B. ZALOKAR and I. JURKOVIĆ

COPPER DEPOSITS OF THE SOUTHERN SHAN STATES, BURMA

With 6 figures in the text, 1 figure in the annex, and 1 table

Field and microscopical investigations of some ore veins in the Southern Shan States (Burma) proved two paragenetic types: a) baritic veins with small quantities of quartz II, pyrite, chalcopyrite, tetrahedrite and rarely of enargite and calcite; b) quartz veins with quartz I or quartz II as main mineral and with small quantities of tetrahedrite or pyrite with chalcopyrite, rarely some siderite and chalcedony are present, too. Ore veins are of hydrothermal origin and its occur in partially silicificied or marbleized limestones.

Terenskim i mikroskopskim istraživanjima nekih rudnih žica u Južnim Shan Državama (Burma) utvrđena su dva paragenetska tipa: a) baritske žice s malim količinama kvarca II, pirita, halkopirita, tetraedrita te rijetko energita i kalcita i b) kvarcne žice sa kvarcom I ili II kao glavnim mineralom te manjim količinama ili tetraedrita ili pirita s halkopiritom; rjede se nalazi malo siderita i kalcedona. Pojave su hidrotermalnog porijekla epitermalnog do mezotermalnog stadija, a nalaze se u djelomično silificiranim ili marmoriziranim krečnjacima.

INTRODUCTION

The Southern Shan States occupy the mid-eastern portion of the Union of Burma. The region is actually a part of the Shan Plateau, a high upland region build of Archaen, Palaeozoic and Mesozoic rocks. There is often an abrupt drop more than 600 m from the edge of the plateau to the neighbouring alluvial plains of the Irrawaddy.

Whereas the Northern Shan States are very well known by their famous complex lead and zinc mine at Bawdwin, in the Southern Shan States there are a number of smaller lead and copper mines (see index map of Burma — Fig. 1, and the general geological map of the Taunggyi — Kalaw area — Fig. 2*). Some of the deposits were the subject of a brief prospecting of the Geoistraživanja's group of mining geologists.

The purpose of this study is to establish the nature of the appearance and the mineral paragenesis and genesis of the ores.

* Fig 2 see in the annex.

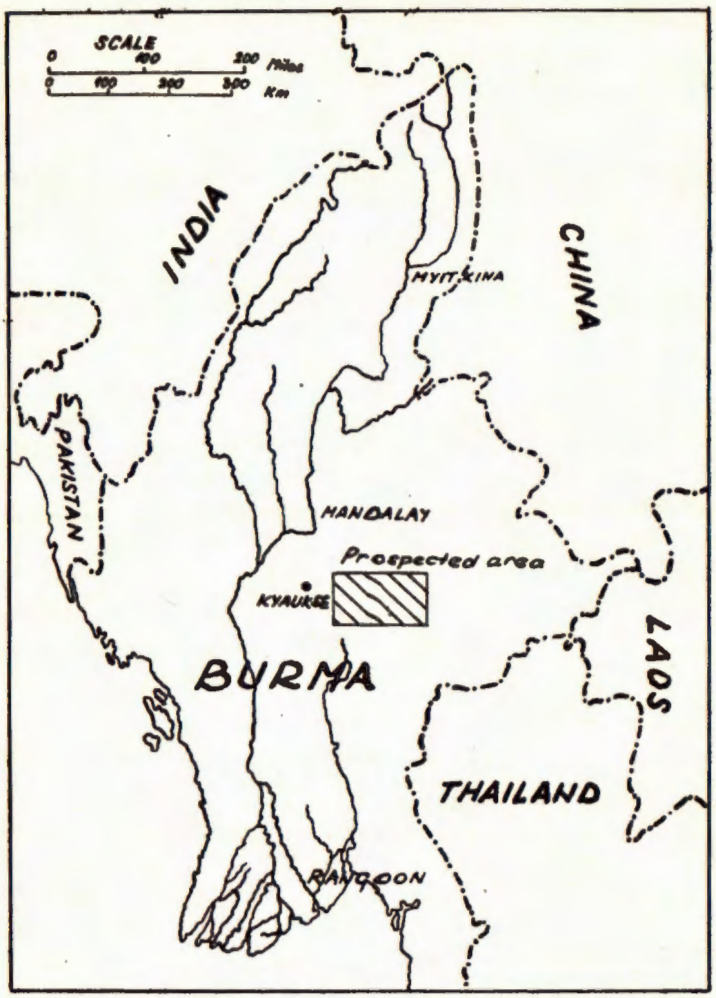

Fig. 1. Index Map of Burma.
Sl. 1. Pregledna karta Burme.

PREVIOUS WORK

The geology and the stratigraphy of the Southern Shan States have been described by Coggin Brown, La Touche and Cowper Reed. Chhibber, Clegg and Kyaw Myint described the different deposits of copper and their relation to the mineralization.

According to the later authors, copper ores occur in the following places:

— Alechaund (21°00′; 96°33′30″). Stains and coatings of oxidized ores are of frequent occurrence.

— Heho (20°43′; 96°22′). Films of malachite and azurite are seen encrusting fragments of shale and vein quartz. Chalcocite is also sometimes present.

— Peak 7,300 (21°07′; 96°37′). Copper ores in the form of films and lumps of malachite and azurite were noticed.

— Peinnebin (20°43′; 96°51′). Carbonates of copper are found as thin films on shaly outcrops.

— Ya-taung (20°59′; 96°35′). Antimonial tetrahedrite with carbonates of copper and containing small quantities of arsenic, iron, lead and silver occurs at a number of places about peak Ya-taung and about five miles due south near Myindwin (20°51′; 96°36′).

— Zawgyi (20°50′; 96°40′). A vein about three feet thick, consisting mainly of barites and calcite but also containing small amounts of malachite has been noted.

— Mwedaw hill-mass (20°51′; 98°30′). Copper staining pockets and strings of malachite are frequently met.

— Kyawk Htap (20°51′; 96°20′). Malachite is worked.

Copper is also said to occur near Magwe (20°08′; 96°36′), Kywemasa (20°03′; 96°32′), Kyatpye (20°08′; 96°20′), Paungdaw (20°39′; 96°10′), Tettawya (20°02′; 96°50′), Pathedaung (20°55′; 96°50′), Myegedwin (20°51′; 96°59′), Tunghko Mong Hsawk (20°35′; 96°56′), Sagha and Hwe Tawk.

The geological map — Fig. 2 (in annex) prepared by the authors of this publication represent a condensed reproduction from the available maps, but the authors of the original maps are unknown .

ACKNOWLEDGEMENT

The field work was done during January 1955 by the late B. Tribusson and by B. Zalokar. The ore specimens collected during this period were the subject of a comprehensive study by Dr. I. Jurković, University of Zagreb, Faculty of Mining and Technology.

Acknowledgement is made to Mr. Kyaw Myint, Burma Geological Department, Rangoon, for his kind cooperation in supplying maps and information, and to Mr. Kyaw Niunt, mine proprietor, Mandalay, for his help in arrangement of the field work.

