

# PYRITE NODULES OF THE TIMAGAMI COPPER-NICKEL DEPOSIT

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## ABSTRACT

Porous nodules composed essentially of cellular pyrite, noted by company geologists and collected by the writer from the chalcopyrite ore exposed in the open pit of the Temagami Mining Co. Limited on Timagami Island, are described. The nodules appear to occupy relatively smooth-walled cavities within massive chalcopyrite, from which they may be readily separated and removed in places almost intact. Platy ribs and seams of pyrite extend from the nodules into the enclosing mosaic of chalcopyrite crystals, within which they assume a delicate rhombohedral pattern, formed by an intersecting network of chains of minute pyrite cubes. The textural relationships described and illustrated suggest that the nodules may have been formed by recrystallization of pyrite-carbonate-silicate material that was engulfed by fluid magmatic chalcopyrite ore.

## INTRODUCTION

Chalcopyrite-rich deposits in rhyolite and diorite on Timagami Island near the southwest end of the long Northeast Arm of Lake Timagami, about 60 miles northwest of North Bay, Ontario, have been mined by Temagami Mining Co. Limited for copper, gold and silver since 1955. Associated pyrite-rich deposits have been found for the most part to be too low in copper, nickel and precious metals to permit economic recovery to date. The general geology and history of the deposits have been described in a recent report by Simony (1964), in which a detailed compilation map of geology and mine workings by W. S. Savage is presented. Mineralogy and geochemistry are discussed in a separate paper by the writer to be published elsewhere.

Specimens on which this study is based were collected in 1956 with the cooperation of T. O. H. Patrick, then Chief Geologist of the Temagami Mining Co. Limited, and of many others at the mine, all of whom were most helpful in many ways. Spectrographic analyses were made by J. P. Malone, and  $x$ -ray fluorescence analyses by G. R. Lachance, in laboratories of the Geological Survey of Canada. The manuscript has had the benefit of critical reading by colleagues in the Mineral Deposits Section, and by S. E. Jenness of the Geological Survey of Canada.

The occurrence of the pyrite nodules described below was drawn to the writer's attention by Mr. Patrick and others at the mine, and the specimens taken by the writer all came from massive chalcopyrite from the open pits on Timagami Island. So far as is known, the pyrite nodules are found only in the chalcopyrite-rich ore. Nodules of a similar nature have been noted in some of the copper deposits in Chibougamau area of Quebec (personal communication, S. M. Roscoe), and perhaps they are more common than is realized. However, the writer suspects that they are rare, and worthy of detailed description and illustration.

#### DESCRIPTION OF THE NODULES

The nodules are roughly ovoid shaped lumps, composed mainly of cellular pyrite, that occupy relatively smooth-walled cavities in massive crystalline chalcopyrite (Figs. 1, 2, 3). They range in size from about 1/2 inch to 8 inches in diameter, and most of them have 3 unequal axes of dimension. The nodules are porous, vuggy masses of pale-coloured, fine-grained pyrite, criss-crossed by minute, irregular, platy ribs, seams, or stringlets of the same kind of pyrite, in such a manner as to form a stockwork of irregular cells, each of which is lined by the inward projecting faces of minute pyrite cubes. Many of the cells are empty, even in the centres of the nodules but a few are partly filled with dark quartz. Small amounts of quartz and carbonate gangue occur within the chalcopyrite and as rare tiny stringers, some of which connect with the nodules. The cells are more numerous and slightly larger around the margins of the nodules, which makes it possible to dislodge some of the nodules, more or less intact, leaving a relatively smooth-walled cavity in the surrounding chalcopyrite (Figs. 1, 2, 3). A number of cavities on the weathered surface of the ore were formed by loosening and removal of the nodules by weathering and erosion. Some of the nodules near surface have been more or less altered to limonite and goethite by oxidation and hydration of the pyrite *in situ*.

The platy ribs and indeed also the larger cells in some of the nodules show a preferred orientation in the general direction of the plane of the long axes of the nodules (Figs. 1, 2, 3). Many of the pyrite ribs extend continuously from the nodule a short distance into the chalcopyrite, particularly off the elongate ends of the nodules, as shown in (Figs. 3, 4). Having penetrated about 1/8 inch or so into the chalcopyrite, the pyrite ribs lose their identity, apparently becoming dispersed in regular rhombohedral pattern along favoured intersecting rhombic planes within a mosaic of twinned anhedral chalcopyrite crystals. This is best shown

