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CONTENT

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The Cupriferous Schist of Pnom Sarakam.

BY

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Introduction.

During the recent world war, Siam felt a pressing need for metallic copper. She had not made any intensive search for copper deposits before, although there are numerous occurrences of this base metal; accordingly from 1943 onwards the Department of Mines and the Thai Mineral and Rubber Co., Ltd. dispatched many geologists to various parts of Northern Siam in search of this mineral. The result was disappointing; nearly all the deposits turned out to be too small for any development, notwithstanding the apparent richness in value of the outcrop. Only the deposits at Jan Tük and Pnom Sarakam were worthy of attention; and as the Sarakam deposit appeared more promising, some time was spent in studying its surface show. The result, though not yet conclusive, shows promise in that it may turn out to be a large deposit with low copper value. The two organisations ceased their activity immediately after the war, but, owing to shortage of copper especially in the U.S.A., the writer decided to give some description of this queer copper occurrence, which, though it might not have even the slightest value in mining economics, may throw some light on the occurrence of copper elsewhere. The exploration of this copper deposit has been performed principally by the writer and his students, but he was accompanied for some time by Nai Chumjate Charunchavanapet B. Sc. (Hons.), A.R.S.M. and Nai Sompan Pisolyabutr B.S.(Colorado). Nai Smarn Buravas B.Sc. (Hons.), A.R.S.M. gave much help in the identification of the rocks and minerals and thanks are also due to all the technical experts of the Department of Mines, who made chemical analyses and made this exploration for copper a real science.

Situation.

The copper deposit of Pnom Sarakam is situated at Huey Hin Dart, lat. 13° N, long. 101 25', Koo Yai Mee sub-district, Pnom Sarakam district in the Province of Cha Cherng Sao.

Accessibility.

The road from Bangkok passes through the town of Cha Cherng Sao which may be also reached by means of the Cambodia-Siam Railway. From Cha Cherng Sao or Pad Riu there are daily passenger boats to Koh Kanun, passing through Klong Ta Lart, a winding river. On the way the boats stop at various places, including the district office of Pnom Sarakam. At Ta Kanun there is a light railway, belonging to the Er Vidya Co., Ltd. which was directly down south for a distance of some twenty two kilometres. Huey Pru station. 10 km. south of Ta Kanun, is the stopping place for Huey Hin Dart. A small cart track about 3 1/2 km. long then connects the copper deposit with the railway. Communication between the deposit and Bangkok may be improved in various ways. For example, a road may be cut to connect the road from Pad Riu to Sri Maha Bodi, thus making a direct communication of the deposit with Bangkok, or it may be directed to Pad Riu or the Bang Pakong river, thus making contact with Bangkok through the Gulf of Siam or Bangkok-Cholburi road. Pad Riu is 60 km. east of Bangkok and a total distance of 110 km. has to be traversed before the copper deposit is reached.

Environment and Topography.

The Pad Riu river drains a large part of south-eastern Siam; its water-shed is joined to the water-shed of Menam Chao Phya. The copper deposit forms the edge of this plain, therefore the topography consists of a high ground covered with thick laterite beds and is gently undulating. Occasional hills rise up from the high ground, the most important being Kao Phra Bart and Kao Nam Yod which rise to 130 metres and 140 metres respectively. The surface soil is fine silt overlying laterite. Monsoon forest covers a large part of this area and the perenial rainfall is considerable (2000-3000 mm.). There are tracks of dry forest but they are not characteristic of this part of Siam.

Geology.

It has been suggested by Nai Smarn Buravas that old rocks of pre-Cambrian age underlie the plain of Chao Phya River. This appears to be true as pre-Cambrian rocks crop out all over the rim of the plain. Sri Raja, Cholburi and Pnas Nikom contain quartzites, schists, crystalline limestones and granite gneisses alleged to be of old age. The crystalline schist of Pnom Sarakam forms a part of this series of pre-Cambrian rocks.

A wide belt of gneissic granites occupies the southern part of Pnas Nikom, where a gold field is situated. This formation seems to include a greenish slaty shale which is pebbly in parts.

At Lard Kating a red shale formation can be seen on top of the crystalline schist, which crops out at Kao Kaew. A wide expanse of laterite region separates the crystalline schist from the gneissic granites and it is impossible to correlate the two formations.

The crystalline schist of Huey Hin Dart occupies a wide area from a small hill some five kilometres south of Pad Riu to Huey Hin Dart, 25 km. ENE of it. The schist is covered with a thick laterite crust which begins at the surface as a silty soil and is followed by true laterite bed full of quartz breccias. The lower bed consists of an iron-cemented schist which is four to five metres thick. To unexperienced geologists this would have been recorded as laterite. In the cemented schist, every kind of geological body can be seen in situ such as intruding-quartz veins. The schist contains a high amount of pyrite and the origin of iron is easily traced. Surely, if the bed above the cemented schist is called "true laterite", laterisation would be no other than a special kind of iron cementation.

