Type deposits of primary gold mineralization in the Central Belt of Peninsular Malaysia

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Abstract: A study of gold mineralization of the Central Belt of Peninsular Malaysia was made, based on fluid inclusion, mineralogy and field observations. The gold mineralizations in the Central Belt can be divided into three types, viz., gold mineralization in quartz veins, gold mineralization in massive sulphides and gold mineralization in skarn. Of the three types, gold mineralization in the quartz veins is the most dominant and being actively mined while the others are limited and of less economic importance. Gold mineralization in quartz veins is distributed from Batu Melintang, Panggung Lalat in Kelantan, through Tersang, Selinsing, Kecau Tui, Penjom and Raub in Pahang to Gunung Ledang in Johor. This mineralization has two styles, viz., gold together with sulphides and gold together with base-metal and carbonate. Fluid inclusion studies indicate that gold –bearing quartz veins in Central Pahang are formed at 50–1,500 m depth, at a temperature range of 100–350°C and salinity of 0.5-4.8 wt% Gold-bearing quartz veins are steeply dipping fault and shear zones trending roughly north-south. Common associated sulphide minerals are pyrite and arsenopyrite while galena, chalcopyrite, sphalerite, tetrahedrite, stibnite and cinnabar are occasionally observed at certain localities. Gold mineralization in massive sulphide is found in Manson's Lode, Sokor, Kelantan and Tasik Chini in Pahang and its common associated minerals are galena, pyrite, sphalerite, chalcopyrite, pyrrhotite and hematite. This type of gold mineralization was once mined and is regarded as a Kuroko-type massive sulphide, formed in an underwater marine environment. Gold mineralization in skarn is not economically important and has been traced in Sungai Sok, Kelantan. The types of primary gold mineralization in the Central Belt are exemplified.

Abstrak: Suatu kajian terhadap permineralan emas di Jalur Tengah Semenanjung Malaysia telah dilakukan, merangkumi kajian bendalir terkepung, mineralogy bijih dan cerapan lapangan. Permineralan emas di Jalur Tengah ini boleh dibahagikan kepada tiga jenis iaitu permineralan emas dalam telerang kuarza, permineralan emas dalam sulfida massif dan permineralan emas dalam skarn. Antara tiga jenis ini, permineralan emasa dalam telerang kuarza paling banyak dan dilombong manakala yang lain terhad dan kurang penting. Permineralan emas dalam telerang kuarza tersebar dari utara iaitu Batu Melintang, ke Panggung Lalat di Kelantan, ke Tersang, Selinsing, Kecau Tui, Penjom dan Raub di Pahang hingga ke Gunung Ledang di Johor. Permineralan ini mempunyai dua gaya, iaitu gaya kuarza emas bersama sulfida dan gaya emas bersama logam bes serta karabonat. Kajian bendalir terkepung menunjukkan pembentukan telerang beremas bagi sample di Pahang terbentuk pada kedalaman antara 50–1,500 m, pada suhu 100–350°C dengan kamasinan air garam 0.5-4.8 wt%. Telerang emas berkemiringan tinggi, terdiri daripada zon sesar dan ricih berarah hampir utara-selatan. Mineral-mineral sulfida lazim bersekutuan dengannya ialah pirit dan arsenopirit manakala galena, kalkopirit, tetrahedrit, stibnit dan sinabar kadangkala dilihat pada lokaliti tertentu. Permineralan emas dalam sulfida massif terdapat di Manson's Lode di Sokor, Kelantan dan di Tasik Chini Pahang dengan mineral-mineral bersekutu terdiri daripada galena,pirit, sfalerit, kalkopirit, piroottit dan hematite. Jenis ini pernah diusahakan dan dianggap sebagai sulfida massif jenis Kuroko terbentuk di dasar laut. Permineralan emas jenis skarn tidaklah penting di Jalur Tengah dan dikesan di Sungai Sok, Kelantan.

INTRODUCTION

Most gold deposits are characterized by mineral association, e.g. pyrite, chalcopyrite, arsenopyrite, sphalerite and galena. Gold mineralizations in the Central Belt of Peninsular Malaysia contain sulphide minerals, related to sheared quartz veins and breccia. Gold is present in quartz veins and not observed to be disseminated in wall rocks. Auriferous vein systems are structurally controlled. Among structural controls are: (1) spatial distribution along reverse fault; (2) syn- to late timing relative to the ductile-brittle deformation; (3) lateral fault and sheared zone. In the present study samples from Sokor, Kecau Tui, Tersang, Selingsing, Raub and Penjom were analysed.

