunerites. Sundius (6) has attempted to define a field towards the iron side of the diagram restricted to such monoclinic amphiboles and the limits of his field are approximately indicated in the figure. Across this field two analyses of cummingtonite (22 and 28) have been joined by tie lines to their respective paragenetic anthophyllites (Ryfylke, Norway (6), p. 425, and Isopää, Finland (7), p. 482).

The existence of natural monoclinic amphiboles containing more than 60 per cent magnesio-cummingtonite has not yet been established. Since Sundius's work an example described by Simpson (8) from W. Australia is reported to contain as much as 76 per cent of the magnesium member, but it has recently been shown by Winchell (9) that the analysed material was composite and consists largely of rhombic amphibole. Winchell's identification of the second constituent of the sample analysed as a cummingtonite of comparable composition rests as yet on insufficient evidence.

It is certainly worthy of note that cummingtonites are rarely mentioned as metamorphic products of highly magnesian rocks as peridotites, serpentines, etc. We need only recall the common association of anthophyllite-schists with serpentine or the mantles of anthophyllite surrounding magnesian olivines of peridotites.

Here we may contrast the cummingtonitic character of the colourless amphiboles associated with the more iron-rich rhombic pyroxenes as in certain norites and xenolithic rocks related to them. This apparent lack of data on magnesium-rich cummingtonites is the more remarkable considering the synthesis by Bowen and Schairer (10) of a wide range of monoclinic magnesium-iron fluor-amphiboles. It is evident that the anthophyllite-cummingtonite series of minerals still holds some problems—both mineralogical and petrological—the solution of which requires continued investigation.

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REVIEWS.

Geology of India. By D. N. Wadia. Pp. xx + 460, 20 plates, 45 text-figures. London: Macmillan and Co., Ltd., 1939. Price 24*s*.

The first edition of this book was published in 1919, and received favourable notice as filling a "long felt want". In 1926 it was reprinted, with only minor modifications. In the present edition, however, the book has been brought up to date, and incorporates the advances that have been made during the twenty years that have elapsed since the first edition was published, notably in the sections dealing with the Himalaya, in investigating which the author has himself taken a leading part. The general layout of the book is the same as in previous editions, a chapter on the physical features of India being followed by chapters describing the stratigraphy of each system, a chapter on the economic geology of India, and a final chapter on the geology of Kashmir in which the geological history of one region, unusually complete in its records, is given as a recapitulation of the geology of the Himalayan region. This last chapter, however, while of much interest in itself, comes rather near to upsetting the balance of the book, for the history of this region was vastly different from that of the major portion of India. The most welcome innovation is the addition of a coloured geological map of India and Burma on the scale of 96 miles to 1 inch, which embodies the results of recent surveys in the Himalaya, Rajputana, and Assam. Though small in scale, it provides an adequate picture of the geology of this sub-continent, which a larger map would do no better.

In the previous editions the weakest part of the book was undoubtedly the section dealing with the Archaean rocks; and though this has been improved in the present edition, the treatment still remains very inadequate. Of the 253 pages devoted to general stratigraphy, but 30 pages have been allotted to the Archaean (the same number as to the Pleistocene and Recent), though these rocks make up roughly three-fifths of Peninsular India, provide a large proportion of India's mineral wealth (including gold, iron, manganese, amd mica), and have probably received more attention from geologists than the rest of India put together. Admittedly the geology of these old rocks provides many problems of great difficulty, but it is also of great interest and deserves more adequate treatment. It is the reviewer's opinion that this section of the book would have been greatly improved (certainly from the point of view of the Indian student) if the general principles underlying the classification and correlation of these old rocks had first been discussed, followed by the application of those principles, in so far as is possible, to the