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MINERALOGY OF THE MA ON SHAN IRON MINE, HONG KONG

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CONTENTS

ABSTRACT

The Ma On Shan Iron Mine in the Leased Territories of Hong Kong has a proved reserve of 10 million tons of magnetite. The mine, which until 1957 was worked open-cast, is about 250 m above sea level in an area of rugged topography. There are about 2,000 m of underground workings. The production of ore in 1959 was 119,800 tons.

The major rock groups exposed are granites and volcanics that range in age from middle Jurassic to late Cretaceous. The magnetite ore body is lens-shaped and dips gently to the northwest. These rocks have been affected by major earth movements and volcanism during early Tertiary times.

The typical mineral association of the main ore body is magnetite and chondrodite. Surrounding the magnetite is a skarn with a mineral assemblage that includes talc, serpentine, garnet, olivine, pyrite, chalcopyrite and fluorite. At the base of the skarn there are beds of calcite, dolomite and quartzite. The ore body is highly disseminated. A ball-mill using a wet magnetic separator beneficiates it to 56% Fe. Almost the entire output goes to Japan. Quartz veins in the country rocks carry wolframite and molybdenum. Some oxidation and supergene enrichment are present. The mineral assemblage of the skarn in this deposit suggests a contact pyrometasomatic origin. The mineral chondrodite is typical of such a deposit and its occurrence explains why the content of magnesia is so high in the iron ore.

INTRODUCTION

THE following study expands the description of the iron deposit at Ma On Shan recorded in "The Geology of Hong Kong" by S. G. Davis (1).

The views expressed in the earlier description of the mode of occurrence have been considerably modified. This has been made possible by the greater number of new sections exposed by more intensive open cut and underground mining and the very thorough exploration drilling of the Nittetsu Mining Company of Japan.

Location and Topography.—The Ma On Shan Iron Mine is situated in the Leased Territories of Hong Kong about 250 m above sea level. It is on a deeply dissected north pointing peninsula that is surrounded on the west, north and east by a highly indented coastline. It is about 1,300 m southwest of the hill (700 m) also named Ma On Shan. It is also approxi-

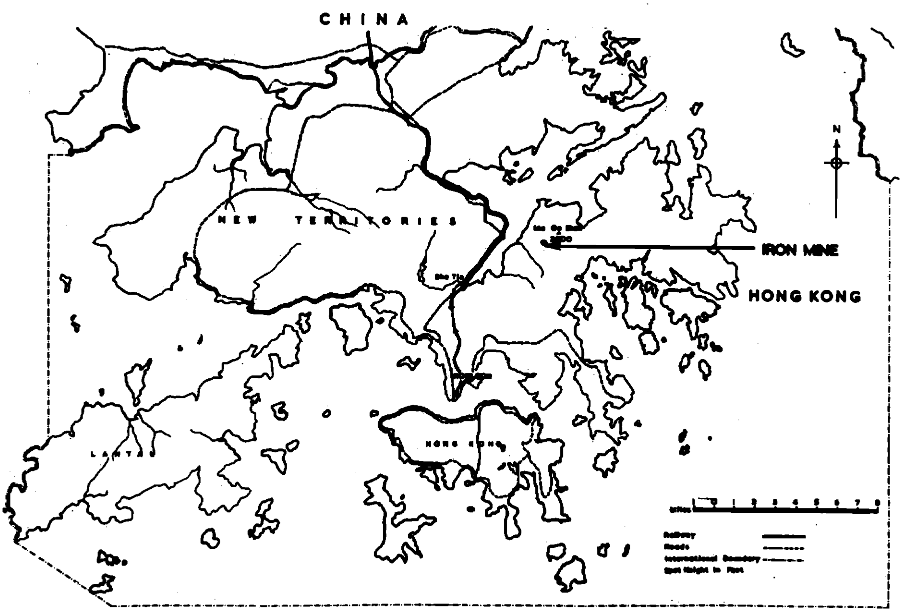


FIG. 1. Location of Ma On Shan iron mine.

mately 16 kms due north of the east end of the Harbour of Hong Kong (Fig. 1). The extent of the horse-shoe shaped open-cut terraces is shown in Figure 7. The length along the north bench is about 500 m and the width 200 m. The long axis of the concealed magnetite ore body is 450 m.

