

An occurrence of morenosite in Ireland

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Summary. An Irish locality for morenosite is recorded. A chemical analysis shows that a small amount of magnesium is present and this agrees with the composition as indicated by refractive index measurements. X-ray powder data confirm the identification and the genesis of the mineral is briefly discussed.

IN March 1961 we visited the St. Patrick's copper mine at Avoca, Co. Wicklow, Ireland. Whilst collecting specimens from the opencast workings we found a greenish-white mineral occurring as an efflorescence in cavities and joints in the mineralized areas. It was found only where overhanging rock had protected it from the direct effect of rain. Traces of limonite give some specimens of the mineral a perceptible brown tint, and limonite, gypsum, and native sulphur are the associated secondary minerals. At the end of our visit, Dr. G. J. Murphy, the Mine Geologist, handed us a specimen of a fine-grained white efflorescence collected from an old adit in the mine area. Qualitative tests indicated that both these specimens were nickeliferous and worthy of further investigation. This has shown that both are the nickel sulphate heptahydrate—morenosite.

Physical properties. The specimens from the opencast working and from the abandoned adit consist of an efflorescence of tiny crystals whose average prism length is about 0.12 mm. The opencast material was pale apple-green when collected, but that from the adit, which had been in a centrally heated office for some time, was white. After several months of storage, again in centrally heated conditions, the opencast material became much paler in colour. Both specimens, however, became pale apple-green when moistened.

Mounted in refractive index oils individual crystals are colourless and one distinct cleavage is apparent. Measurements of the refractive indices in sodium light gave $\alpha = 1.467$ and $\gamma = 1.489$ for material from the opencast workings. These values are close to those given for

morenosite by Dufet (1878) ($\alpha = 1.4693$, $\gamma = 1.4923$) and by Frondel and Palache (1949) ($\alpha = 1.470$, $\gamma = 1.500$).

Chemical properties. The mineral is readily soluble in hot water and has a strong astringent taste. It loses water very rapidly on heating; most of it can be driven off at temperatures below 105° C. After heating at 240° C for some hours a white anhydrous powder is formed. An analysis of material from the opencast workings by gravimetric methods gave: NiO 25.06, MgO 1.31, SO₃ 29.48, H₂O < 105° C 34.85, H₂O 105°–225° C 7.43, H₂O > 225° C 1.87 % (by difference); total H₂O 44.15 %.

X-ray powder photographs of the opencast and adit specimens were taken. The patterns were essentially the same, but carried more lines than are given on the ASTM Powder Data File card no. 1-0403. A powder photograph of morenosite from Austria prepared for comparison purposes was almost identical with those from the Irish material. A consideration of the chemical analysis, the X-ray powder data, and the refractive indices shows that the material from St. Patrick's copper mine is morenosite and not retgersite (NiSO₄.6H₂O). Dr. M. H. Hey has suggested to us that the extra lines obtained from the natural material are due to partial breakdown or dehydration of the morenosite caused by powdering or by exposure in the X-ray beam.

Discussion of properties. The chemical analysis shows a significant content of magnesia and indicates that this Irish material falls within the solid solution series from morenosite to epsomite. Hutton (1947) demonstrated that the refractive indices decrease linearly to the values for epsomite as magnesium substitutes for nickel. The optical and chemical data for the Irish specimens are plotted on an adaptation of part of Hutton's figure for this solid solution series, given here as fig. 1. They are in good agreement with his lines.

A further point that should be mentioned is that the amount of water determined is below that expected for a heptahydrate. It is, however, a little above that for the hexahydrate retgersite. Frondel and Palache (1949) report that morenosite generally dehydrates on standing to retgersite and it might be argued that a doublet observed at about 4.28 Å and 4.38 Å for the Irish material indicates a mixture of morenosite and retgersite—the principal line for the latter is at about 4.25 Å. However, when mounted in oil of refractive index 1.489 no phase with a higher refractive index could be detected. It is therefore concluded that no significant alteration to retgersite has occurred and that morenosite can lose a small amount of water without its

physical properties being appreciably affected. A similar conclusion was reported by Hutton (1947) when discussing the properties of nickelian epsomite from New Zealand.

