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The Prospects for Hardrock Gold and Tin Deposits in Malaysia

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Abstract

Tin and gold mineralization in Peninsular Malaysia is found as distinctive parallel belts, which are apparently related to the structures and the tectonic setting of this region. Sarawak and Sabah, across the South China Sea, are hosts to gold deposits related to the magmatism of the region. Tin deposits in the Western and Eastern belts of Peninsular Malaysia that had been mined using hardrock methods are: quartz topaz aplite, cassiterite-magnetite skarn, cassiterite-malayaite skarn, skarn pipes in limestone, greisen, structurally-controlled complex lodes, sheeted veins, and replacement ore bodies in granite. Primary tin deposits mined as soft rock deposits using alluvial mining technologies include: cassiterite-bearing pegmatites, greisen type, xenothermal vein swarm and sheeted veinlets. The best potential for hardrock tin deposits are: 1. Structurally controlled lodes; 2. Greisen types (massive greisens and greisen-bordered veins); 3. Sheeted veins and veinlets, and 4. Cassiterite-magnetite skarns. The Greisen type and sheeted vein types are potential targets for modern opencut bulk mining techniques. Old "lampanned" areas on higher ground upstream of very rich alluvial tin deposits are good targets for systematic exploration and evaluation for hardrock and soft-rock mining. The rather widespread gold mineralization in Peninsular Malaysia is dominated by the deep source Mesozoic mesothermal veins hosted largely in the strongly folded and weakly to moderately metamorphosed rocks of Paleozoic to Triassic age. Based on the style and the location, the primary gold mineralization can be divided into 4 distinct N-S belts. Recent prospecting of long abandoned hardrock gold mines in Gold Belt 2 and 3 had lead to the opening of one hardrock opencut mine (Penjom) while two more (Selinsing and Buffalo Reef) are on stream. In Belt 4, the gold rush of 1989-1991 in the Lubok Mandi area, Trengganu had yielded a hardrock mine exploiting multiple mesothermal gold-quartz veins in shear zone mineralization in Upper Carboniferous metasediments. The most prospective sites for commercial gold deposits are along the 340° to 350° striking regional fractures in Gold Belts 2 and 4, which tap deep source gold-bearing solution. In Gold Belt 3, commercial veins and gold mineralized zones are expected to strike along 345° and 030°. Central Kelantan and northern Pahang show potential for gold-bearing volcanogenic massive sulphides. In East Malaysia, economic gold mineralization in Bau, Sarawak is regarded as the classical epithermal Au-Ag-As-Sb-Pb-S vein type associated with dacitic igneous intrusives of Miocene age. Cu-Mo-Au porphyry , Cu-Au skarns, replacement ore bodies in shales and limestones and disseminations in shales have recently been identified. The Bau area and its extensions towards the north and south are being investigated presently. In Central Sarawak, (Sibu-Sarikei) a younger and still not fully exposed Au-Sb-Ag-Hg mineralized zone is a good prospect for large gold deposits. In the Sabah, gold had been commercially produced from a small Cu-Au porphyry deposit (Mamut) that was genetically related to the Gunung Kinabalu granodiorite-diorite intrusive. Mamut located within the Central Sabah geochemically anomalous belt which shows potential for porphyry, epithermal, massive sulphide and classical Au-Sb-As-Hg vein types gold deposits. It is predicted that the Central Sabah geochemically anomalous belt will become one of the most sought after area for exploration of gold and other metals in the near future.