The topography of the mine district is steep and rugged (Fig. 3). Uplands and sharp peaks are the eroded remnants of one small part of the great southeast China batholith of acid rocks. The major rock formations are clearly distinguished by their differing responses to a weathering predominantly controlled by the chemical action of a humid tropical climate aided by typhonic winds.

The mine is linked with Tide Cove, a sea inlet, by a winding but well graded, double-tracked road 2½ kms long. The ore is carried by trucks down the road to a dressing plant which is about 200 m from the sea shore. After

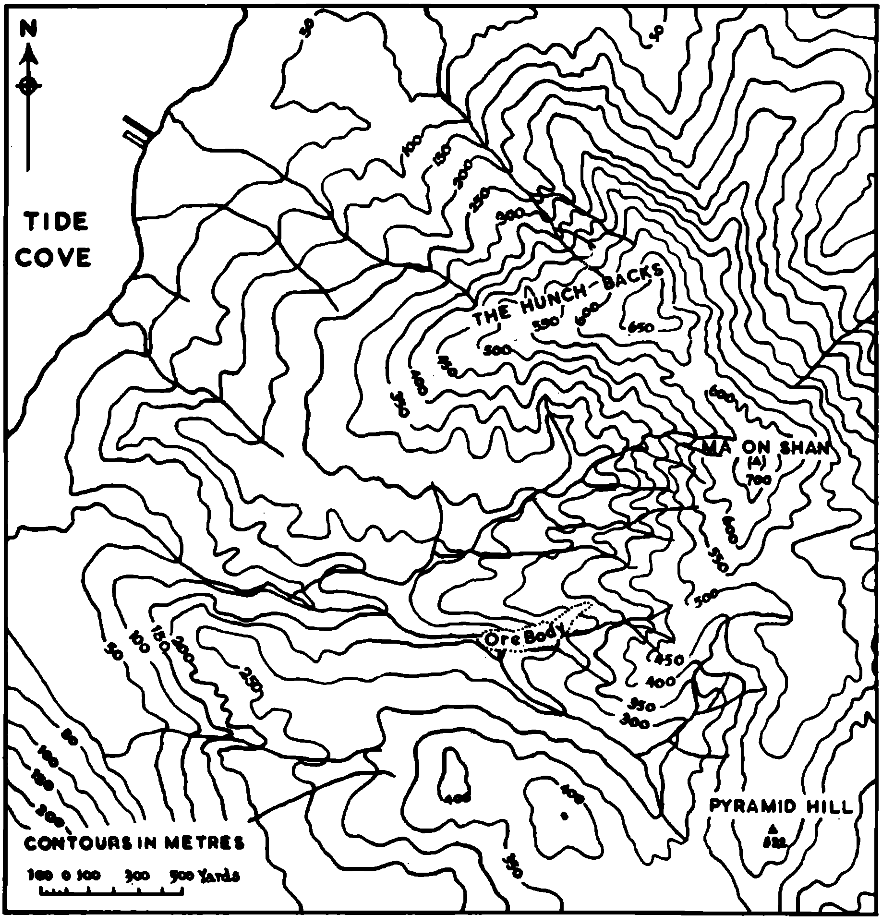


FIG. 2. Location map of the Ma On Shan iron mine.