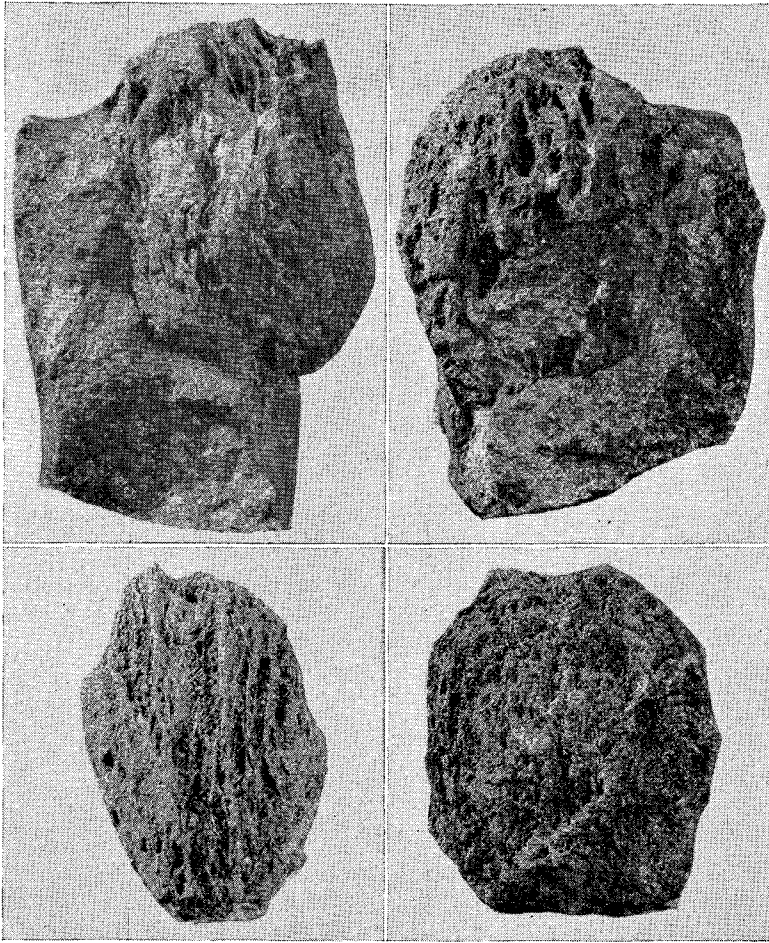


FIG. 1. *Top*. Front view (left) and side view (right) of cellular pyrite nodule in massive chalcopyrite, shows the three dimensional spread of the nodule, its cellular character, and the elongated nature of some of the cells. *Bottom*. Front view (left) and side view (right) of a cellular pyrite nodule that has been removed from the cavity in massive chalcopyrite in which it was found, shows ribbed nature, shape and cellular character of the nodule. Natural scale.

in polished section (Figs. 4, 5), where under the reflecting ore microscope each pyrite stringlet is shown to be a chain of tiny subhedral pyrite cubes, and the formation of the pyrite in the stringlets appears to have been either contemporaneous with, or only slightly later than, the chalcopyrite. The intersecting pyrite stringlets farther away from the

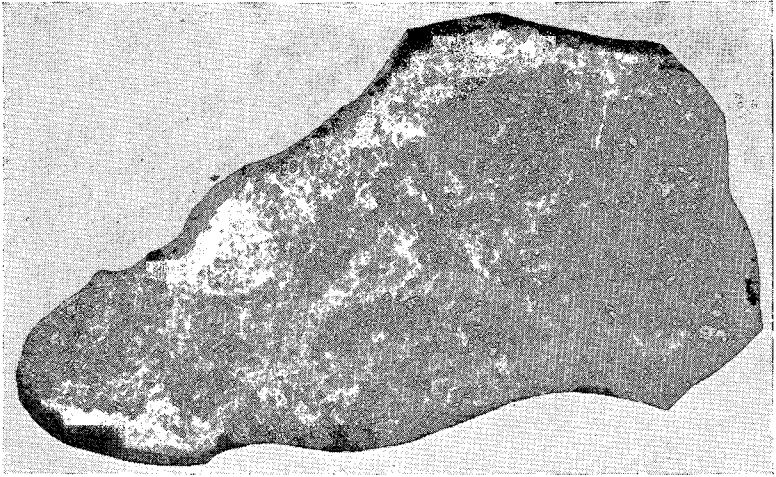


FIG. 2. Hand specimen of massive chalcopyrite, shows broken half of ovoid cavity (dark, in shadow) from which a cellular pyrite nodule has been removed. The cavity in the chalcopyrite shows relatively smooth walls.  $\frac{2}{3}$  natural scale.