GENERAL GEOLOGY

The investigated copper deposits and occurrences lie within the Taunggyi — Kalaw quadrangle. The major rock types consist of a thick section of Ordovician rocks which have been classified according to Coggin B r o w n into (1) Mawsön Series, (2) Orthoceras Beds and (3) Pindaya Beds, and Plateau Limestone, which is divided according to La Touche into two systems, (1) Lower Plateu Limestone — Devonian, and (2) Upper Plateau Limestone — Anthracolithic.

The Mawsön Series forms the eastern part of the Mawsön highland, wich is actually a broad anticlinal fold. The strata on the east of the central faulting differ from those on the west. Lithologically, the eastern limb of the anticlinale is composed of argillaceous limestones and calcareous shales overlying the mudstones, shales and sandy shales. The series continues southwards, and according to Coggin B r o w n probably forms nearly the whole of the Heho range.

The Orthoceras Beds form the great part of the western limb of the Mawsön anticline. They consist of hard, flaggy, pinc purple or reddish argillaceous limestones and calcareous shales. The Orthoceras Beds occurring to the nort-east of Pindaya contain a greater proportion of shales.

The Pindaya Beds are developed at Pindaya range between the Permo-Carboniferous limestone, wich build the frontal escarpment overloooking the Pindaya valley and the crest of the range. The beds are composed of calcareous shales, slates and thin bands of argillaceous limestones interbedded with mudstones and siltstones.

Rocks of Ordovician age are met also on the top of the Taunggyi ridge and to the north of Hopong. They also form part of the Taunggyi range between the town itself and the Yaungshwe valley.

The Plateau Limestone is by far the most widespread rock formation of the Southern Shan States.

The Lower Plateau Limestone consists of crystaline dolomite and dolomitic limestones which are highly crushed. According to Coggin Brown the Thamakan — Heho ridge is composed of white and grey brecciated dolomites. Dolomite is to be found on the Heho range, where it overlies the older Ordovician rocks. It atttains considerable dimensions in the neighbourhood of Taunggyi. Both divisions of this formation are present, extending up to mile 28-3 east of Tauggyi, the lower one consisting of grey brecciated dolomites which becarne in places friable and often contain harder greyish-white recemented material, the upper one comprising thin-bedded, concretionary, tabular limestone with interbedded marly and shaly layers.

Archaen, Jurassic (Coal-measures and »Red Beds« of Kalaw) and Tertiary sedimentary rocks do not crop out near the mines, and consequently their description is not presented in this report.

DESCRIPTION AND MINERALOGY OF THE DEPOSITS

In the following lines a decription of the prospected deposits as well as the relevant results of the microscopis studies are given.

ZAWGYI

This locality is about 1,5 km from the Zawgyi village due northwest near the foot of the mountain range west of the Zawgyi river.

The vein consists of barite, which is the predominant gangue mineral, while copper minerals, principally secondary basic copper carbonates, are the minor minerals.

The exploration work consists of a shallow trench, and all that can be observed at present are several lumps of nearly pure barite inserted in the reddish, desintegrated rock. Some hand specimens of the ore intended for microscopic studies were collected on the old ore dump.

The ore vein is supposed to be very small and inpersistent, but probably there are also very rich ore shoots. The Geological Department of Burma is in the possesion of such a rich block of this ore which consists of white barite and weathered silicified dolomite densely crossed with veins of tetrahedrite and azurite; malachite is also present, but it is subordinate to azurite. Anyhow, the mode of occurrence does not promise a larger deposit.

Microscopic determinations of the minerals in transmitted light as well as the studies under reflecting microscope have disclosed the following paragenesis: The hypogene minerals are *barite I, barite II, quartz II, pyrite, chalcopyrite* and *tetrahedrite,* while supergene minerals are *chalcocite, covellite, goethite, lepidocrocite, malachite* and *azurite.*

By far the most abundant is barite, while sulfides and sulfosalts are very subordinate in quantities. Tetrahedrite appears to be the most common primary mineral, whereas chalcocite is predominant among the supergene minerals.

Barite I is coarse-grained, the individual grains measuring several millimetres in diameter. Optically it is anomalous, which is probably due to post-genetic movements. The irregular extinction is caused by uneven stress as well as by divergent and sudden pressures, whereas the undulatory extinction and the thin twin lamellae which are frequently slightly bent are caused by normal stress. By lasting and especially strong pressure barite I is recrystallized in a fine grained aggregate of barite II. Recrystallization begins along the boundaries of barite I, thereby producing wreaths and stringers of recrystallized grains. Recrystallization advances also along twin planes, and eventually frontally, until all the coarse grains of barite I are recristallized in the fine grained aggregate of *barite II,* the size of grains ranging from 50 to 100 microns in diametre.

Quartz II is younger than barite and replaces the latter along the cracks and cleavage plans as well as along the grain boundaries. Sporadically, the relicts of more resistant barite crystals embedded in quartz are noticed (so-called sievelike textures). The quartz occurs most commonly in association with the ore minerals, representing along with them the younger generation of minerals. Quartz is observed to be tinted and sporadically also replaced by supergene minerals especially by malachite and azurite.

Pyrite is a rather sparse ore mineral; only minute corroded masses of microscopic size appear in the barite.

Chalcopyrite is an accesory constituent of the ore. It is found in barite, forming irregular impregnations of microscopic size. The chalcopyrite is found to be altered to covellite and chalcocite.

Tetrahedrite is included in the forms of oval or irregular masses in the chalcocite. These are probably relicts of alteration in the zone of secondary enrichment.

Chalcocite is the main secondary ore mineral. It appears in smaller or larger masses, veinlets and impregnations in the barite, but frequently it is associated with quartz. Chalcocite is of a thinly lamellar structure with perfectly developed basal cleavage.

Covellite is a product of alteration of chalcopyrite and tetrahedrite. It is of typical optical and structural properties.

Malachite and *azurite* are very frequent secondary minerals. Both of them exhibit a fine-grained or radially-acicular texture, coloring both the barite and quartz.

Goethite and *lepidocrocite* occur in the forms of coatings, impregnations or thin films of colloidal texture.

MYINDWIN

The Myindwin mine is located approximately 2,5 air km northeast of the Myindwin village, on the werstern slopes of a ridge which stretches due south between the peaks 5.610 and 6.143.

Ore veins occur within and near the associated fracture and shear zone in a thick series of well-bedded, calcite and siderite veined, bluish-grey limestone, supposedly of the Ordovician age — Pindaya Beds.

The mineralogy of the copper veins, as can be determined by unaided eyes, is a simple one. Both hypogene and supergene minerals were observed. The main vein and gangue mineral is barite. The primary sulfidic minerals are tetrahedrite, pyrite and most probably some chalcopyrite. Pyrite an chalcopyrite are very scanty. The tetrahedrite veinlets crossing barite are very variable in dimensions. The ore veins are small and inpersistent, having an average width of about 0,7 — 1,00 m. The exposed ore veins are covered over with malachite and azurite stainings, giving the false impression of very rich copper veins.