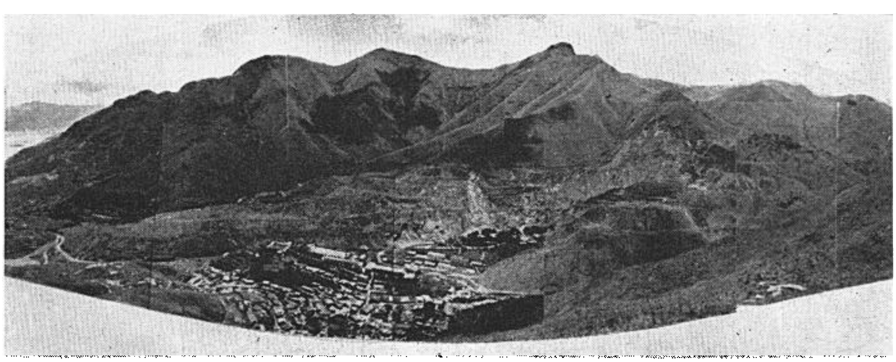


FIG. 3. Panorama of iron mine looking north. Ma On Shan (Saddle Mountain) in center.

beneficiation the ore is loaded on to lighters and carried to ocean-going freighters that lie about one kilometer off-shore.

History.—The first license to prospect and later mine the Ma On Shan deposit was issued to the Hong Kong Iron Mining Company in 1906. In 1931, the New Territories Iron Mining Company, was granted a Crown Lease for fifty years. In 1940 another company, South China Iron Smelters Ltd., took over the property with the intention of building a blast furnace on the sea front. From 1942 to 1944 the mine was operated sporadically by the Japanese and employed about 1,500 workers. As there was no mechanical transport the ore had to be carried by coolies down to the sea-shore. In 1949 the Mutual Trust Company took over the mining rights. The Company signed a contract with the Supreme Command of Allied Headquarters in Japan to supply 150,000 tons of ore annually. In 1953 the Nittetsu Mining Company of Japan joined with the Mutual Trust Company to operate the mine. During this year the change-over from opencast to underground mining was begun. In March 1954 a fully mechanized ore-dressing plant was installed. In 1959 all mining was underground. Recent annual productions of iron ore for 1957, 1958 and 1959 were 94,181, 105,125 and 119,892 tons.

Mining operations follow the old established Chinese custom of subletting work. The work in 1959 was sub-contracted out to 9 companies who between them employed about 350 miners underground. In addition there was a staff of about 800 employed on the surface.

The average grade of the crude magnetite ore in 1958 had an Fe content of 32 percent. This was beneficiated up to 56% Fe. The dressing plant has a daily capacity of 700 tons.

Reserves are estimated at 10,000,000 tons and planned annual production for the next few years is 120,000 tons of concentrates. Since 1954 the entire output of the mine has been shipped to Japan. Technical assistance and advice in the mine and dressing plant is provided by a Japanese firm. Diamond drilling is still continuing in order to establish the reserves accurately.

PREVIOUS GEOLOGICAL WORK

Only one brief report on the deposit by C. M. Weld (6) in 1914 has been published. Several private reports and maps were in existence before World War II but were lost during the Japanese occupation. Mine maps prepared since 1953 by Japanese engineers together with some general information from drill logs have been made available by the Mutual Trust Company.

ROCK FORMATIONS

Extreme tropical weathering, coupled with the major erosion of the Tai Hang river and its tributaries which have cut steep-sided valleys, has been responsible for exposing the rock sequence. Thus the contact between the Repulse Bay volcanics (Middle Jurassic) and the Hong Kong granite (Upper Cretaceous) is clearly exposed (Fig. 4). One kilometer to the west of this contact is a long narrow outcrop of the Tolo Channel sediments (Lower Lias) which are marine in origin and are regarded as the basement beds of the area. Three kilometers to the north are Pat Sin conglomerates (Lias) which are of continental origin and derived from the earlier basement formation of the Lower Lias.