The schist crops out at Kao Pra Bart, Kao Nam Yod, Kao Din and Kao Ta Jeed, some three hundred metres west of Huey Hin Dart. At the copper deposit itself, the schist is under thick laterite, and only in the stream bed of Hin Dart does the schist crop out. Had it not been for a duck owned by a local inhabitant there, a copper deposit would not have even been thought of! The story goes that some twenty years ago a duck swallowed a few pieces of native copper while seeking its daily food in

the stream. The owner killed the duck for food and found the copper in its stomach. Thinking that the copper was gold the owner of the duck immediately excavated the ground in search of gold and made a "gold" chain out of it. The secret was out, people flocked around from all the villages to search for the gold and surely they must all have been disappointed to have found only copper!

In the stream bed a black soil is to be seen over the schist. On panning, this has been found to contain heavy minerals of the schist with native copper and marcasite. The average value for copper of the black soil over a thickness of 1.5 metres is 1.5%. Under the soil before the decomposed schist is reached there is some 30 centimetres of quartz pebbles with white plastic clay.

The marcasite in the black soil was formed as a precipitate on decomposed wood which turned black. The sulphide of iron has been reduced from ferrous sulphate in a weak solution of sulphuric acid obtained from decomposition of pyrite in the schist. The colour of the soil suggests a reducing environment, just as is being now formed in Bangkok canal beds.

The schist is similar in composition and constitution in every outcrop but there is dissimilarity in structure.

In constitution it consists principally of sericite and quartz and is wholly crystalline, no part of it appears as slate or phyllite. In many parts of the area the sericite has changed into green chlorite. Other constituents are almandine garnet, topaz, green garnet (uvarovite?), kyanite, and epidote. The kyanite and quartz also occur in separate pockets in the schist, while epidote and quartz with pyrite are seen in veinlets traversing the schist, kyanite and epidote never being found together.

Igneous rocks are not to be found anywhere in this area of crystalline schist. At Huey Hin Dart a piece of quartz porphyry was seen while pitting for copper; it seems to have come from a dyke but the search for such a dyke failed. In the schist several interbedded quartzites are present and at Kao Pra Bart a small seam (6 inches) of barytes is seen in it. Decidedly the Pnom Sarakam schist is of sedimentary origin and not of igneous descent.

There are numerous milky white quartz veins along the "bedding" plane of the schist. They are from 1 inch to 12 inches wide. Cross veins are less numerous and are smaller. They have been found to contain a trace of silver.

The highly metamorphic nature of the schist suggests that it forms the roof of a batholith of igneous rock not far down; but if this is true there is no need to assign the schist to be of "old age". There are, however, rocks of known age and old enough to approach igneous rocks but metamorphism seen in such rocks is not as intense and extensive as this. Therefore, the Pnom Sarakam schist has been classed as pre-Cambrian by the writer.

As to structure there appears something like a " bedding plane " among the schist and this strikes WNW to NNW, dipping to the east from 25° to 35°. The persistence in direction of dip either suggests that the "thickness" of the schist is enormous or the " bedding plane " is no bedding plane at all but a plane of schistosity. The latter view is strengthened by the fact that the foliation is parallel to the " bedding plane " and the flat crystals of sericite are arranged along such plane. However, there is minor warping and even contortion of the bed, resulting in the appearance of small synclinoriums. In many places the schist is contorted to the minutest scale of one centimetre across the anticlines and this shows intense pressure during its formation. At Pad Riu the schist is devoid of any contortion and even at the prospecting pits there are outcrops of uncontorted schist although the constituent is the same. It has been observed that the seam of barytes mentioned and quartzite beds are parallel to the "bedding plane" so that it is highly probable that the schistosity plane coincides with bedding plane. If this fact is taken into consideration the schist is over 10,000 feet thick.

Ore Deposit.

It has been found that where the schist is contorted there is copper, and this occurs originally in cupriferous pyrite which seems to be disseminated all over the schist and suffers the same earth movement. There are also veinlets of quartz, epidote and cupriferous pyrite and these are parallel to the bedding plane. The pockets of quartz with kyanite and

quartz with muscovite are devoid of pyrite. This shows that the cupriferous pyrite occurs in a much lower-temperature surrounding. Sometimes the pyrite is massive and occupies the whole of the veinlets. Under the microscope the pyrite shows octagonal and pyritohedral forms but never cubic forms.

