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ON THE OCCURRENCE OF LIMURITE IN TASMANIA.

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Limurite (Frossard), described by F. Zirkel (N. Jahrbuch für Mineralogie, 1879).

This peculiar and interesting rock occurs in considerable quantity at North-east Dundas, on the property held under mineral lease by the Colebrook Prospecting Association (Section 216, 93M). It apparently consists of a huge contact mass, which is of an irregular lenticular form, being bounded on its eastern side by a hard dark-coloured metamorphic slate, probably of silurian age, and on the western side wholly or partially by green serpentine, which is in places much decomposed.

So far as known, no granite rock exists in immediate connection with its occurrence, but such acidic rocks are abundant within a comparatively short distance. By the decomposition of the rock itself, as well as of the iron-bearing ores it contains, the actual outcrop of the mass has been converted to a gossan material, which projects with extreme irregularity above the surface of the enclosing rocks, after the form of a laccolite. Samples of the rock broken from, beneath its outer crust present a very attractive appearance and show clearly the violet-coloured mineral axinite in extremely well-formed oblique rhombohedral plates, which are almost tabular, the browner augite and milk-white calcite with occasional patches of actinolite.

Macroscopically the axinite is found in large lustrous crystal masses, the individual crystals often reaching half an inch in length, thus forming specimens of great interest to the mineralogist. The augite is also in large crystals, but scarcely distinguishable from the more abundant axinite. The calcite is at times obtained in somewhat large masses, in which are often imbedded isolated crystals of axinite, which can be readily freed from the matrix by digestion in acid. The actinolite varies from felted aggregations of microscopic size to radiating collections of blades, occasionally some inches in length, in the latter case presenting unusually fine examples of the species. Various metallic minerals are found as accessory constituents, of which pyrrnotite is apparently

most abundant; but pyrite, chalcopyrite, and more rarely leucopyrite, occur in patches of variable size throughout the rock. These are decomposed on the surface to iron-oxide, thin films of native copper, and small quantities of the carbonates of the same metal. In thin sections, when examined under the microscope, the bulk mass of the rock is seen to consist of axinite, augite, and calcite, with some hornblende. The other minerals appearing in lesser quantity are quartz, chlorite, actinolite, tourmaline, and granular sphene.

Details of Micro Examination: Axinite.—This is in large, irregular, and also sharply defined crystals, in section of a pale lavender colour to a deeper shade of the same tint. Interference colours, lavender, yellow, blue, sometimes interpenetrating twins. Cleavage lines irregular, Pleochroism scarcely perceptible. The axinite has enclosures of quartz and fibrous augite, and has been replaced occasionally by clear quartz and vermicular chlorite, the latter light green in colour, pleochroic, showing fixed dark cross, and polarising steel grey. The quartz is very clear, and contains small prisms and needles of strongly absorptive tourmaline. The tourmaline-bearing quartz is probably original, and the tourmaline may be looked upon as resulting from the same boracic acid emanations which were involved in the crystallisation of the axinite. Where the quartz is secondary, replacing axinite and augite, it contains long needles of actinolite.

Augite.

This mineral is in large plates and crystals, sometimes twinned. The sections out of the zone of the vertical axis give an extinction angle as high as 40deg. The augite is changing to hornblende; sometimes it is quite uralitic, *i e.*, the crystal form is still that of augite, though its substance has been converted into fibrous hornblende. The substance has often been replaced by calcite and quartz. In the granite contact zone of Cornwall the augite of the foliated diabase is often uralitic, becoming hornblende at the margins, whereas in the Colebrook rock it has suffered uralitisation all through in patches. The uralitic fibres, greenish in colour, are parallel and pleochroic, and between them are parts of the non-pleochroic augite which have remained unaltered.

Hornblende.

There are a few lozenge-shaped sections, colourless without the cleavage lines or pleochroism of hornblende, but which appear to be that mineral. They resemble many of the sections occurring in amphibolites.