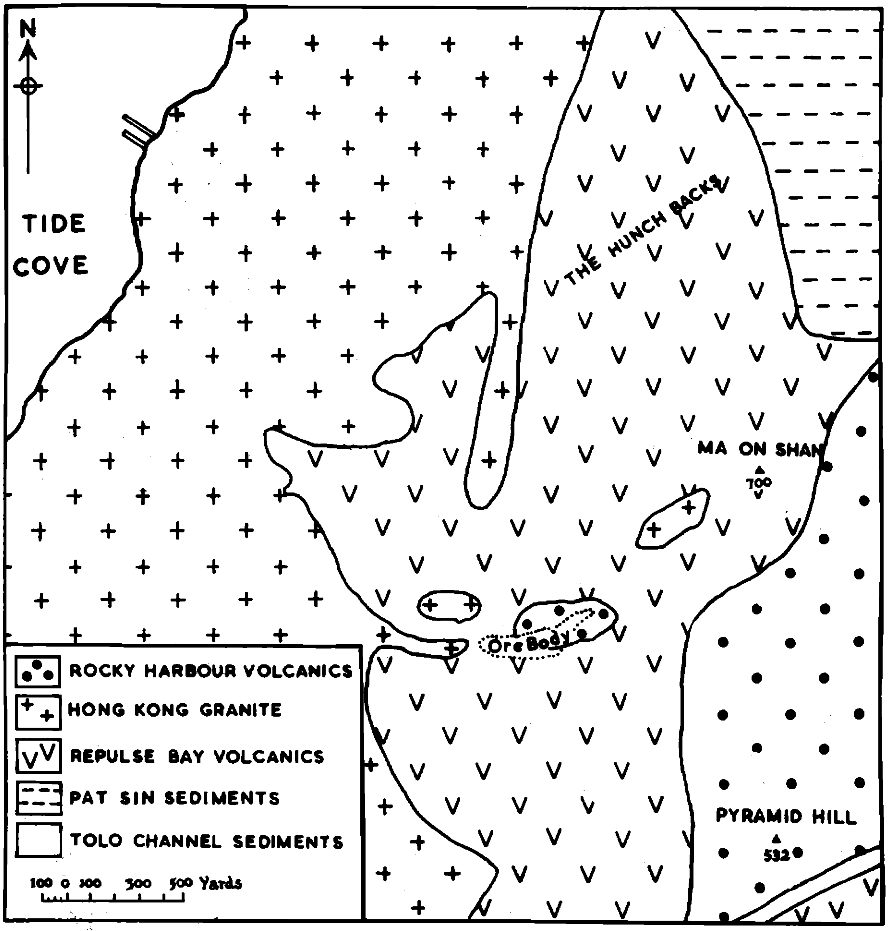


FIG. 4. Map of Ma On Shan District, New Territories, Hong Kong.

About 18 kms due north of the iron mine is an agglomerate that is included in the Rocky Harbour volcanics (Miocene) and contains boulders of limestone. This agglomerate rests on a felsite surface which dips north at an angle of 45°. The agglomerate appears to be the filling of a volcanic fissure. The limestone boulders on the evidence of their fossils have been classified as Permian in age. It is suggested that this part of the New Territories of Hong Kong is underlain by late Palaezoic formation from which fragments in the form of xenoliths have been brought to the surface during the intense diastrophism and volcanic eruptions of the Jurasside Revolution (Yen Shan Number One).

In the immediate area of the iron mine are beds of calcite, dolomite and quartzite. These are certainly not younger than any other rocks in the area and are possibly contemporaneous in age with the limestone in the agglomerate.

Petrology.—The Repulse Bay volcanics are the principal country rocks into which the granite was intruded. They vary widely in character, even within a few yards. The complete range of beds is estimated to have a thickness of over 2,000 feet. The most typical rock-type is a rhyolite porphyry. The groundmass is normally a deep brown color and has a crypto to microcrystalline texture. Flow structure is common. The phenocrysts are alkalic and sodic feldspars and quartz of about 1 to 1.5 mm.

The rocks that form the immediate roof of the granite intrusion show strong contact metamorphism. Commonly they are altered to a quartz sericite rock, and in places are highly silicic and cherty. Andalusite crystals, up to three centimetres in length, are common.