Prospek Emas dan Bijih Timah Batuan Keras di Malaysia

Abstrak

Pemineralan bijih dan emas di Semenanjung Malaysia didapati bersifat selari dengan jaluran yang berkaitan dengan struktur dan kedudukan tektonik rantau ini. Sarawak dan Sabah yang melintasi Laut China Selatan merupakan punca endapan emas yang berkaitan dengan magmatisme rantau ini. Endapan bijih di bahagian jalur barat dan timur yang telah dilombong mengunakan kaedah batuan keras adalah; aplit kuarza-topaz, skarn kasiterit-magnetit, skarn kasiterit-malayait, paip skarn dalam batu kapur, greisen, komplek lod kawalan stuktur, telerang terlembar dan penggantian jasad bijih dalam granit. Endapan bijih timah primer dilombong sebagai endapan batuan lembut mengunakan teknologi perlombongan aluvial termasuk: pegmatit bersifat kasiterit, jenis greisen, telerang paya xenoterma dan telerang tak terlembar. Potensi terbaik endapan bijih timah batuan keras ialah: 1) Lod kawalan struktur; 2) jenis greisen (greisen masif dan telerang disempadani greisen) 3) telerang terlembar dan telerang tak terlembar dan 4) skarn kasiterit-magnetit. Sebaran pemineralan emas di Semenanjung Malaysia didominasi oleh sumber dalam telerang mesoterma Mesozoik yang kebanyakannya terlipat dengan rencam dan merupakan batuan metamorf rendah hingga sederhana berusia Paleozoik hingga Trias. Berdasarkan sifat dan lokaliti, pemineralan emas primer boleh dibahagikan kepada 4 jaluran U-S utama. Prospek baru lombong emas batuan keras yang telah lama terbiar di Jalur Emas 2 dan 3 mendorong pembukaan sebuah lombong potongan terbuka batuan keras (Penjom) manakala 2 lagi (Selinsing dan Terumbu Kerbau) di sungai. Di jalur 4, jumpaan emas 1989-1991 di Lubok Mandi Terengganu telah menonjolkan lombong batuan keras melalui eksploitasi pelbagai telerang mesoterma kuarza-emas dengan pemineralan dalam zon ricih metasedimen yang berusia Karbon Atas.

Di Malaysia Timur, pemineralan emas ekonomi terdapat di Bau Sarawak dan dikenali sebagai jenis telerang epitermal Au-Ag-As-Sb-Pb-S klasik yang berkait rapat dengan intrusi igneus dasit berusia Miosen. Porfir Cu-Mo-Au, skarn Cu-Au, penggantian jasad bijih dalam syal dan batu kapur dan penyerakan dalam syal telah dikenalpasti. Di Sabah, emas telah dihasilkan secara komersial daripada longgokan kecil porfirit Cu-Au (Mamut) yang berkaitan dengan intrusi granodiorit-diorit Gunung Kinabalu. Mamut yang terletak di bahagian tengah Sabah merupakan jaluran anomali yang menunjukkan potensi longgokan emas jenis porfir, epiterma, sufida masif dan telerang klasik Au-Sb-As-Hg.

INTRODUCTION

It is well known that tin mineralization occurs in two distinctive tectonic settings; one related to orogenic belts at subduction margins of continents and the other at the intra-continental plate region (Mitchell, 1977; Taylor, 1979). The tin mineralization in Peninsular Malaysia is set in the continental margin where the S-type granites were generated involving collision of micro-continental fragments (Yeap, 1993). Gold mineralization on the other hand has no distinctive tectonic setting but can occur as deep source mesothermal veins, magmatic related deposits, volcanogenic exhalatives, deep source sediment hosted replacements and epithermal deposits. The gold mineralization in Peninsular Malaysia is largely of the mesothermal vein type with minor occurrences of volcanogenic massive sulphide types and a skarn.

PRIMARY TIN DEPOSITS

Tin mineralization in Peninsular Malaysia can be divided into the Eastern and Western tin belts. Subtle differences in these two tin provinces are listed in Table 1.

In Peninsular Malaysia, the more well known hardrock tin deposits which are mined or had been mined in the past are listed in Table 2.

Many of the primary tin deposits have been subjected to deep and intense tropical weathering, which made them soft enough to be cut or even broken up by monitors. Some of these were mined using the opencast or combination of opencast and gravel pump mining method (Table 3). Many primary deposits which were discovered in the alluvial mine pits were also mined successfully (see Ingham and Bradford, 1960). The presence of 124 localities of primary tin occurrences in the Kinta valley till 1960. About 20 of them were mined successfully as hardrock deposits.

PROSPECTS FOR PRIMARY TIN DEPOSITS

There was hardly any systematic exploration for hardrock tin deposits in Peninsular Malaysia. A few exploration programmes were carried out by foreign companies (Pruesag and Mcmahon of Australia and Serem of France) but did not yield any meaningful results. Local tin mining companies that were operating also carried out some exploration now and then but these never led to any discovery of new primary tin deposits. Systematic geochemical exploration was done by the PCCL of Sungei Lembing, Pahang but they concentrated their effort mainly within their mining lease. In view of the lack of systematic exploration and the meagre interest in the past, it is deemed that Malaysia still possesses very high potential for hardrock tin deposits.

Table 1: Differences between Western tin and East tin belts.