GOLD MINERALIZATION IN CENTRAL BELT

The Central belt is the richest gold-bearing belt of Peninsular Malaysia (Fig. 1). In this belt, the distribution of gold mineralizations stretches from Batu Melintang near the Malaysia-Thai border in the north through Sokor, Panggung Lalat and Gua Musang in Kelantan through Selinsing, Kecau Tui, Penjom and Raub in Pahang and ends in Gunung Ledang, Johor. The gold mineralization episode appears to be related to the intermediate intrusives rather than acid Triassic granites. In most cases the host rocks for the mineralizations are volcano-clastics, limestone and metasedimentary rocks.

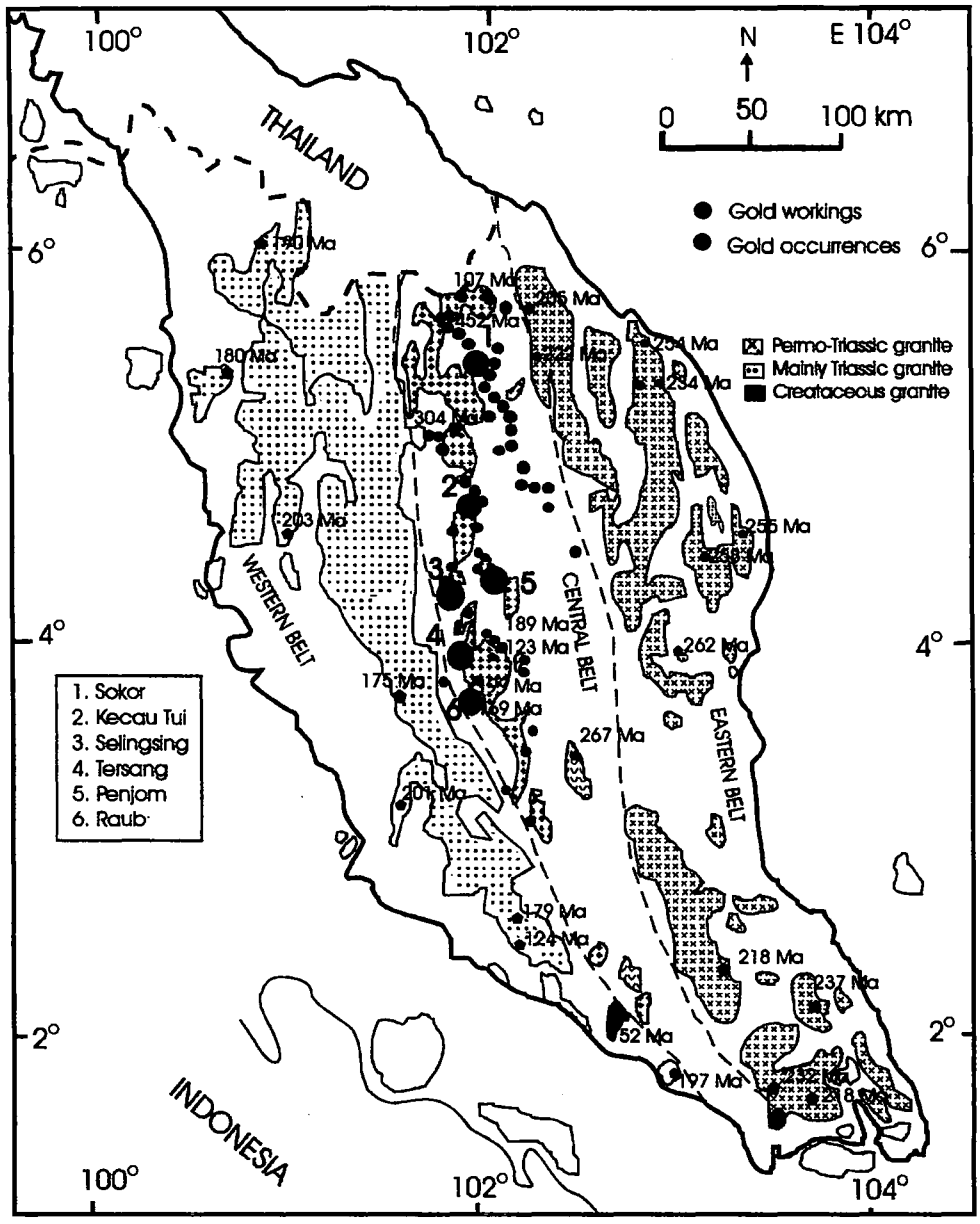

Figure 1. Gold occurrences in the Central Belt of Peninsular Malaysia.