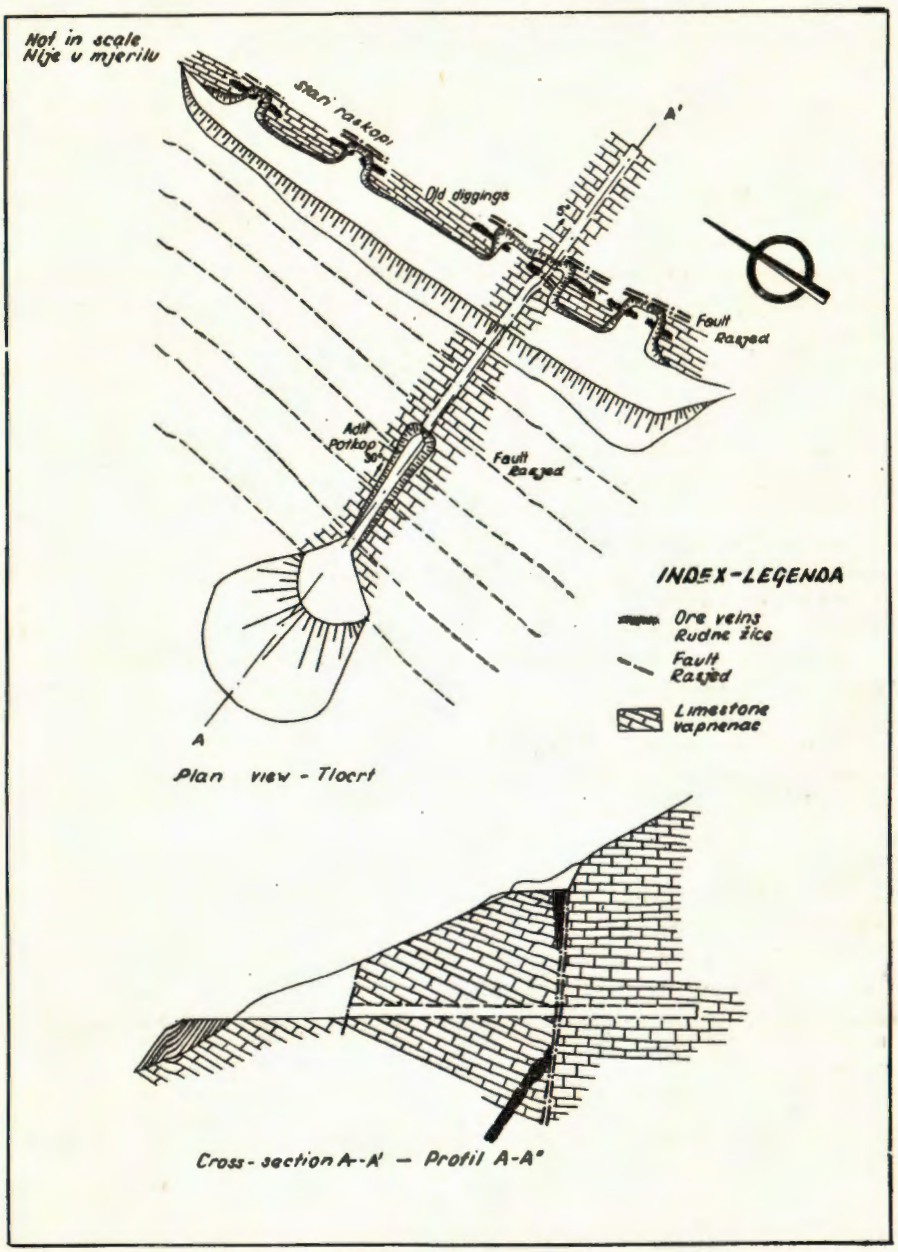

Fig. 3. Sketch of the Copper Deposit of Myindwin.
Sl. 3. Skica ležišta bakra Myindwin.

Previous exploration work consist of four diggings, which lie approximately on the same contour line, and one adit, which is situaded about 20—22 m lower (Fig. 3).

By these diggings the outcroping veins were explored along a stretch of 55—60 m. The fractured zone with associated ore veins is supposed to have an approximate N—S strike, dipping nearly vertically. On the ore dumps in front of the diggings there are still about 400—500 t of ore. According to our visual estimate, the average grade of the hand-picked ore is about 5—6% of Cu.

Throughout the whole length of the adit no traces of copper mineralization were found. The adit was driven into the dark greyish, well stratified limestone.

A minerographic determination disclosed the following mineral paragenesis: the hypogene minerals are *barite I, barite II, calcite, quarzt II, pyrite, tetrahedrite, chalcopyrite* and *enargite,* while supergene minerals are *malachite, azurite, covellite, chalcocite* and *goethite.*

Barite is the main vein mineral, while quartz and calcite are accesory gangue minerals. Sulfidic minerals are rather sparse. Tetrahedrite and chalcopyrite are noticeable by the unaided eyes, but enargite is observed merely under the microscope.

Barite I is developed in the form of tabular crystals forming rosettes or fanlike and subparallel aggregates, the interstices being filled with calcite and some quartz. Crystals of barite I exibit undulatory or irregular extinction, which is probably due to slight bending. Barite I is partly recrystallized in a fine-grained aggregate of *barite II.* Recrystallization is especially advanced along the boundaries of well-developed tabular crystals.

Calcite is allotriomorphically grained, filling the interstices of barite crystals and replacing them simultaneously, thus indicating that the calcite is younger than the barite.

Quartz II occurs in association with the sulfosalts and represents along with them a younger generation of the primary minerals. It is invariably equigranular and occurs in the form of individual grains or granular masses.

Tetrahedrite and *chalcopyrite* are closely associated and intimately intergrown, tetrahedrite being prevalent over the chalcopyrite. Both minerals are intensively altered to *malachite, azurite, covellite, chalcocite* and *goethite.*

Enargite is very rare and is only noticeable under the microscope. Owing to its typical rosy color, the readily observable reflecting pleochroism and high anizotropic effects, it is easily distinguishable among the other sulfidic minerals.

HEHO-KHWEAIKTAUNG

The Heho mine is about 1 km due north of the Heho village on the west slopes of the Heho ridge.

Extensive mining works were carried out in the past. The old Chinise miners were apparently the first to start exploitation of this copper deposit. To this epoch belong probably the short and narrow adits and shaft. After the First World War Col. Johnson resumed exploration work but soon closed the mine down.

Since all the mining workings were performed in more or less solid rocks, it was possible for us to inspect them all. The country rocks are argillaceous limestone, calcareous shale and mudstones.

The mining exploration workings consitst of three adits, one shaft and two diggings (Fig. 4).

Adit N° 1 is 5 m. long and passes through well — stratified but very weathered calcareous shales of yellowish — grey color No traces of copper ores were observed either on the walls of the adit or outside on the vaste dumps.

Adit N° 2 is about 8 m. below adit N– 1, and it is driven along the strike of the copper veins.

The vein is still visible in the roof and at the face of the adit, displaying an average thickness of about 1 m. The main vein and gangue mineral is quartz. Both hypogene and supergene copper minerals are observed; tetrahedrite is the principal primary sulfidic mineral. Supergene copper mineralization is pronounced; nearly all the walls of the adit with the adjacent inclined stope are stained with supergene basic copper carbonates — malachite and azurite.