Characteristics	Western Tin Belt	Eastern Tin Belt
Host Rock	Schist, marble, phyllites, arenites and argillites. Ordovician to Upper Permian.	Arenites, argillites, volcanics, limestone Lower Carboniferous to Permian.
Granitoids	Epizonal to mesozonal composite batholith of S-type. Endo and Exo-contact pegmatites. No associated volcanics of same age. Upper Permian to Upper Triassic.	Epizonal and meszonal composite batholith. Mainly S-type. Dikes of aplite and lamprophyre common. Volcanics of the same age. Upper Carboniferous to Upper Permian.
Mineralization	Diverse styles and largely confined to the granitoid-country rock contact. Mainly fissure filled hypothermal and xenothermal veins / lodes, replacement ore bodies, pipes and veins, greisen. Minor styles- Malayaite skarn, hydrothermal breccias. Zoning absent. Telescoping and xenothermal textures common.	Near distance and substantial distance form the contacts. Mainly fissure filled veins/lodes of substantial vertical extent, cassiterite-magnetite-pyrrohtite skarn, massive greisen and veins. Minor styles: replacement veins and ore bodies. Zoning apparent.
Main Associated Minerals	Fe - Pyrite and pyrrhotite (magnetite and hematite absent). W - Mainly wolframite and hubnerite	Fe – Magnetite, pyrrhotite, with pyrite and hematite. W – All are ferberite.

Table 2: Mined primary tin deposits in Peninsular Malaysia.

Types of Deposits	Locations	Types of Mining
1. Quartz-topaz aplite	Gunung Bakau in Pahang	Aditing and shafting
2. Cassiterite-magnetite skarn deposits	Bukit Besi, Trengganu Pelepah Kanan, Johore	Opencut hardrock
3. Cassiterite-malayaite skarn	Sungei Gow, Pahang	Adit hardrock
4. Skarn type pipes in limestone	Lahat and Menglembu, Perak	Shaft.
5. Greisen-type	Gunung Bujang Melaka, Perak and Ulu Keleh, Trengganu	Adits and shafts – hardrock
6. Structurally-controlled complex lodes	Sungei Lembing, Pahang Kajang Kemaman, Trengganu. Menglembu, Perak. Sintok, Kedah.	Hardrock underground by Shafts and adits.
7. Sheeted Veins	Klian Intan, Perak.	Opencut Hardrock
8. Replacement ore bodies in granite	Sungei Besi, Selangor	Opencut – Hard and Soft Rock

Table 3: Some examples of primary tin deposits mined by softrock methods.

Types of Deposits	Locations	Types of Mining
1. Cassiterite-bearing pegmatites	Semiling , Kedah	Gravel Pump – Palong
2. Greisen type (veins and massive)	Sungei Yai, Kelantan	Ground Sluicing
3. Xenothermal vein swarm	Gopeng, Perak	Gravel Pump - Palong and opencast
5. Sheeted veinlets in granite	Gambang, Pahang	Gravel pump – Palong
6. Sheeted Veinlets in granite	Brusih, Perak	

Potential primary tin deposits in Peninsular Malaysia can be grouped into:

1. Structurally controlled lodes
2. Greisen types (massive greisens and greisen-bordered veins)
3. Sheeted veins and veinlets
4. Cassiterite-magnetite skarns

Out of these four types of deposits, the greisen type and the sheeted veins would have potential to be mined by the opencut hardrock bulk mining method. Besides, primary deposits which are hosted by siliceous rocks, when subjected to weathering can form eluvial deposits, which can be mined using alluvial mining techniques.

Structurally Controlled Lodes and Veins

Structurally controlled lodes and veins occur in the form of tabular ore bodies largely hosted in meta-sedimentary rocks which were intruded by the tin-bearing granites. The mineralization is epigenetic and the hydrothermal minerals generally filled fractures which originated as faults (Sungei Lembing, Kajang Kemaman, Sungei Ayam), fault zones (Bukit Payong, Keroh, and Bidong Darat) or shear zones (Menglembu). The fault movements were active during the time of mineralization and thus the lodes and veins are complex in structure. Shearing, fracturing and replacement textures are common. Lodes are of substantial strike lengths and depths. Wall rock alteration range from chloritization (main type) to greisenization, silicification and propylitization.