Genesis. Murphy (1959) reports that the Avoca ore-bodies consist of low grade sulphide replacement deposits in schistose tuffs, lavas,

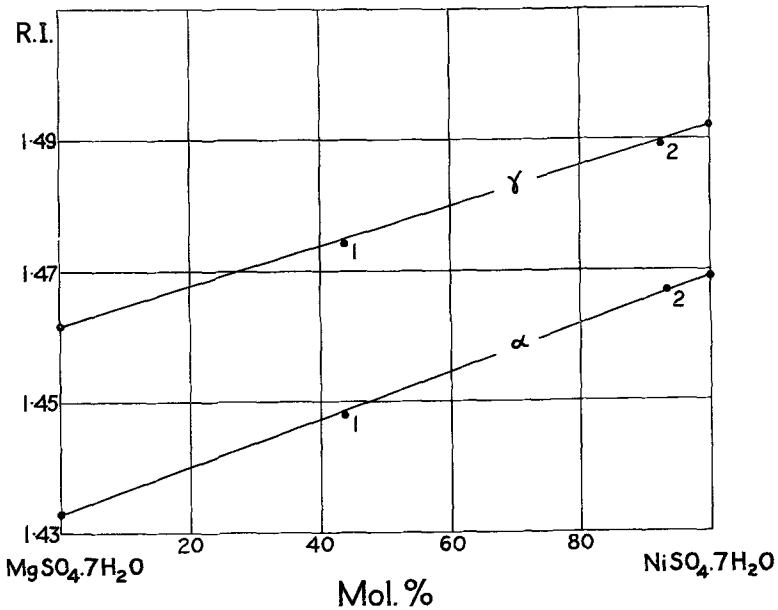


FIG. 1. Properties of the epsomite-morenosite series adapted from Hutton (1947). Points 1 are for nickelian epsomite from New Zealand and points 2 are for the morenosite discussed in this communication.

and intrusions of a dominantly acidic nature and in fine-grained argillaceous sediments. The ore minerals, in order of abundance, are pyrite, chalcopyrite, blende, and galena, with rare arsenopyrite and tetrahedrite. Appreciable amounts of gold and silver occur in some of the ores. Murphy remarks on the apparently complete absence of pyrrhotine in the ore bodies. The principal gangue minerals are quartz and carbonates.

The absence of basic rocks from the mine area suggests that most or all the nickel for morenosite formation has come from one of the ore minerals rather than from the weathering of nickelian silicates. It is, however, present in the ore in very small quantities as assays of the mill concentrates only show 0.001 % nickel (H. D. Forman, personal

communication). A number of polished sections were therefore prepared and examined for traces of a primary nickel mineral. None was found and no traces of pyrrhotine—a common host of nickel—were seen. A number of spot tests for nickel were made on specimens of the major sulphides. As might be expected, the only positive results were obtained from samples of pyrite and weathering of this mineral has presumably provided the nickel for the formation of morenosite. The magnesium in this morenosite has probably been derived from the weathering of magnesian carbonates present in the gangue.

The last point that requires some discussion is the reason for the development of morenosite rather than retgersite. Frondel and Palache (1949) state that Steele and Johnson have shown that retgersite can be crystallized from pure water solutions at temperatures between 31.5° C and 53.3° C, while Rohmer has shown that retgersite can crystallize at temperatures down to 0° C from solutions with a sufficient excess of sulphuric acid; they consider that this factor may determine its formation in nature in place of morenosite. This probably accounts for the development of morenosite at the St. Patrick's copper mine, for oxidation effects, though striking in parts of the opencast working, are on the whole slight, and Murphy (1959) wrote ' . . . oxidation of the *in situ* rock is generally unimportant'. This, of course, is quite a usual feature of sulphide deposits in recently glaciated areas. Thus, although the pyrite content of the ore-bodies is high, it appears that the concentration of sulphuric acid in the oxidizing solutions was low, causing morenosite rather than retgersite to form.

As far as we know this is the first record of a morenosite occurrence in Ireland. The only other occurrence in the British Isles known to us is near Glen Sanda Castle, Argyllshire (Hedde, 1901). As a result of Frondel's and Palache's work on the nickel sulphates, this record of a Scottish occurrence now needs confirmation.

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