In the test channel, the average value for a horizontal width of 8.5 metres is 0.67% copper; a cross channel was sunk at an angle of 60 degrees to the bedding plane and samples were taken along the pit every five metres. These gave the following values, 1.30%, 0.18%, 1.20%, 0.59% 0.41%, minor fault, 0.21%, 0.67%, 0.38%, and 0.40%, Cu. Test pits were also sunk and copper schist was struck wherever the schist was contorted. At Kao Ta Jeed copper was detected in the decomposed schist; even at Kao Nam Yod and Kao Pra Bart some five to seven kilometres away there are traces of copper in the leached decomposed schist. There is also one water well at the northern end of Kao Pra Bart where there was a report of native copper.

It is rather strange that there is a total absence of the usual oxidised zone of copper where there may be seen brilliant hues of malachite, azurite and chrysocolla. The pyritic schist becomes speckled with green spots when left to weather artificially but above the schist in situ, there is no copper show at all. This may be explained by the fact that the present topography favours leaching and this takes down all the copper. There is however a zone of enrichment but covellite and chalcocite are missing. There is found instead metallic copper and cupriferous martite which occurs in well-formed octahedral crystals in the schist. The martite is black in colour or may be grey like chalcocite. It is slightly magnetic and may be lifted by a horse-shoe magnet. Every sample of this martite contains iron sulphide and it is oxidised to red haematite when treated with nitric acid. Probably this is no new mineral at all but a pseudomorph of iron oxide and copper oxide after pyrite.

The occurrence of metallic copper at Hin Dart is rather strange. The metal is found both as disseminations in limonite which replaces schist or as coatings and veinlets through schist and such limonite. The copper in limonite is easily explained as being formed by the decomposition of pyrite but the occurrence of coatings and veinlets of copper

crystals travesing schist and copper limonite requires a new explanation as to its probable origin. Usually in text books on copper deposits, metallic copper is explained as being formed from the action of ferric sulphate solution on chalcocite thus:

$$Cu_2S + 3Fe_2(SO_4)_3 + 4H_2O = 2Cu + 6FeSO_4 + 4H_2SO_4$$

This, however, only explains the occurrence of metallic copper in limonite but not of the free metallic copper which coats other rocks in cauliflower form or replaces other rocks as veinlets. In such occurrences, the copper must first have been precipitated from the solution just as in a Daniel cell and in reality the "free" metallic copper in the form found at Hin Dart is similar to the precipitate from a Daniel cell. The following reactions then must have taken place.

(i) Oxidation of cupriferous pyrite.

$$CuFeS_2 + 8\,O = CuSO_4 + FeSO_4$$

$$FeS_2 + 7\,O + H_2O = FeSO_4 + H_2SO_4$$

(ii) Reduction of $CuSO_4$ in solution by $FeSO_4$ (also in solution) yielding copper precipitate:

$$CuSO_4 + 2FeSO_4 = Cu + Fe_2(SO_4)_3$$

The metallic copper zone at Hin Dart is rarely half a metre thick but on both sides of a minor fault as in the south end of the test channel it extends down but was not followed during prospecting. The black "martite" was found in decomposed schist at many places and surely the copper must have been leached out so that only traces of it were left. The red soil covering the schist outcrop also contains this black mineral, therefore it is concluded that the cupriferous schist is extensive and further pitting is needed to delineate the cupriferous schist, while percussion or diamond drilling should follow to test the presence of copper in depth.

A representative sample of cupriferous schist from the test channels assayed two ounces of silver to the ton. The pyrite content ranges from five to fifteen percent of the schist. This show that the revenue from copper extraction would be nearly doubled when the silver is also taken into consideration and the pyrite is used for making sulphuric acid. Kyanite and garnet may be concentrated and separated by magnetic sepa-

rators. These will also yield revenue. At the worst, the schist may be cut and used in rock gardens! Taking everything into consideration, then, the cupriferous schist of Pnom Sarakam affords a great future for the technical students of Siam if the government will only reconsider its old scheme of copper exploration and pay attention to this well known Hin Dart copper deposit.

Origin.

The occurrence of native copper in limonite, which is jet black, suggested the erroneous view to every geologist who first visited the deposit that this was a deposit of copper basalt! Careful observation brought to light the existence of cupriferous pyrite in the schist. As this is disseminated throughout the rock and appears to arrange itself parallel to the schist it was thought that the pyrite was an original constituent of the argillite which turns into schist, and the idea of sedimentary copper brought into mind. Now, the enormous thickness of the schist is contrary to this theory, and there have been found veinlets of solid pyrite or pyrite with quartz and epidote parallel to the bedding plane. These suggest that the pyrite has infiltrated into the schist or soaked into it before the age of schist formation; but as no igneous rock is present, this theory is not substantial enough unless an igneous rock is further postulated to lie not far below the rock. With the evidences collected up to the present the infiltration theory seems to offer the best explanation.

Conclusion.