A good example of this is the Sungei Lembing Lodes which were first mined in the late 19th century (Fitch, 1952). The mineralization occurs in the slate hornfels which was intruded by Triassic biotite adamellite. The mineralized lodes occurs within a 3 km wide zone which is elongated approximately N-S for a length of about 4.4 km. There were no less then 41 lodes within this zone and they strike along three major directions of E-W, NE-SW and WNW-ESE. Strike lengths of individual lodes ranged up to 700 m and some have been mined to a depth of 400 m. Stooped widths of lodes range from 10 cm to over 30 m. From 1892 to 1970, underground tunneling (shafts and adits) methods yielded about 8,472,750 tons of ores. Ore grades range from 2.96 % of Sn (1887 - 1914) to 1.1 % of Sn (1929 - 41) and in later years dropped to 0.8 % and 0.6 % of Sn. Based on the available records, these ores contained 86,717 tonnes of tin metal. Even by 1974 there were still 16 lodes which were being actively worked.

Up to now no other hardrock tin mines can match Sungei Lembing in terms of size and yield. Some structurally controlled lodes and veins which were mined were largely concentrated in several areas:

1. East of Menglembu in Perak.
2. Bukit Lentor Tinfields, Trengganu (Chand, 1978).
3. Manchis, Pahang.
4. Sintok, Kedah.
5. Kemaman and Air Putih, Trengganu.

The structurally controlled lodes and veins would be the best prospect for the hardrock tin mining in Peninsular Malaysia. Exploration of such deposits would require systematic geological input and spur and ridge soil geochemistry (for Sn) which has been proven to be workable in the Malaysian terrain.

Greisen Type

Greisen was formed when the hydrothermal solution emanating from a mineralizing granite altered the rocks (the granite itself or the overlying rock) to that which consists largely of muscovite and quartz and quite frequently other minerals like tourmaline, topaz, fluorite, beryl and economic minerals like cassiterite, wolframite, tantalite and columbite. The cassiterite can be found as part of the accessory mineral of the greisen bodies (massive greisen) or in the veins (greisen veins and greisen-bordered veins) which may contain other minerals like quartz, tourmaline, topaz and sometimes arsenopyrite, pyrite, wolframite and others.

One of the greisens type deposits that had been mined in the past is Ulu Petai, Perak where the massive greisen was mined by adits. Another example of mining of greisen type deposit is in Ulu Keleh, Trengganu. Here the massive greisen and vein greisen are found in the granite and the overlying meta-sedimentary host rock.

Greisenized areas where cassiterite had been known to occur and which had been exploited are: Tebak, Trengganu, Menglembu, Perak (Ingham and Bradford, 1960), Fraser's Hill, Pahang (Roe, 1951), Gambang, Pahang, Ulu Klang, Selangor (Yeap, 1979), Eastern Kinta Valley, Perak (Ingham and Bradford, 1960).

Sheeted Veins and Veinlets

Sheeted veins refer to swarms that occur as parallel to sub parallel sets. The origin of these veins or veinlets can be quite varied. Some obviously originated as parallel shear planes that were then opened during the tensional phase. Others may be tensional cracks associated with intrusive mineralized granite. Others can be tensional en echelon veins related to parallel movements of faults. These veins can occur in mainly the host rock or they may occur in the mineralized granite itself.

Several of the sheeted vein types of primary tin deposits have been mined. One good example is Klian Intan which has been mined since 1902 (Scrivenor, 1928) and it is still active now as an opencut mine. There are several sets of sheet vein swarms in Klian Intan which were formed as en echelon fractures related to the movements of the parallel faults (Yeap, 1993). Veins are quite thick (1 cm to 30 cm) and may show strike lengths of from several metres to over 100 metres. Distance between veins range from 10 cm to 2 metres. Generally the mineralogy is simple with many containing just quartz, some sulphides and cassiterite. The vertical depths where these veins have been worked downwards is > 200m and there are signs that they still continue downwards. Other areas in which such sheeted veins and veinlets have been mined are:

1. Tekka, Perak - sheeted and sometimes stockwork of xenothermal veins.
2. Jeher, Perak - sheeted veinlets in meta-sediments mined as soft rock deposits by ground sluicing.
3. Brusih, Perak - sheeted vein lets in meta-sedimentary rocks mined by gravel pump-palong method.
4. Gambang, Pahang - sheeted veinlets in greisenized granite mined by gravel pump-palong method.