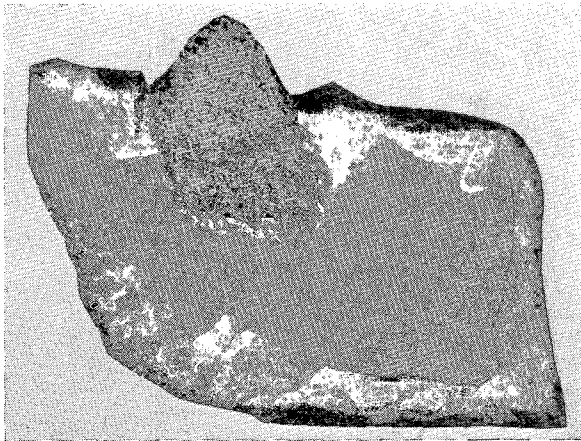


FIG. 3. Polished surface cut through a cellular pyrite nodule within massive chalcopyrite, shows the porous nature of the nodule (pyrite, white; cavities, black), its roughly ovoid shape, the penetration of pyrite stringlets from the nodule into the chalcopyrite (grey), and the rhombohedral pattern made by tiny pyrite stringlets (white) within the chalcopyrite (grey). Natural scale.

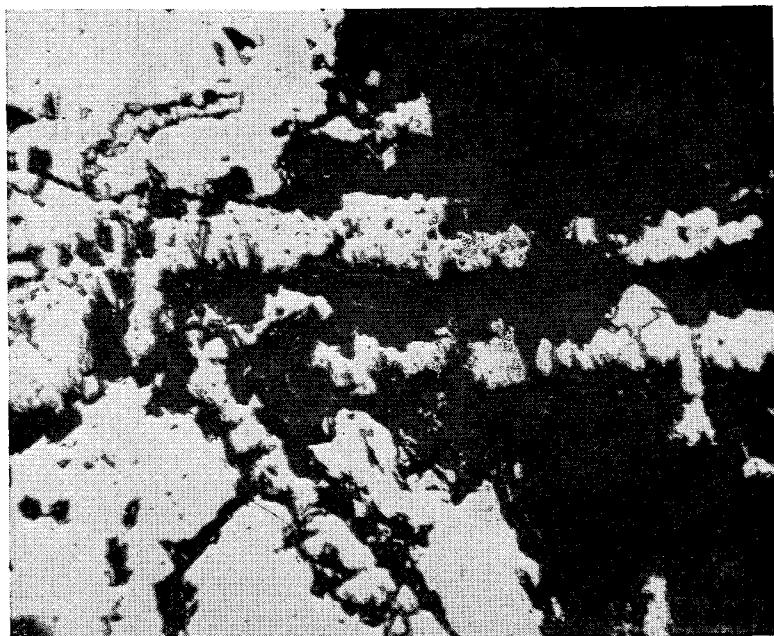


FIG. 4. Photomicrograph of polished surface of end of nodule shown in Fig. 3, shows cavity at end of nodule (black), in contact with chalcopyrite (white, smooth, low relief), both penetrated by stringlets of pyrite (white, rough, blocky, higher relief). Reflected light, parallel nicols,  $\times 48$ .

nodules are also shown to be of a similar nature and they form a delicate pattern so regular that it strongly suggests either crystallographic or structural control. The writer suspects that some pre-existing structure, such as that of a carbonate mineral, was the control, since the stringlets show no apparent relationship to crystal boundaries or twinning planes in the chalcopyrite mosaic, as they might be expected to do if they were the result of exsolution. However, it is possible that recrystallization of the chalcopyrite may have masked the original texture.

A carefully chosen sample from a pyrite nodule proved to be relatively pure, showing a content of 46.5 per cent iron by  $x$ -ray fluorescence analysis (theoretical 46.6 per cent), as well as 0.5 per cent copper, 0.2 per cent nickel, 0.002 per cent silver, and traces of Si, Mn, Mg, Ca, Al and Cr from spectrographic analysis. Of these elements only silver appears to be appreciably enriched over that in pyrite of the associated pyrite-rich deposits.