From the middle of the adit a narrow cross-cut is driven through completely weathered calcareous shales in a southerly direction.

Adit N– 3 is located about 35 m. lower, just on the bank of a deep, nameless ravine. The adit is so located that it follows the irregular contact between the calcareous shales and the overlying calcareous limestones. Rather thin and impersistent veins occur on or near the contact, both in the limestone and in the shales. The strike of the veins declines for a few grades from the E—W direction, while the dips are 80—85° to N.

The principal and by far the most abundant vein and gangue mineral is quartz. In this level too, being still above the water table, both hypogene and supergene copper minerals are present. According to visual inspection tetrahedrite appears to be the most abundant sulfidic mineral. It fills the former fissures and cracks. Usually the quartz is compact, cemented by ore minerals. Where quartz is almost or completely barren, it is highly shattered, suggesting that mineralization was preceeded by a tectonic phase which rendered the quartz veins suitable channelways for the deposition of the mineralizing solutions. Average thickness of the veins waries from 0,3 — 0,4 m, but in some places they broaden up to 1,2 — 1,5 m. The thickness of the ore veins, veinlets and stringers waries greatly from a few tenths of a milimetre to 0,8 — 1,2 cm. Supergene copper minerals are very widespread, but not abundant. A very rich ore was noticed in a short parallel drift on the right side of the adit.

This portion of the deposit was already stoped out. No connection of these underground workings with the surface by a shaft was noticed. According to previous information the shaft is about 8—10 m. deep. Barite veins, mentioned in Kyaw Myint's report, were not found in spite of a thorough search.

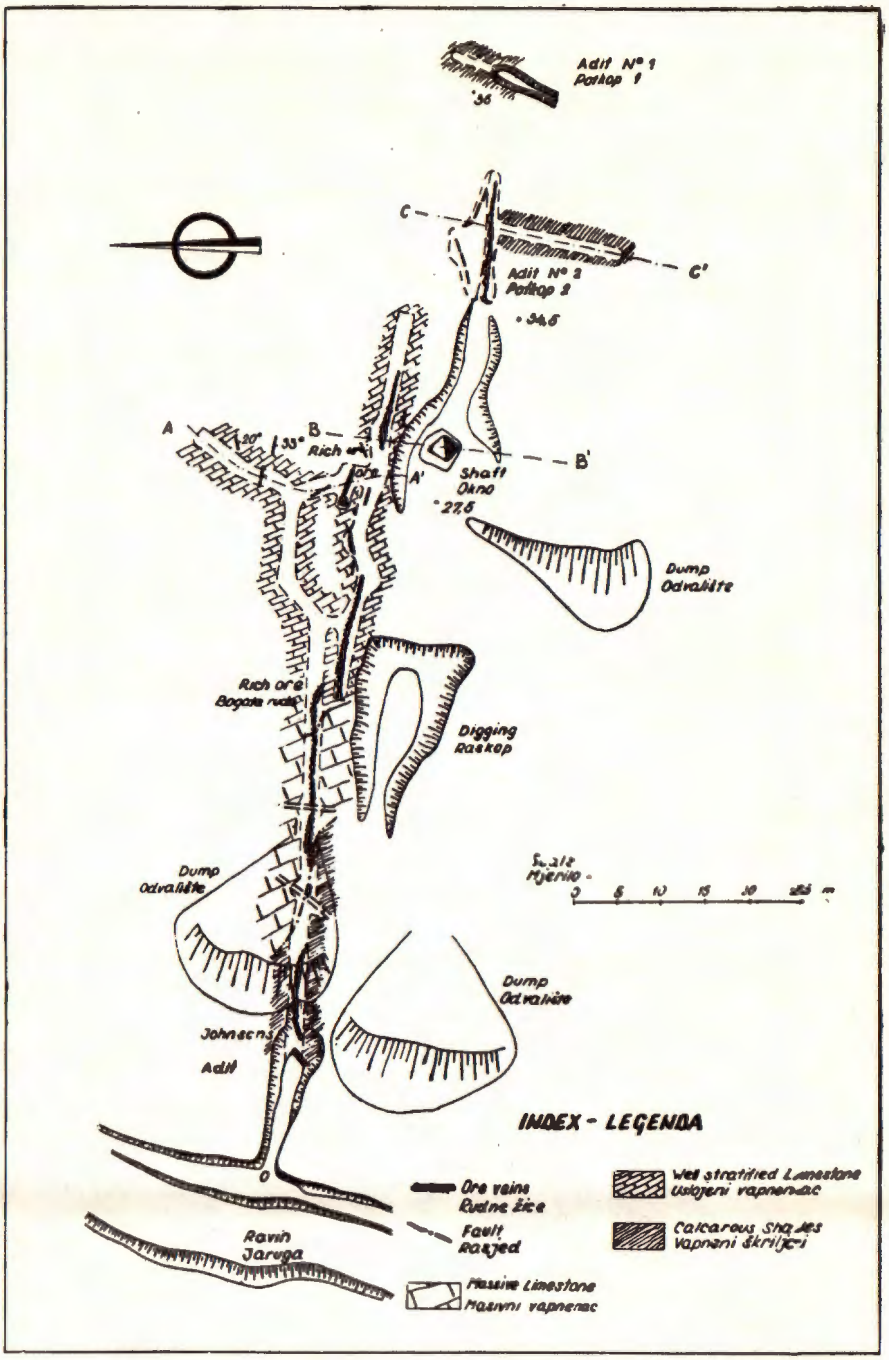

Fig. 4. Geological Map of the Mining Workings of Heho-Kweaiktau ng.
Sl. Geološka karta rudarskih radova Heho-Khweaiktaung.

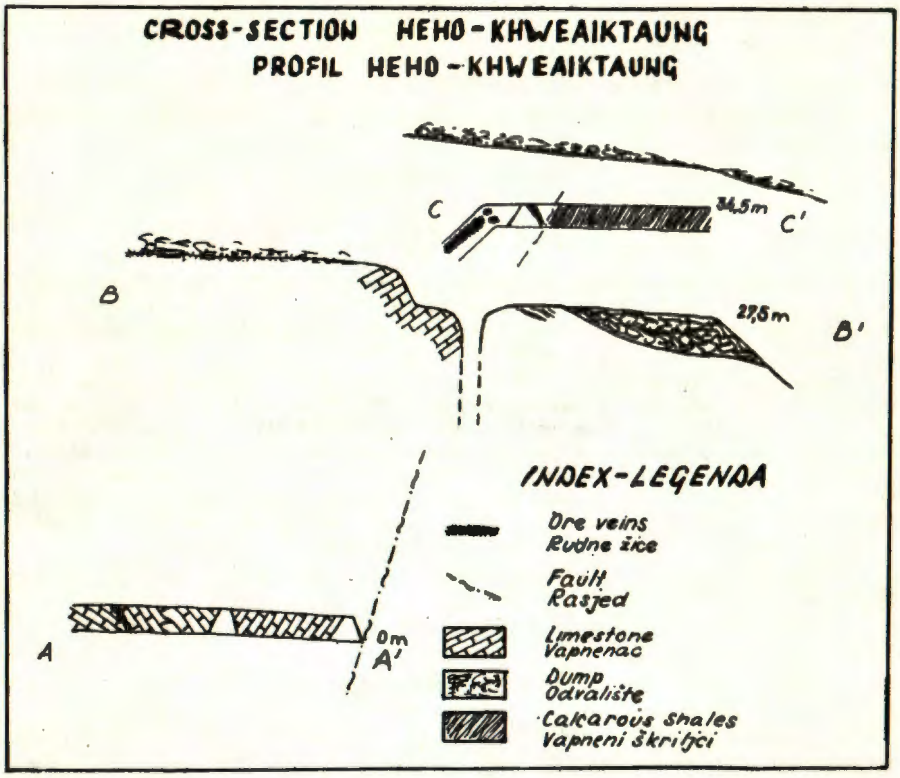

Fig. 5. Cross-section of Heho-Kweaiktaung.
Sl. 5. Profil Heho-Khweaiktaung.