Magnetite - Cassiterite Skarn

These are skarn deposits which are generally found at the contact between the host rock and the intrusive granites. The ore bodies are generally irregular and there may be quite a number of ore bodies occurring within a strong mineralized area or zone. The main minerals are magnetite and some times quartz; fluorite and sulphides (pyrite and pyrrhotite) are present. The cassiterite is found associated with the magnetite or often as some distinct cassiterite - magnetite lodes or ore bodies. The cassiterite may be magnetic and thus there are a lot of problems in beneficiating such ores. Many of these deposits have been mined generally for its Fe content. However, if the Sn content exceeds certain amount (0.1 %), then the magnetite cannot be used as iron ore.

There are quite a number of examples of these types of deposits occurring in the Eastern Tin Belt. The best known are Bukit Besi and Pelepah Kanan. Bukit Besi, Trengganu started as an iron mine where the ores were exported to Japan. Its production from 1930 to 1965 is reported to be 35,919,261 tons of iron ore averaging about 54.4 % Fe and 0.1 % Sn (Bean, 1969). Some of the ores were known to contain up to 8.00 % Sn. Certain ore bodies and certain parts of the largest ore bodies in the main pit contain cassiterite. The Batu Tiga mine (part of the Bukit Besi mining lease) was known to be quite rich in cassiterite. From 1966 to 1970, 199,833 tonnes of the Fe-ores from Batu Tiga mine was extracted and treated. The ores yielded an average grade of 1.59 % to 3.52 % of Sn. It was prematurely closed in April 1977 and had remain so until now. Other examples of such deposits which have been mined for its tin content are Pelepah Kanan and Pelepah Kiri, Johore. The Pelepah Kanan ore body consists of a large lensoid mass of magnetite (largely martite) which replaced some metamorphosed basic volcanic rock. The feeder zone from granitoid intrusive below is composed of magnetite-quartz-cassiterite and the banded wrigglite (of magnetite, fluorite, chlorite, cassiterite and quartz). At the base of the lensoid magnetite ore body and surrounding the feeder zone, there are vein swarms of quartz-feldspar-casiterite-fluorite-loellingite-sulphide veins. Some parts of the lensoid magnetite ore body, the feeder zones and the vein swarms, were exploited for its tin by opencut method since 1957. Pelepah Kanan was evaluated to contain 1,000,000 tons of Fe-ore with 0.8 % Sn and 2,000,000 tons at 55 % Fe and 0.65 % Sn. The highest grade of Sn detected 2 % to 16 % SnO_2.

Other magnetite-cassiterite deposits found are: Bukit Bangkong, Sungei Pandan and Sungei Panching and Pulau Manis all in Pahang; Susur Rotan, Johore; Machang Setahun, Trengganu.

"SOFT ROCK" PRIMARY TIN DEPOSITS

Prospecting for hardrock primary tin deposits is costly and requires a lot of geological input. It is suggested that many of the primary tin deposits can be initially exploited as soft rock deposits. On reaching the hardrock parts, consideration can be made for bulk opencut or even underground mining. Many old "lampanned" areas located on higher ground upstream of very rich alluvial tin deposits are good targets for systematic exploration and evaluation for soft rock mining.

PRIMARY GOLD DEPOSITS

The contrast in the types of gold mineralization in Peninsular Malaysia and East Malaysia reflects the differences in the tectonics of these two regions. The gold mineralization in Peninsular Malaysia is dominated by the post magmatic deep source Mesozoic mesothermal veins which are hosted largely in strongly folded and weakly to moderately metamorphosed rocks of Paleozoic to Triassic age. Sabah and Sarawak, both of which are located in the Tertiary Northwest Borneo mobile belt, are host to many intrusive related gold deposits.

Gold Mineralization in Peninsular Malaysia

Gold occurrences in Peninsular Malaysia is quite widespread. The primary gold mineralization can be divided into 4 distinct belts which runs parallel to the N-S structural trend of the peninsula (Fig. 1). Gold belt 1, on the west, is rather diffused and is located on the western block where much of the gold were recovered as byproducts of alluvial tin mining. Some primary gold mineralization is known to occur as minor veins in the mainly Lower Paleozoic sediments and volcanics. Towards the east is Gold belt 2 which forms a narrow strip of about 15 km broad and running parallel and east of the Raub-Bentong suture which divides the Western Block from the Eastern Block of Peninsular Malaysia. The most important gold deposits of Peninsular Malaysia are located largely within this belt. They take the form of mesothermal veins and mineralized shear zones both of which mark regional fracture systems which strike 345° and dip mainly to the east at high angle. These deposits are hosted mainly in metamorphosed sediments, carbonates and volcanics. Further east is Gold Belt 3 which is rather broad and the gold deposits take the form of mesothermal veins and shear zones (striking 345° and mainly dipping east at high angles). A few veins occurring by the side of the main shear zone is known to strike along 080°. In addition volcanogenic massive sulphides (Ulu Sokor and Tasik Chini) and polymetallic-Au skarns (Mengapur) also coour in this belt. On the far east, nearer to the coast, is the narrow Gold Belt 3 which shows similarities to Gold Belt 2. Economic deposits within this zone are found as mesothermal veins and mineralized shear zones striking from 340° to 350°, which also dip east with angles of about 80°.