The typical Hong Kong granite is a coarse, equigranular rock with an average grain size of about 2 mm. Some pink feldspars occur up to 1 cm in length. The rock is light in color with a white or pink tint according to the color of the feldspar. The essential minerals, quartz and orthoclase and plagioclase feldspars are easily distinguished by eye, as is the biotite, which is commonly present. Other minerals present in different specimens are magnetite, zircon, hornblende and muscovite.

STRUCTURE

The violence caused by the intrusion of the granite into the volcanics is recorded by major faulting and fracturing. Along the north face of the 1st Bench there are two parallel faults well marked by slickensides. They can also be distinguished, together with a third fault, just above the 5th Bench. They strike approximately N 70° E. The north tributary of the west-flowing Tai Hang river exploited the weakness of a fault zone above the iron ore mass. The down-cutting of its valley later exposed the deposit.

During heavy typhonic rains the loose cap or mantle-rock above the 300 m level has slumped several times to cause serious landslides. The mantle-rock is a mixture of lateritic clay and rock boulders and fragments. Landslides occurred in 1957, 1958 and June 1959. On the last occasion the slump was between two major fault zones and completely blocked the portal to the 240 m level.

Post-mineral movement is clearly seen in the 1st and 2nd sub-level crosscuts of the main ore body. One major fault, that is primarily lateral, trends N 25° W. Other structural evidence elsewhere in Hong Kong and Kwangtung suggests that this post mineral faulting is related to the Pliocene diastrophism of the Alpine revolution.

ORE DEPOSIT

In Hong Kong, as in the neighboring province of Kwangtung, the metamorphic contacts of the granite with the volcanics are not generally accom-

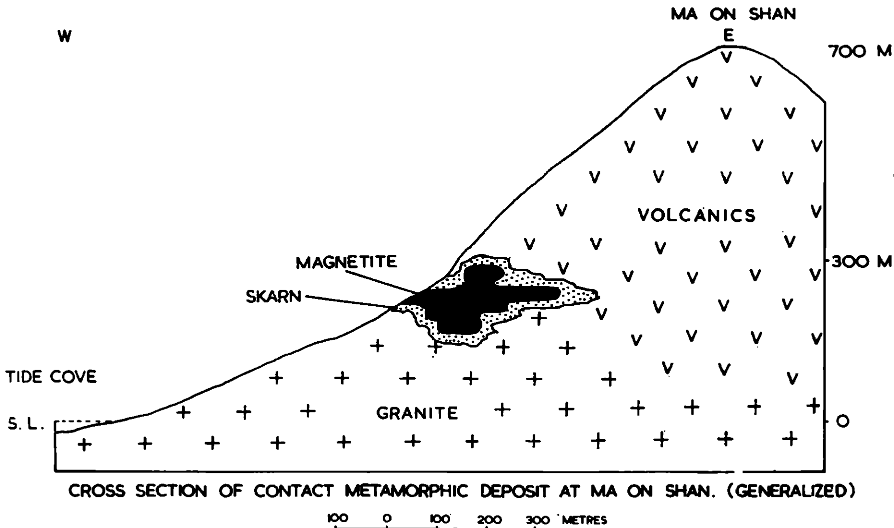


FIG. 5.

panied by mineral concentration and deposition, but involved only recrystallization of the country rock to give hornfels with a granular fabric. However the contact metamorphism at Ma On Shan is distinguished by the magnetite deposit (Figs. 5, 6). The genetic relationship of the ore body to the granitic intrusion (Figs. 5, 8) points clearly to one of magmatic emanations given off from the magma during its consolidation. A magnesium limestone provided favorable fluxing conditions for pneumatolytic transfer and the concentration of the iron oxide.

The deposit is broadly divisible into two members: a central lenticular mass of magnetite which is intermixed with hematite; and a surrounding calc-silicate skarn or tactite.