By minerographic studies the following mineral assemblage was observed:

Hypogene minerals — *quartz II, quartz III, chalcopyrite* and *tetrahedrite*
Supergene minerals — *malachite, azurite, goethite* and *lepidocrocite*

The vein mineralogy consists chiefly of quartz; sulfides and sulfosalts ar epresent in minor amounts.

Quartz II is xenomorph, fine to medium-grained. The size of the quartz grains ranges from 0,1 to 0,5 mm, in diameter; the grains are cemented by ore minerals. The shrinkage cracks and fractures are filled with fine-grained *quartz III* of the second mineral generation. Most probably quartz II is recrystallized quartz I. The quartz grains, as well as the very fine cracks in the quartz are coated by the secondary minerals malachite, azurite, goethite and lepidocrocite.

Pyrite is generally present in the form of small grains, and it is rather sparse.

Chalcopyrite appears in small masses, and it is intensively altered to supergene minerals.

Tetrahedrite is the most abundant ore mineral. It is rarely fresh, more frequently it is altered to malachite and to the basic sulfates of copper.

PEINNEBIN

This locality is situated about 3 km south-west of the Heho village on the southern end of the Heho range. According to Kyaw Myint, in this particular locality extensive mining working exist. He states in his report that there are several pits running to a depth of 8—10 m.

Unfortunately we were not lucky enough to find the reported mining workings after a whole day of thorough search. We succeded to find only an old ore dump near the cart road and several outcrops of strongly silicified dolomitic limestone, crossed by veins of shattered quartz, in which traces of malachite and very sparse sulfidic minerals were observed. In addition, on the slopes of the ridge some trenches and a narrow pit suggestive to be mining workings were noticed, but neither remnants of vaste nor ore minerals usually scattered around mining workings could be found.

The country rock is argillaceous limestone similar to that of the Heho-Khwealktaung area.

MYEGEDWIN

This copper deposit is situated about 3 km north-east of the Heke-Kyibuikan village on the 6th mile of the road Shwenyaung — Lawksawk.

The occurrence of copper ore appears in close connection with the quartz vein, which crops out on the gentle slope of a low hill. The outcrops are exposed in an area having about 40 m, in length and about 8 m in width. The quartz vein strikes 27° N, probably concordantly with the poorly stratified dolomitic limestone. The appearance of this ore is markedly different from other deposits of the Southern Shan States. The most striking feature is the relative abundance of iron minerals as well as chalcopyrite and supergene chalcocite. Besides, in some specimens thick veinlets of malachite and azurite were observed. The ore minerals are suposed to occur in pockets and irregular masses within the quartz vein. According to Kyaw Myint, fresh, hand-picked specimens of this ore contain about 12,5% Cu (most probably this refers to specimens of unoxidized ore), while specimens of weathered ore contain less than 1% Cu.

This deposit was not sufficiently nor properly explored. Only three ore shoots of the outcropping quartz vein were caved out, but no underground exploration work was done (Fig. 6). In spite of the fact that no larger deposits of copper in connection with the quartz veins are known, this deposit is considered to be one of the most promising of all the copper deposits of the Southern Shan States.

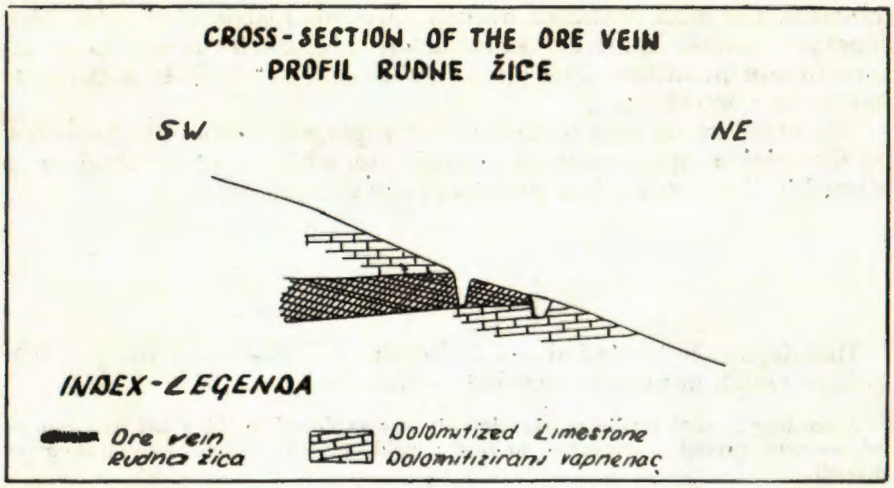

Fig. 6. Cross-section of the Ore Vein of Myegedwin.
Sl. 6. Presjek kroz rudnu žicu Myegedwin.

By minerographic studies the following mineral paragenesis is proved:

Hypogene minerals — *quarz I, calcedony, pyrite, chlacopyrite* and *tetrahedrite* (?)

Supergene minerals — *covellite, chalcocite, goethite, lepidocrocite, malachite, azurite* and *hydrohematite*

Quartz is the main vein mineral. Pyrite is sparse, while chalcopyrite is only noticeable under the microscope. Of the supergene minerals the most abundant are iron hydroxides, while basic copper carbonates are present in but minor amounts.

Quartz occurs in two generations. One generation of quartz i.e. *quartz* I appears in coarse-grained crystals, while the second one occurs as *calcedony* of a very fine-grained, fanlike texture. The interstices and fine cracks within the quartz are filled with supergene minerals.

Pyrite is by greater part oxidised to *goethite* and *lepidocroite* or *hydrohematite* respectively. Pyrite relicts are of very iregular forms. Rarely, euhedral pyrite crystals are observed to be included into the mass of supergene iron minerals. The pseudomorphosis of goethite and lepidocrocite on the idiomorphic crystals of pyrite is a common feature.

Chalcopyrite is a rather rare and sparse ore mineral in the specimens obtained. It is hardly noticeable by the unaided eyes. The greater part of this has already been converted into supergene minerals.
Supergene minerals. Oxidation of pyrite, chalcopyrite and probably of tetrahedrite had given origin to various supergene iron and copper

minerals. The most abundant minerals are *iron hydroxides*. while the supergene copper minerals as *malachite* and *azurite* are present in subordinate quantities. *Covellite and chalcocite* are merely noticeable under the microscope.