Recent prospecting work in a number of abandoned hardrock gold mines in Gold Belt 2 and 3 indicates the presence of viable gold resource in several of them and presently one hardrock opencut mine (Penjom) is in operation. In Belt 4, the gold rush of the early 1989 to 1991 in the Lubok Mandi area, Trengganu had subsequently yielded a hardrock mine. The mine exploits mesothermal gold-quartz veins and shear zone mineralization hosted in folded carbonaceous metasediments of Upper Carboniferous age. About 4 tonnes of gold have been mined by opencut method, with further resource below the opencut pit being evaluated for underground mining.

Gold Mineralization in East Malaysia

In East Malaysia, the economic gold mineralization in the Bau area, Sarawak is regarded as the classical epithermal Au-Ag-As-Sb-Pb-S vein type associated with dacitic igneous intrusives of Miocene age (Wolfenden, 1965; Pimm, 1967). Besides the epithermal veins, Cu-Mo-Au porphyry, Cu-Au skarns, replacement ore bodies in shales and limestones and disseminations in shales have been identified (Mustard, 1997) (see Fig. 2). In the Sabah state of East Malaysia, gold had been commercially produced from the Cu-Au porphyry deposit (Mamut) which was genetically related to the dioritic intrusives of the Gunung Kinabalu. The Mamut Cu-Au deposit (Lim, 1975) is a small Cu-Au deposit with a resource estimated to be around 200 million tonnes and a mineable reserve of 83.6 million tonnes assaying 0.59 % Cu and about 0.5 g / t of Au (Akiyama, 1986).

Potential of Primary Gold Deposits in Peninsular Malaysia

The most prospective sites for commercial gold deposits in the Peninsular Malaysia are along the 340° to 350° striking regional fractures in Gold Belts 2 and 4, which tap deep source gold-bearing solution. In Belt 2 there is evidence that some of the rich gold veins do strike along 080°. Geochemical study of the soil along this narrow belt will be the best method for delineating the anomalous zone. Gold Belt 3 has similar potential and the veins and gold mineralized zones are expected to strike along 345° and 040°. It will be more difficult to locate gold mineralized veins within this broad zone. Structural studies, air borne geophysical data (some of which are available from the Minerals and Geoscience Department) and satellite imagery will be of great help in the initial exploration stage. Regional geochemical investigation of central Kelantan and northern Pahang, which come under Gold Belt 3 are available (Chu *et al.*, 1981; Lee *et al.*, 1982). This Belt also shows good prospect for gold-bearing volcanogenic massive sulphides showing association of Au-Ag-Cu-Zn-Pb. The Manson Lode