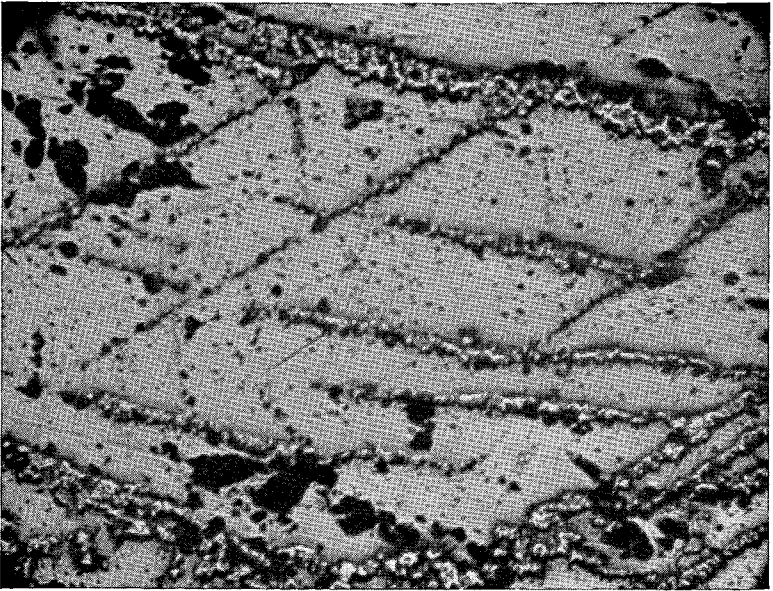


FIG. 5. Photomicrograph of part of polished surface pictured in Fig. 3, about half an inch from the end of the pyrite nodule, shows chalcopyrite (smooth, white, low relief) carrying grains of disseminated gangue minerals (black) and penetrated by intersecting stringlets of pyrite (blocky, white, high relief). The pyrite stringlets form a rhombic pattern within the chalcopyrite. Reflected light, parallel nicols,  $\times 130$ .

#### ORIGIN OF THE NODULES

The question arises as to whether the cellular pyrite nodules represent xenoliths of older pyritic ore that were surrounded by fluid magmatic or hydrothermal chalcopyrite, or whether they represent fluid-filled vacuoles (vesicles) formed within magmatic chalcopyrite. The obvious differences in texture between the cellular pyrite of the nodules and the pyritic ore suggest that if the nodules are xenoliths they must have been entirely recrystallized under fairly high temperature, possibly between  $300^{\circ}\text{C}$ . and  $743^{\circ}\text{C}$ . (the melting point of pyrite), neglecting the unknown temperature modifying effect of high pressure and fluids. The coke-like box-work or vuggy nature of the nodules suggests the activity of fluids and the evolution of gas during its formation. However, selective leaching of an acid-soluble mineral such as a carbonate might also account for the cellular character of the remaining pyrite. The nodules were most certainly not formed on surface, but they do appear to have been formed in a healed sheeted fracture zone or zones that

possibly allowed a release in pressure sufficient to enable gas to evolve and fluids to escape, particularly off the elongated ends of the sheared vacuoles, through fractures in the chalcopyrite, which were later sealed by deposition and recrystallization. The presence of quartz and carbonate in the chalcopyrite and in tiny stringers connected with the nodules lends some support to the hypothesis that carbonates were incorporated by chalcopyrite as well as subsequently introduced.

While evidence supporting a xenolithic origin of the nodules is not entirely conclusive, it is perhaps stronger than that supporting a vesicular origin, for while the rounded ovoid shape of the cavities suggests such a completely gaseous origin their restricted distribution belies it. To have formed nodules, pyritic xenoliths must have been recrystallized with accompanying evolution of gas, to account for the porous, cellular character of the nodules, and the rounded shape of the cavities in which they are contained. The penetration of chalcopyrite by stringlets of pyrite crystals suggests that these nodules and textures were formed penecontemporaneously with the crystallization of the chalcopyrite and pyrite there. Thus it seems possible that the nodules were formed by a combination of processes directly as a result of incorporation and recrystallization of fragments of pre-existing pyrite-carbonate-silicate assemblages, such as the pyritic ore material, following their engulfment by fluid magmatic chalcopyrite ore.

It is possible that post-nodule acid fluid leaching of carbonates from the central cavities of the pyrite cells in a reducing environment was an important factor in producing the cellular box-work texture of the pyrite, but the marked geometric pattern of pyrite stringlets in chalcopyrite (as illustrated in Figs. 3, 5) is taken to be better evidence of structural control in the immediate vicinity of the nodules than of unrelated later penetration of pyrite into chalcopyrite.

If the information above has been correctly interpreted, the condition of the nodules suggests that they were formed within invading chalcopyrite ore magma. In general, there appears to be a close genetic relationship between the pyrite and chalcopyrite deposits, despite the fact that the two main types are more or less distinctly separated spatially at the mine. The same may be said to be true of the pyrrhotite and chalcopyrite deposits of the Sudbury area, but generally in the Sudbury area the separation into copper-rich and nickel-rich deposits is even less distinct, with certain notable exceptions such as the copper (chalcopyrite-rich) orebody in the foot-wall of the Creighton mine. The bulk of the Timagami pyritic ore appears to have formed only slightly before that of the massive chalcopyrite, and both appear to have crystallized from hot concentrated magmatic fluids that were

under strong pressure and probably capable of dissolving and penetrating, as well as forcibly invading, fractured country rock.

The source of the mineralizing fluids that formed the ore is not certain but the diorite sill referred to by Moorhouse (1946) and/or satellite dykes is the most obvious. The ores were probably derived from a differentiating mafic magma and associated with its intrusion into the older rocks; the diorite sill and dyke meets these requirements, but the diorite itself is penetrated by tongues of ore, so the possibility of a deeper seated, or younger source rock such as the Nipissing diabase is not eliminated.

#### REFERENCES

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