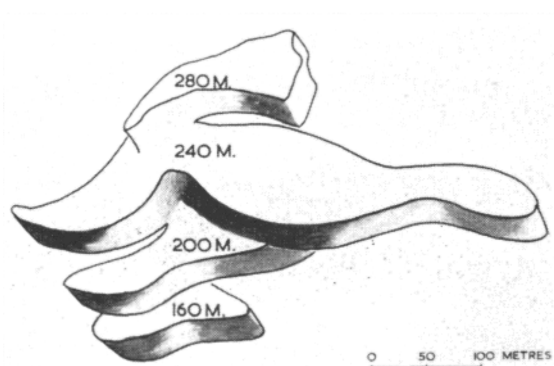
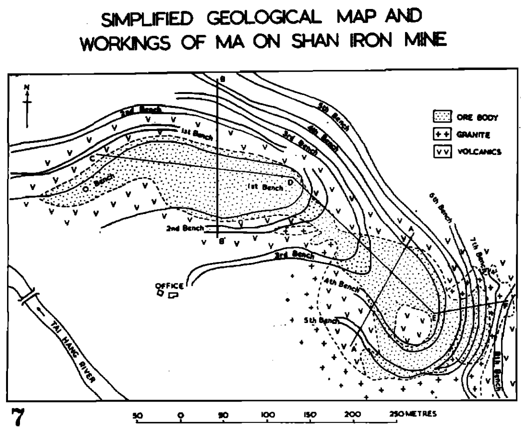


FIG. 6.

Magnetite.—The magnetite from a mining point of view is capricious since it is highly disseminated. It occurs in bodies ranging from minute isolated crystals that are cemented or held together by silicates up to masses of many tons. In its pure massive form the magnetite is black, magnetic, rather soft and granular. There are no well defined boundaries between the ore and



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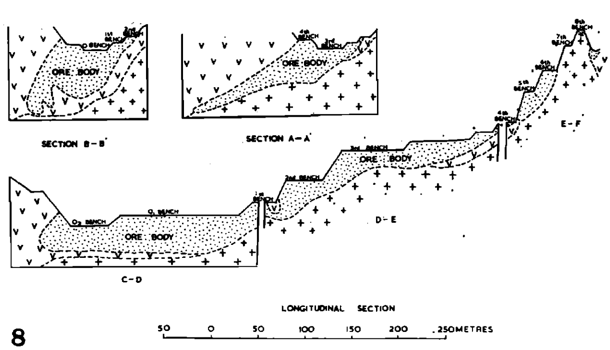

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FIGS. 7, 8. Plan and sections of ore body.

the gangue. The ore grades imperceptibly into the matrix, which is within the range of a granite-granodiorite-quartz group. Some parts of the matrix are pegmatitic with well developed clusters of quartz, feldspar and biotite.

Hand picked lump ore runs about 47% Fe, with about 13% SiO_2 and MgO each; concentrates run around 57% Fe, 8% SiO_2 and 6% MgO.

Skarn.—A calc-silicate-hornfels rock is characteristic of both the hangingwall and footwall of the main iron mass. The contact aureole or skarn carries diminishing amounts of magnetite, hematite and other iron minerals, especially chondrodite. The hangingwall section exposed along the 5th Bench of the open cut has a garnet-pyroxene-epidote zone of high-temperature minerals. Some clusters of large garnets (Fig. 9) make up between half to three-quarters of the total volume of the rock. Also present in the footwall along the Zero Bench of the open cut are small patches of coarse crystalline pinkish wollastonite. Pyrite, chalcopyrite, and galena are also present in minor quantities. Cores drilled from the footwall at depths of about 40 m have revealed some beds of calcite, one twenty feet thick. Small vugs yield beautiful crystal specimens of both nail head and dog tooth calcite and blue to purple clusters of cubic fluorite.