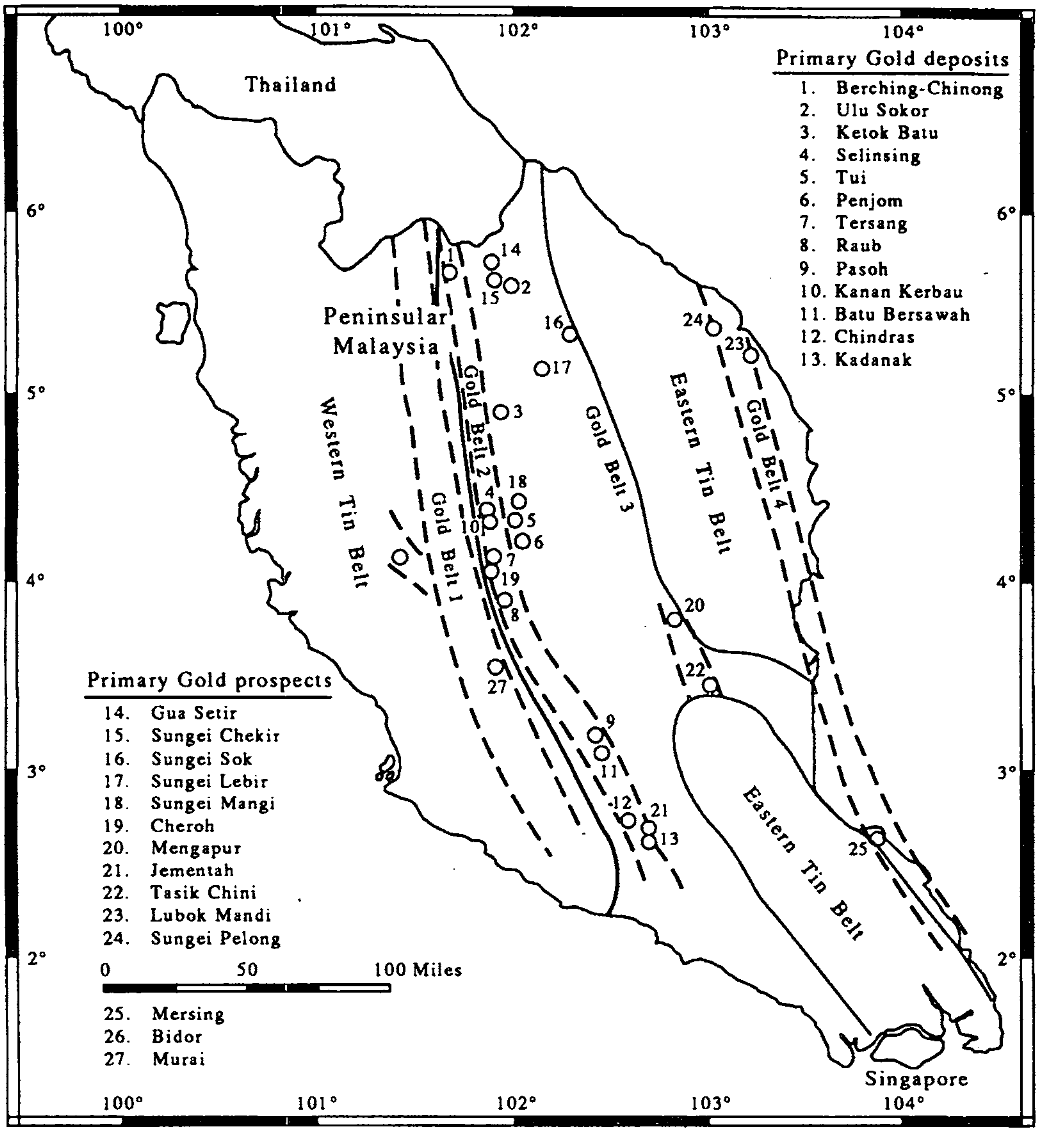

Figure 1: Map of Peninsular Malaysia showing mineral belts and primary gold deposits.

in Ulu Sokor (a Cu-Pb-Zn-Au-Ag – massive sulphides – see MacDonald, 1967; Rajah, 1970; Aw, 1973) has a long history of prospecting and has also been reevaluated recently.

Prospects For Gold Deposits in Sarawak

The Bau area and its extensions towards the north and south are yet to be investigated. The shale-limestone replacement and the shale hosted replacement and dissemination show the best promise. Overall the present investigated area contains substantial gold resource (1,000,000 ounces) waiting for exploitation at the right moment. In Central Sarawak, the area stretching from Sibu-Sarikei towards the interior is interpreted to constitute a younger and still not fully exposed Au-Sb-Ag-Hg mineralized zone which is worth testing. The Sb-As-Au mineralization is hosted in sediments and associated with thrust fault zones (Wilford, 1956; Phlemon, 1995). The potential for the epithermal and Carlin-type Au deposits in this part of Sarawak is very bright.

Prospects for Gold Deposits in Sabah

In Sabah, the Mamut Cu-Au porphyry deposits is located within the Central Sabah geochemically anomalous belt. This huge area shows potential for various types of gold deposits which include porphyry, epithermal (Lim, 1981), massive sulphide (Newton-Smith, 1967) and classical Au-Sb-As-Hg vein types. It is predicted that the Central Sabah geochemically anomalous belt (JICA, 1994) will become one of the most sought after area for exploration of gold and other metals in the near future.