There are many copper deposits in Siam especially in rocks of old age. The copper appears to be connected with the intrusions of Permo-Triassic igneous rock-andesites, porphyrys, older granites and diorites. These deposits are of small extent only.

In the south, among tin and tungsten belts, there have been found ores of copper in stanniferous and wolfram veins of all types especially those of hydrothermal and contact metamorphic origins. There is however, insufficient copper for any serious consideration in such deposits.

Only one deposit remains and this is the cupriferous schist of Pnom Sarakam. So far prospected, this seems to be a large deposit but of low value for copper. The mines may however be worked if all by-products are made to yield useful commodities like silver, sulphuric acid, garnet paper, kyanite refractories and red ochre. In the near future there will be world shortage for copper, and with the rise in price of this commodity, this Hin Dart deposit may become a source of great wealth to agricultural Siam.

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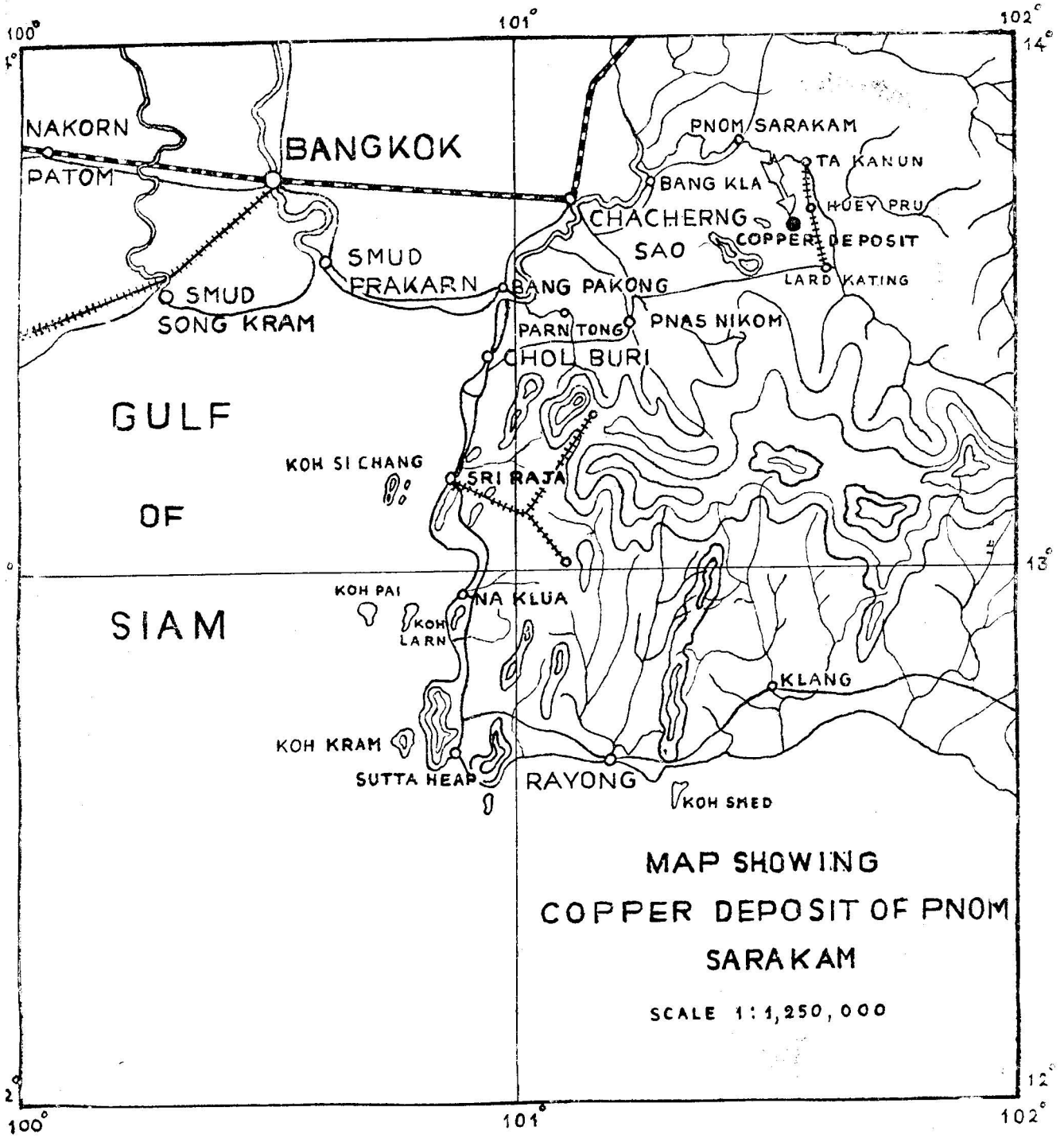
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