Calcite.

This is in variable quantity, sometimes very plentiful. It fills the angles of the rock, and is generally limited by sharply defined linear boundaries. Its rhombohedral cleavages are strongly marked.

Quartz.

This is everywhere clear. There seems to be two phases in which it occurs. Its original condition is where it contains tourmaline prisms, its secondary one where its enclosures are needles of actinolite.

Sphene.

This is always granular, is abundant, and has probably separated out during the alteration of the augite.

The rock constituents seem to be present in about the same proportions as those assigned by Zirkel to limurite, and vary in the same manner. Thus he remarks that the axinite is the basis of the rock, in which it appears now and again in the form of large homogeneous crystals, while other parts of the rock show augite and hornblende intergrown plentifully. Professor Zirkel has been good enough to send to one of us a sample of his limurite, and a copy of his paper "Limurit aus der Vallée de Lesponne," from which we take the following abstract of the occurrence of the rock:—"This rock was first seen in the river bed of the Adour, but was found in large blocks at the Bridge of Gerde. At last Count Limur found it *in situ* as a rock covered with moss above the Cabin Chiroulet in the valley of Lesponne. Nothing further is known of it geologically beyond that in the upper parts of this valley there is mica schist, with andalusite, garnet, vesuviante, as well as tourmaline-bearing granite. The rock is tough under the hammer. To the naked eye there are visible dark violet-green individuals of pure, sometimes striped, axinite, nearly an inch long sometimes; also other confused flakes of axinite, traversed by very fine deep grass-green grains with other green parts which consist of an aggregate of these grains. Here and there are large cavities into which the sharp edges of axinite crystals protrude, or small cavities where the green mineral forms little crystallised heaps like warts, whose component individuals under the magnifier look like little fassaites. Besides these are some granules of clear quartz, specks of iron pyrites, and the fresh rock effervesces in parts with HCL. Under the microscope the following constituents are recognisable:—

"1. *Axinite*, with sections blue, grey-brown, to nearly colourless, no particular cleavage. In coloured sections pleo-

chroism is perceptible, though not specially strong. The homogeneity of the mineral is only disturbed by some fluid inclusions and steam pores. Where the axinite protrudes into the clear quartz it gives very sharp sections of its small crystals.

"2. Plenty of monoclinic *augite*, greenish-yellow to colourless. Many of these small sharply contoured augites show pinacoidal surfaces, and such sections have parallel cleavage cracks. Extinction angle about 45deg.

"3. Dark-green *hornblende*, not so plentiful as augite. Very fibrous and pleochroic, sometimes in transverse sections, extinction angle about 17deg. Often hornblende and augite are so related that one is inclined to believe that the former issued from the latter. In the large light-coloured long sections of augite you often see dark green fibrous hornblende patches, and both merging into one another without sharp boundaries. If it is here probable that the hornblende belongs to uralite, the proof of it has not been found, viz., in hornblende with augite cross sections.

"4. Water-clear *quartz*, with fluid inclusions and movable bubbles. In the quartz are little crystals of augite and titanite.

"5. *Carbonate of lime*, with sharp rhombohedral cleavages; quartz and carbonate of lime where they touch each other are always separated by quite rectilinear boundaries; in the lime are also augite grains.

"6. Pale brown-grey titanite in wedges, usually several crystals together.

"7. Ores.—Iron pyrites and magnetic iron.

"The axinite forms 60 per cent. of the rock, augite and hornblende 30·35 per cent., and lime 10·5 per cent. Axinite seems to be the basis of the rock, but parts of it are so traversed by augite and hornblende that these seem to form the rock. Quartz and lime are only sporadic, and look as if they only filled holes in the rock, though they are probably primary constituents. The rock is characterised by the absence of felspar, also of mica chlorite, or a lime mineral. Petrographically it is a rock quite as typical as eklogite or cherzolite."