CONCLUSIONS

The prospect for tin in Malaysia is very good as there had not been any systematic exploration so far. The best targets are: structurally controlled lodes and veins, greisen type deposits (massive and vein type), sheeted veins and veinlets, and magnetite-cassiterite skarn type deposits. Soft rock mining is a possible option to start off operations. The best targets for locating soft rock type of primary deposits

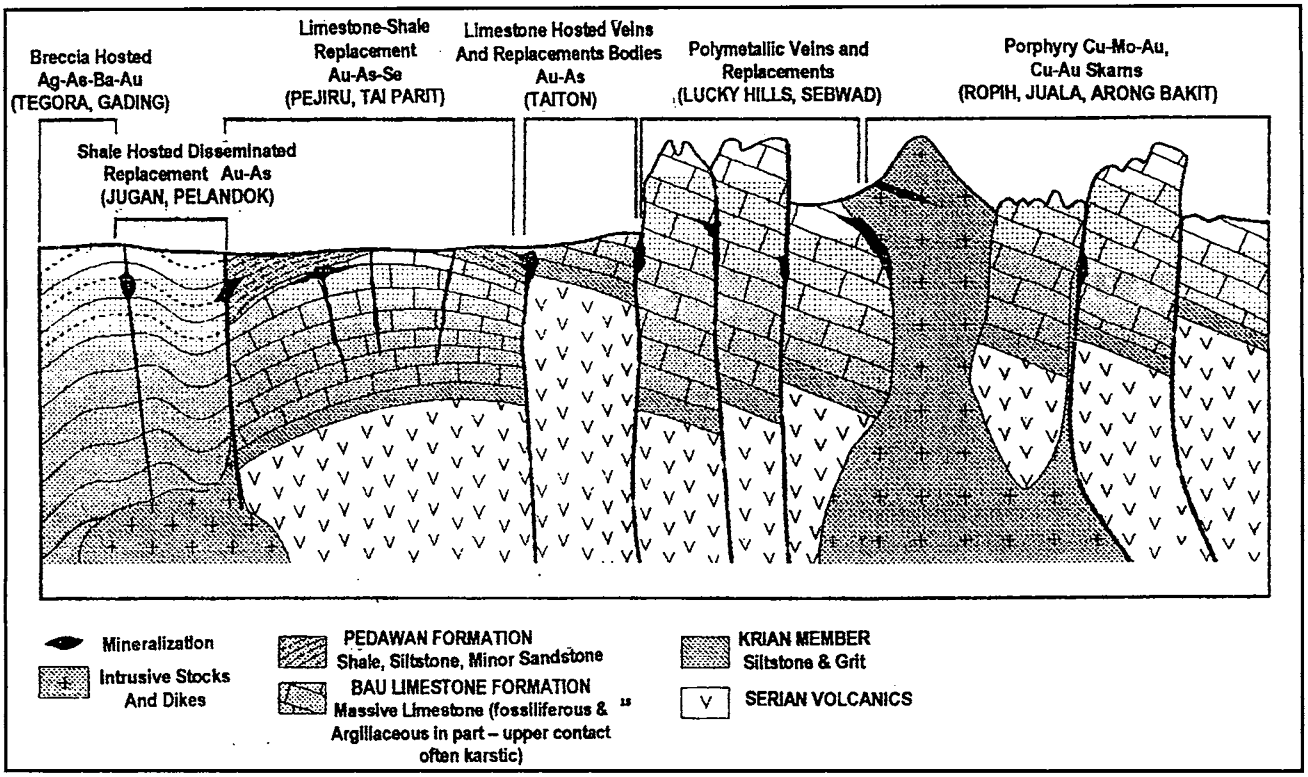

Figure 2: Mineralisation styles of the Bau Goldfield, Sarawak (after Mustard, 1997).

are the old "lampanned" areas occurring upstream of many rich tin mines and old hardrock underground mines.

For gold, the best prospect in Peninsular Malaysia are Belts 2 and 3, where mesothermal vein type mineralization occur. Belt 3 has potential for mesothermal veins and volcanogenic massive sulphide deposits. In Sarawak, the Bau area has been proven to contain substantial gold resource, which can be mined at the right moment. In Central Sarawak, the prospect for epithermal and sediment hosted gold deposits are good. In Sabah, further gold deposits are expected to occur in the Central Sabah geochemically anomalous zone. Prospects would include porphyry, epithermal, volcanogenic massive sulphides and classical epithermal vein types of deposits.

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