The presence of azurite among the supergene minerals indicates on the original appearance of tetrahedrite, which is now completely altered in the near surface portion of the deposit.

HWETAWK

This deposit is located about 12 km due north-east of the Namlok village, which lies on the Hopong — Wan Ying road.

According to oral tradition, the deposit was explored in the past by Chinese miners who probably expected to find a gold and silver-bearing tetrahedrite deposit.

The deposit is in close connection with a fissure zone which strikes nearly in N — S direction. The main vein and gangue mineral is barite. The thickness of this barite vein varries between 1,2 — 1,5 m. Both hypogene and supergene copper minerals are observed in appreciable amounts.

The mining workings are typical of this type of deposits; a small pit on the top of the hill, a shaft with drifts and crosscuts, and eventually an adit at the foot of the hill. The shaft and the adit have already collapsed, and only a few meters of the adit are accesible to inspection (Fig. 7).

Here, in the yellow-reddish weathered rock — a silicified dolomitic limestone — strings of malachite without any traces of primary ores are to be observed.

On the walls of the pit which, is about 25—30 m. long and about 5—6 m. deep, there are still remnants of such vein minerals as barite, quartz, tetrahedrite and chalcopyrite, coated with supergene copper carbonates.

Both primary and secondary mineral parageneses were observed under the microscope. The hypogene minerals are *barite I, barite II, quartz II, pyrite, chalcopyrite* and *tetrahedrite*. Supergene minerals are *chalcocite, covellite, cuprite, tenorite, azurite, malachite, geothite* and *lepidocrocite*.

The characteristics and properties of the minerals are briefly described as follows:

Barite is again the principal mineral of the ore veins. The most abundant sulfides are chalcopyrite and tetrahedrite, but in comparison with barite they are sparse. Quartz is only an accesory mineral, but the salbands of the ore veins are intensively silicified. Chalcocite is the most widespread supergene mineral.

Barite I is coarse-grained, the grains having an average diameter of several millimetres. Optically it is anomalous, and it exhibits an irregular or undulatory extinction. Frequently it is twinned. Recry-

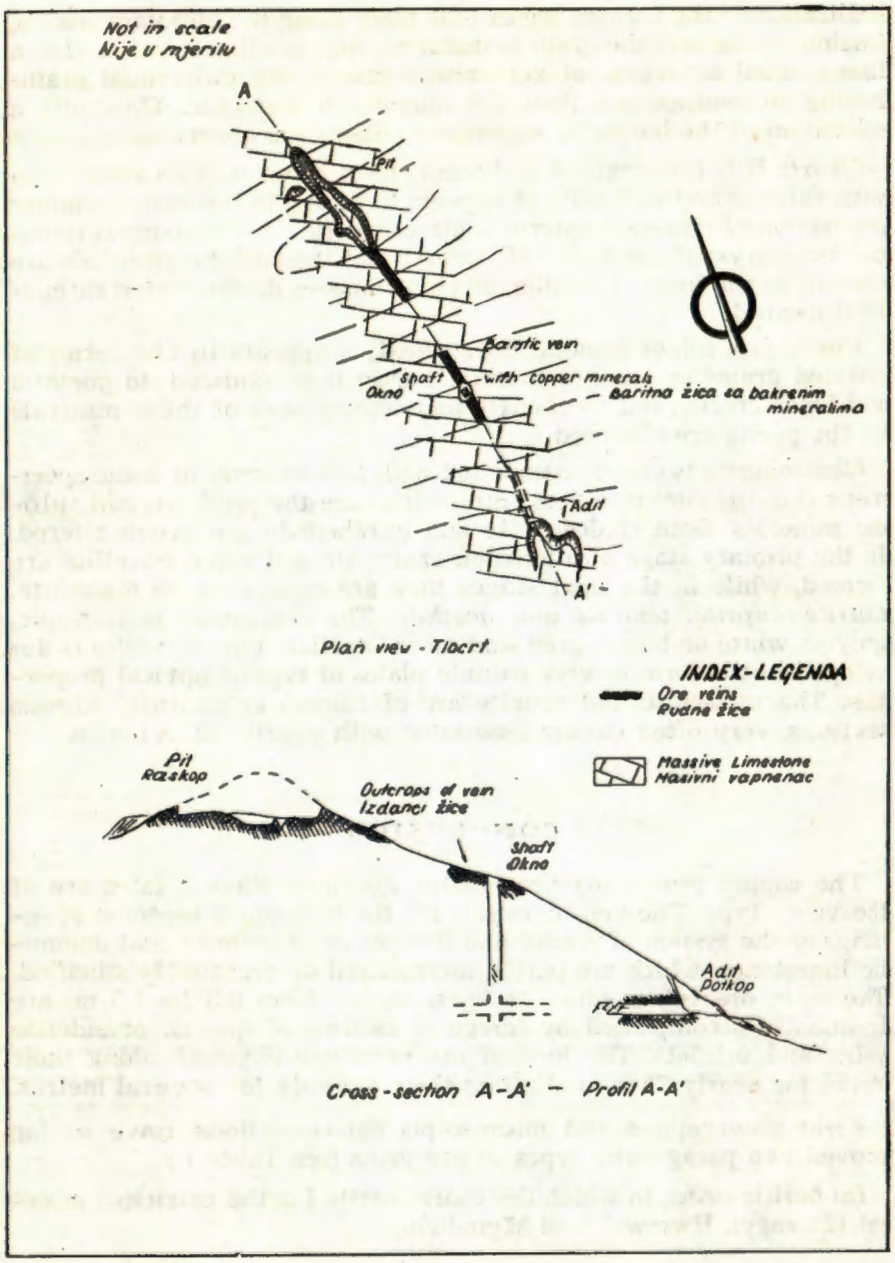

Fig. 7. Sketch of the Coper Deposit of Hwetawk.
Sl. 7. Skica ležišta bakra Hwetawk.

stallization of the various stages took place along the cleavage planes, tension cracks and the grain boundaries. Recrystallized *barite II* is a fine-grained aggregate of xenomorph grains, the individual grains having on average less than 100 microns in diameter. Generally a coloration of the barite by supergene minerals is observed.

Quartz II is fine-grained and occurs most commonly in association with sulfides and sulfosalts. It appears to belong to the same younger generation of minerals. Quartz replaces barite I, and in turn is replaced by recrystallized barite II. Quartz and the sulfidic minerals are present in the form of smaller or larger masses dissiminated throughout barite I.

Pyrite is a minor mineral constituent; it appears in the forms of isolated grains or smaller masses. Partly it is oxidized to *goethite* and *lepidocrocite*, but frequently pseudomorphoses of these minerals on the pyrite are observed.

Chalcopyrite is closely associated with *tetrahedrite;* in some specimens chalcopyrite, in others tetrahedrite are the predominant sulfidic minerals. Both chalcopyrite and tetrahedrite are much altered. In the primary stage of alteration chalcocite and some covellite are formed, while in the next stages they are converted to *malachite, azurite, cuprite, tenorite* and *goethite*. The *chalcocite* is isotropic, greyish-white or bluish-grey and microlamellar. The *covellite* is developed in the form of very minute plates of typical optical properties. The malachite and azurite are of fibrous or radially fibrous textures, very often closely associated with cuprite or tenorite.