In a letter dated October 17, 1896, Professor Zirkel writes:—"According to the latest observations of M. Lacroix in Paris (Comptes rendus CXIV., 1892, 955), this limurite geologically does not belong to the series of crystalline slates, but forms small veins in the metamorphic palæozoic limestones and the adjoining granites, it must be considered as a product of the granitic action, and is, as topaz, tourmaline,

and tin-stone in other places, probably formed by fumaroles, which accompanied the eruption of the granites."

Professor A. Lacroix, in his "Memoire sur l'axinite des Pyrénées, ses formes et les conditions de son gisement, 1892," alludes to limurite as follows:—"This latter variety of axinite is associated with calcite, quartz, pyroxene, and green hornblende. It consists occasionally of small veins several decimetres wide, and at some spots forms a compact very tough rock, found as stones in the bed of the Adour, and described by Zirkel under the name of limurite. This rock, the geological relations of which were hitherto unknown, does not belong to a definite petrographical type. It varies in structure and mineralogical composition in the different parts of the same bed."

Professor Lacroix considers it probable that the formation of axinite in the Pyrenees has proceeded under the influence of boric acid emanations acting on the walls of the sedimentary rocks which they traverse. He has established the constant appearance of axinite at the contact of granite with the palæzoic rocks, and concludes that it owes its origin to granitic fumaroles following the intrusion of the eruptive rock.

M. Daubrée has cited axinite as produced in a palæozoic limestone of the Vosges at its contact with a hornblende or mica porphyrite (Comptes rendus t. XVIII., p. 870, 1844).

In Cornwall axinite, garnet, brown mica, and tourmaline are minerals of the contact zone in foliated diabases and basic hornblende slates, the latter possibly altered lavas, when tourmaline-bearing granites have acted upon them.

Mr. J. Collett Moulden, A.R.S.M., Lond., is the author of "Petrological observations upon some South Australian rocks" (Trans. Roy. Soc., S. Aust., 1895, Vol. XIX.), in which he has described an axinite amphibolite from Rosetta Head. He says the rock consists mainly of hornblende with a colourless augite, and axinite as a rock-forming constituent in considerable quantity. Accessories are biotite, quartz, and chlorite.

Rosenbusch states (Microscopical Physiography, Rosenbusch-Iddings, 1895, p. 344), "Axinite occasionally occurs on the borders of diabases and granites, and among their contact products."

It is thus fairly well established by high authorities that the axinite rock occurring in the Pyrenees and at North East Dundas is of remarkable petrological interest as a rare example of an igneous contact occasioned by acidic plutonic action causing emanations of boracic acid with other matter in the form of fumaroles. Notwithstanding the known occur-

rence of an aberrant form of axinite rock at Rosetta Head, S.A., the discovery here described is unique in Australian petrology, so far as is known, and moreover the only other recorded occurrence of what may be termed true limurite is that originally detailed by Zirkel. The association of copper ores with the Colebrook rock lends additional importance to the discovery, although it is not within the scope of this paper to deal with its economic aspect.

The specimen sent fairly represents the general characteristics of the rock.

EXPLANATION OF PLATE.