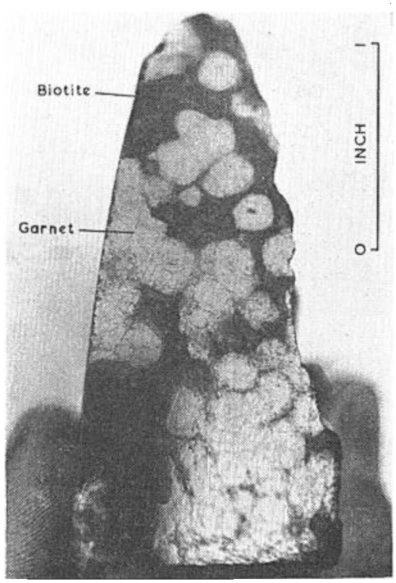

FIG. 9. Hand specimen. Garnet and biotite.

No clear cut metamorphic rock zones are traceable away from the contact. However deeper drilling to distances of more than 80 m has revealed some grading into a chondrodite-quartz-calcite zone. Traces of brownish rhodochrosite are thought to be present in small quantities. Isolated patches of yellowish and brownish green andradite garnet are associated with sericitized feldspar and partly altered chondrodite. Relics of the original volcanic country rock occur commonly in the new hornfels structure. Talc and serpentine are present in masses and also as veining through quartz layers. A one-meter bed of quartzite shows under the microscope a mosaic of interlocking quartz crystals together with small clusters of magnetite and small amounts of green biotite. Also associated with the calcite are wollastonite, olivine, and green-white ophicalcite.

At a distance of about 100 m from the main contact in the hangingwall, there are radiating clusters of slender tourmaline embedded in quartz. At this distance pockets of white kaolin and greisen are common. The mica of the greisen carries some partially altered feldspar. Quartz veins and stringers containing wolframite and molybdenite occur irregularly. The wolfram is present in sufficient economic quantities for it to be worked by the iron miners in their free time.

Paragenesis.—The order of crystallization in the skarn, based on thin sections and polished sections, is shown graphically below. The deposition of the quartz, pyrite, chlorite and fluorite are presumed to have spread over a longer period than both the earlier high-temperature minerals and the later low-temperature minerals that crystallized below the critical temperature of water.

Origin of the Ore.—The various features of the mineral assemblage of the skarn have already been indicated. The origin of the ore is contact metasomatic. Particularly the mineral chondrodite is typical of deposits of this kind. Its occurrence explains also why the content of magnesia is so high in the chemical analyses of the ore.

It seems reasonable to assume that there was a pre-existing bed of magnesium limestone at the contact of the granite and volcanics that acted as a flux to concentrate the iron. The age of the deposit is Paleocene to Eocene.

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J. H. Knapp, Government Superintendent of Mines provided valuable chemical and statistical details. Mr. Harold Service, late Director of Geological Survey, Malaya, following a visit to the mine gave suggestions on the mineral assemblage as shown to him. Mr. David C. Y. Lai (5) of the Department of Geography and Geology, University of Hong Kong took many of the pictures and gathered background material.

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June 15, 1960

REFERENCES

1. Davis, S. G., 1952, The Geology of Hong Kong. Government Printer, Hong Kong.
2. Davis, S. G., 1953, The distribution and occurrence of tungsten minerals in South China and Hong Kong: Proc. Eighth Pacific Science Congress.
3. Davis, S. G., and Snelgrove, A. K., 1956, Geology of the Lin Ma Hang lead mine, New Territories, Hong Kong: Mining Mag., v. 94, p. 73–79.
4. Davis, S. G., 1958, Tungsten mineralization in Hong Kong and the New Territories: ECON. GEOL., v. 53, p. 481–489.
5. Lai, C. Y., 1959, Ma On Shan Iron Mine: unpublished. Dept. of Geography and Geology, University of Hong Kong.
6. Weld, C. M., 1915, Notes on an iron ore deposit near Hong Kong, China: Am. Inst. Min. Eng. Trans., v. 50, p. 236–45.