CONCLUSION

The copper ore occurrences in the Southern Shan States are of the veiny type. The vein minerals fill the individual tectonic openings or the system of cracks and fissures in limestones and dolomitic limestones, which are partly marmorized or eventually silicified. The main ore veins, whose tickness waries from 0,3 to 1,5 m, are frequently accompanied by irregular swarms of quartz or siderite veins and veinlets. The longest ore veins are exposed along their strike for nearly 70 m, and along their dip only for several metres.

Field observations and microscopis determinations have so far proved two paragenetic types of ore veins (see Table I.)

(a) *baritic veins*, in which the coarse barite I is the principal mineral (Zawagyi, Hwetwak and Myindwin).

Barite I represents the first generation in the course of mineralization, but sporadically (Myindwin) it is accompanied by subordinate quantities of something younger calcite. The singetetic tectonic plase, which caused a system of irregular cracks and fractu-

res in the original mass of barite and in the adjoining salbands is characterized by the appearance of a second generation of minerals. Hydrothermal solutions had utilized the system of openings filling them or replacing barite I with fine-grained quartz II and pyrite, chalcopyrite and tetrahedrite. Sporadically (Myindwin) along with the mentioned sulficid minerals there is some sparse enargite associated. The abundance of second generation minerals is relatively small, and the grade of the ore varries from one to several percent of Cu. Of the ore minerals the most abundant is tetrahedrite, thus being the characteristic mineral of the barite deposits of the Southern Shan States.

Tectonic movements in the post mineralizing phase caused the anomalous optical properties of barite I. Besides, there is a clear evidence of recrystallization of the coarse-grained barite I in the finegrained barite II.

In the subsequent supergene phase intensive weathering and oxidation of hypogene minerals took place. The common supergene minerals are chalcocite, covellite, malachite, azurite, geothite and lepidocrocite, while locally (Hwetawk) tenorite and cuprite are noticed.

(b) *quartz veins*, in which either the fine-grained quartz II (Heho-Khweaiktaung) or the coarse-grained optically anomalous quartz I (Myegedwin and Kyaukse) is the principal vein mineral. Quartz I and quartz II respectively are minerals of the first generation in the process of mineralization. The second generation is a generation of lean ore minerals such as pyrite, chalcopyrite and tetrahedrite in association with some siderite (Kyaukse) or calcedony (Myegedwin). The minerals of the second generation replace quartz I and quartz II respectively, or they fill the younger cracks and cavities in the quartz. Heho-Khweaiktaung and Kyauke belong to the type of quartz-tetrahedrite veins, while Myegedwin belongs to the type of quartz-pyrite-chalcopyrite veins.

Tectonic movements in the post mineralization phase caused the optical anomalies of quartz I as well as the beginning of recrystallization of quartz III.

In the supergene phase the hypogene ore minerals suffered a more or less intensive weathering and oxidation, giving origin to chalcocite, covellite, malachite, azurite, goethite, lepidocrocite and sporadically hydrohematite (Myegedwin).

The barite and quartz ore deposits of the Southern Shan States are typical hydrothermal occurrences of the epithermal stage with a transition to the mezothermal stage.

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Minerals / Minerali — Ore deposits / Rudne pojave		ZAWGYI	HEHO-KWEAIKTAUNG	MYEQEDWIN	HWETAWK	MYINDWIN	KYAUKSE
Hypogene minerals – hipogeni minerali	1. Quartz I / Kvarc I			■			■
	2. Barite I / Barit I	■			■	■	
	3. Calcite / Kalcit					▯	
	4. Pyrite / Pirit	⁘	⁘	▮	▯	▯	⁘
	5. Quartz II / Kvarc II	▯	■		▯	▯	
	6. Chalcopyrite / Halkopirit	▯	▯	▮	▮	▯	⁘
	7. Tetrahedrite / Tetraedrit	▮	▮	▯	▮	▮	▮
	8. Enargite / Enargit					⁘	
	9. Siderite / Siderit						▮
	10. Calcedony / Kalcedon			▮			
	11. Quartz III / Kvarc III		▯				▯
	12. Barite II / Barit II	▮			▮	▮	
Supergene minerals – hipogeni minerali	1. Chalcocite / Halkozin	▮		⁘	▯	▯	▯
	2. Covellite / Kovelin	⁘		⁘	⁘	⁘	⁘
	3. Malachite / Malahit	▯	▮	▯	▯	▮	▮
	4. Azurite / Azurit	▯	▮	▯	▯	▮	▮
	5. Tenorite / Tenorit				⁘		
	6. Cuprite / Kuprit				⁘		
	7. Goethite / Getit	▯	▯	▮	▮	▯	▯
	8. Lepidocrocite / Lepidokrokit	⁘	⁘	⁘	⁘	▯	⁘
	9. Hydrohematite / Hidrohematit			■			

Table I. Copper Deposits in the Southern Shan States. Parageneses and Intensities of Appearance of the Minerals. (by I. Jurković)

Table I. Bakarna ležišta u Južnim Shan Državama. Parageneze i intenziteti pojavljivanja minerala. (po I. Jurkoviću)

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Authors:

Dr. Ivan Jurković,
Institute of Mineralogy, Petrology and Ore Deposits, Technological Faculty, University of Zagreb, Kačićeva 26, Yugoslavia

Božidar Zalokar, M. E.
Enterprise »Geoistraživanja«, Zagreb, Kupska 2, Yugoslavia

B. ZALOKAR i I. JURKOVIĆ

POJAVE BAKARNIH RUDA U JUŽNIM SHAN DRŽAVAMA, BURMA

Rudne pojave u Južnim Shan Državama su žičnog tipa. Rudne žice ispunjavaju pojedinačne tektonske pukotine ili sisteme prslina u krečnjacima koji su djelomice marmorizirani ili pak silificirani. Glavne rudne žice, čije debljine variraju od 0,3 do 1,5 m, često su praćene nepravilnim sistemima tankih kvarcnih ili sideritskih žilica. Najduže žice otkrivene su na dužini od 70 m, i po padu na nekoliko metara.

Terenska i mikroskopska istraživanja rudnih žica utvrdila su do sada 2 paragenetska tipa (vidi tabelu I):

(a) *baritske žice* kojima je krupno kristalasti barit I glavni žični mineral (Zawgyi, Hwetawk i Myindwin). Barit I predstavlja prvu generaciju u procesu mineralizacije. Lokalno (Myindwin) prate ga male količine nešto mlađeg kalcita. Singenetska tektonska faza u kojoj je u masi barita i salbandima stvoren sistem nepravilnih prslina karakterizirana je pojavom druge generacije minerala. Hidrotermalne otopine su koristile sisteme prslina ispunjujući ih ili pak potiskujući barit I s finozrnatim kvarcom II te piritom, halkopiritom i tetraedritom, a lokalno (Myindwin) s vrlo malo enargita. Količine minerala druge generacije su relativno vrlo malene i variraju od 1 pa do nekoliko procenata. Od rudnih minerala najviše ima tetraedrita koji je karakterističan za baritske pojave Južnih Shan Država. U postrudnoj fazi tektonski su procesi uzrokovali optičke anomalije na baritu I, a uočeni su i jasni procesi rekristalizacije krupnokristalastog barita I u finozrnati rekristalizat barita II.