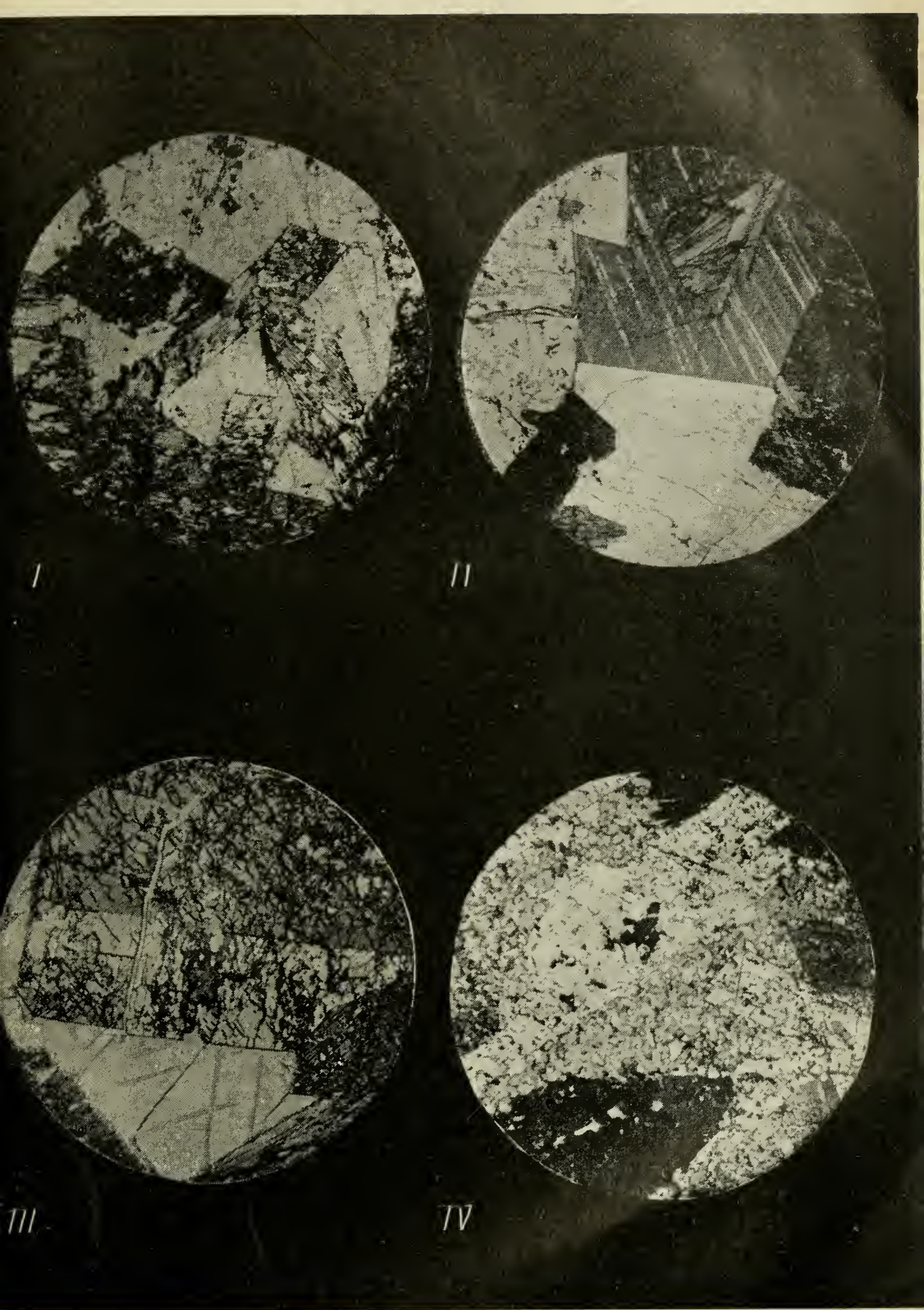
Limurite from North-east Dundas.

Fig. 1. Limurite. × 14. Crossed nicols. The dark periphery is uralitic augite. The crystals in centre of field are actinolitic hornblende. The white portion is calcite. No axinite in this section.

Fig. 2. Limurite. × 14. Crossed nicols. The light areas are axinite. The striped portion is calcite showing cleavages. The dark crystals right and left are augite.

Fig. 3. Limurite. × 20. Crossed nicols. This represents large twinned crystal of augite, bounded by calcite with rhombohedral cleavages.

Fig. 4. Axinite. × 20. Crossed nicols. Section cut through an aggregate of axinite crystals.



TWELVETREES, Photo-Micro.

LIMURITE.