U supergenoj fazi došlo je do intenzivnog trošenja hipogenih rudnih minerala u halkozin, kovelin, malahit, azurit. getit, lepidokrokit, a lokalno (Hwetawk) su uočeni i tenorit s kupritom.

(b) *kvarcne žice* u kojima je ili sitnozrnati kvarc II glavni mineral parageneze (Heho — Hkweaiktaung) ili pak krupnozrnati optički anomalan kvarc I (Myegedwin i Kyaukse). Kvarc I odnosno kvarc II su minerali prve generacije. Druga generacija je generacija malih količina rudnih minerala (pirita, halkopirita i tetraedrita) praćen s malo siderita (Kyaukse) ili kalcedona (Myegedwin). Minerali druge generacije potiskuju kvarc I, odnosno kvarc II ili pak ispunjuju mlađe prsline i šupljine u kvarcu. Heho — Hkweaiktaung i Kyaukse su kvarcno tetraedritske pojave, a Myegedwin kvarc - piritsko - halkopiritska pojava. U postrudnoj fazi tektonskim procesima došlo je do pojave optičke anomalije kvarca I, odnosno početne rekristalizacije u finozrnati kvarc III.

U supergenoj fazi hipogeni rudni minerali su slabije ili jače rastrošeni u halkozin, kovelin, malahit, azurit, getit, lepidokrokit i lokalno u hidrohematit (Myegedwin).

Baritske i kvarcne rudne pojave su tipične hidrotermalne pojave epitermalnog stadija s prelazom u mezotermalni stadij.

»Geoistraživanja«, Zagreb
Tehnološki fakultet, Sveučilište Zagreb
Institut za mineralogiju, petrologiju i rudna ležišta

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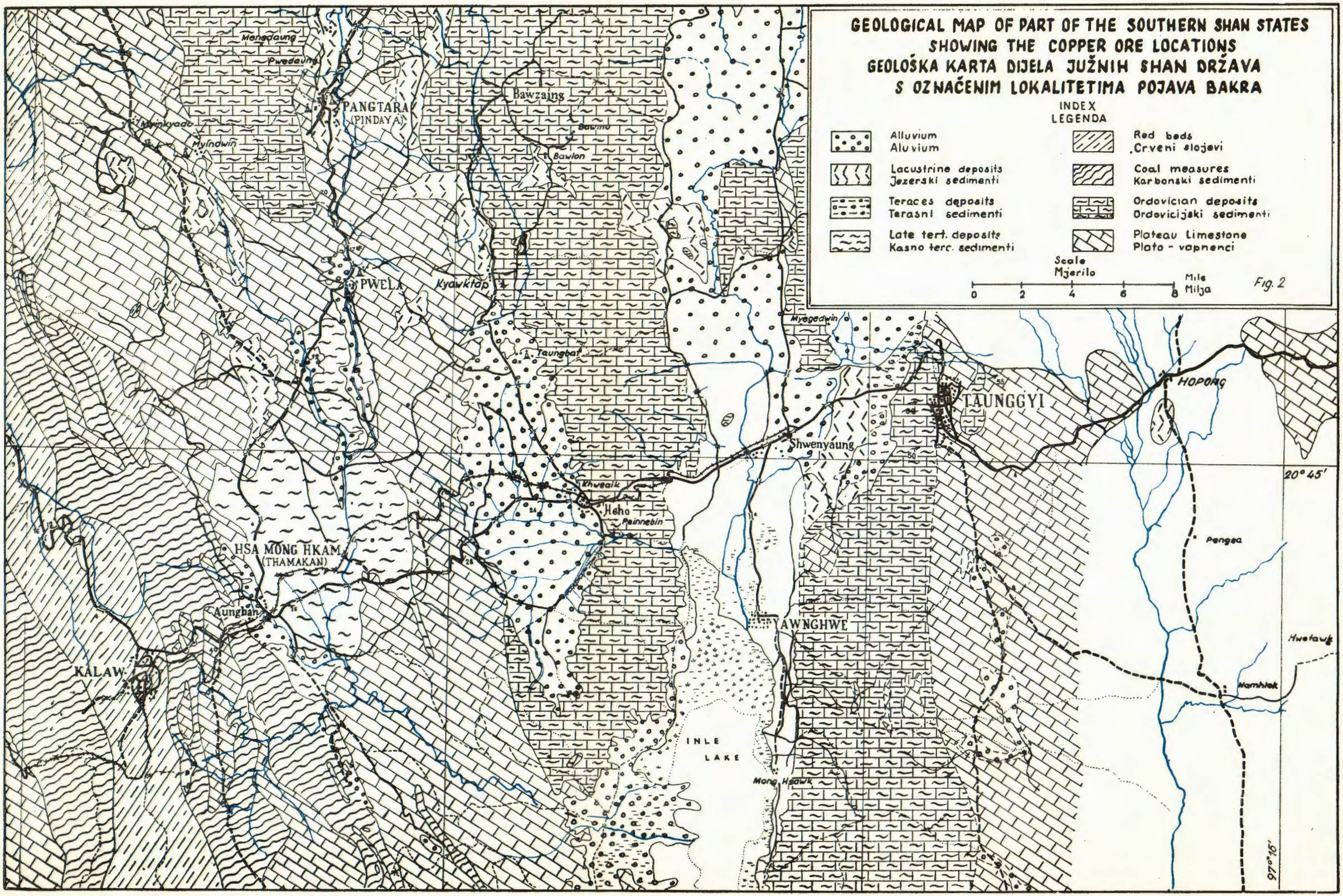
GEOLOGICAL MAP OF PART OF THE SOUTHERN SHAN STATES
SHOWING THE COPPER ORE LOCATIONS
GEOLOŠKA KARTA DIJELA JUŽNIH SHAN DRŽAVA
S OZNAČENIM LOKALITETIMA POJAVA BAKRA
INDEX
LEGENDA
Alluvium
Aluvium
Lacustrine deposits
Jezerski sedimenti
Teraces deposits
Terasni sedimenti
Late tert. deposits
Kasno terc. sedimenti
Red beds
Crveni slojevi
Coal measures
Karbonski sedimenti
Ordovician deposits
Ordovicijski sedimenti
Plateau Limestone
Plato - vapnenci
Scale
Mjerilo
0 2 4 6 8
Mile
Milja
Fig. 2
Mengdaung
Pwedaung
PANGTARA
(PINDAYA)
Bawzaing
Bawmo
Bawlon
Mynkyado
Myindwin
PWELA
Kyawktap
Taungbat
Myegedwin
TAUNGGYI
HOPONG
Shwenyaung
Rhweaik
Heho
Peinnebin
HSA MONG HKAM
(THAMAKAN)
Aungban
KALAW
INLE
LAKE
AWNGHWE
Mong Hsawk
Pengea
Hwetawk
Namhlak
20° 45'
97° 15'