From the nature of the occurrences gold mineralzations in the Central Belt can be divided into three main types: 1) Gold in quartz veins, 2) Gold in massive-sulphide, and 3) Gold in skarn. Gold in quartz veins is the most widespread, and typical examples are found in Tersang, Selinsing, Kecau Tui, Raub and Penjom. Gold in massive-sulphide is well recognized in Manson's Lode, Kelantan, while the Lake Chini massive-sulphide in Pahang is probably similar. Gold in skarn is mentioned from Sok base metal prospect (Teoh *et al.*, 1987) while a similar occurrence is found in Mengapur, Pahang in Eastern Belt. Of the three types, presently primary gold is only actively mined from quartz veins.

Gold mineralization in massive-sulphide

Manson's Lode, Sokor

The deposit is lense-shaped and follow the bedding of volcano-metasedimentary rock. It is expressed on the surface as limonitic and manganiferous gossan. Teoh *et al.* (1987) described it as a manto-type body. The gold mineralization occurs in the massive sulphide consisting of galena, sphalerite, chalcopyrite, pyrite and pyrrhotite and hematite. Tonnage was estimated at 165,770 tonnes of Pb-Zn sulphide assaying 296.7 g/t Ag and 44.7 g/t Au (Rajah, 1970; Teoh *et al.*, 1987). Bedding of volcano- sedimentary rock is

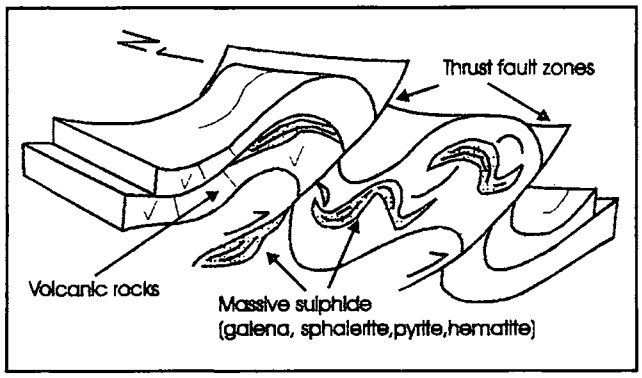

Figure 2. Type deposit model of gold mineralization in Manson's Lode, Sokor, Kelantan.

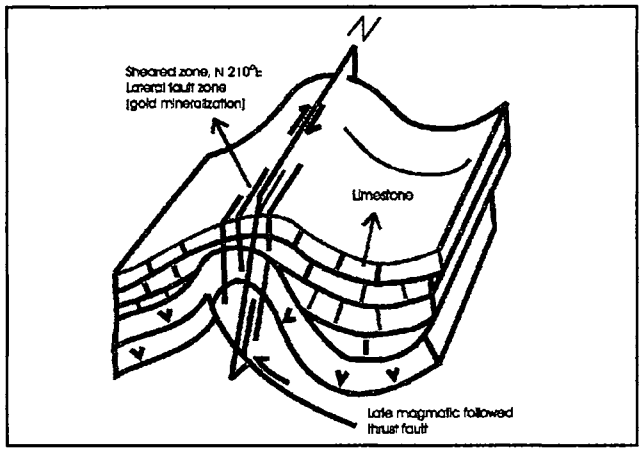

Figure 3. Type deposit model of gold mineralization in Kecau Tui, Pahang.

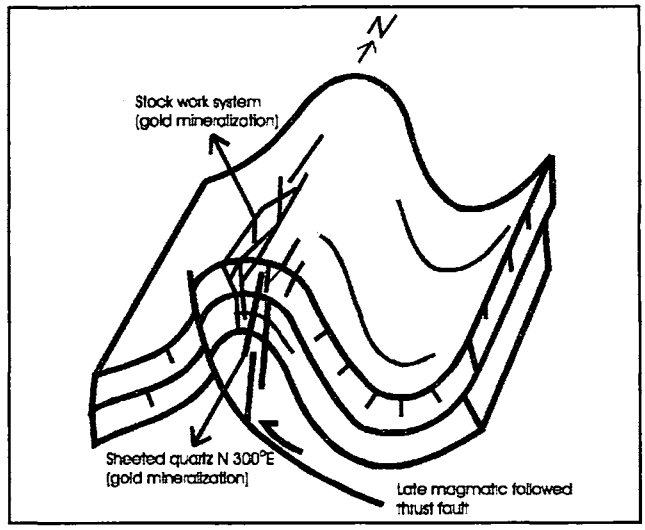

Figure 4. Type deposit model of gold mineralization in Tersang, Pahang.

Table 1. Fluids inclusion analysis from quartz vein in Kecau Tui (Sampel : HFL 06/01)

No.	Th °C	Tm °C	NaCl wt%	D (m)	P (bar)
1	158.1	- 0.6	1.077	52.17	5.83
2	158.1	- 0.6	1.077	52.17	5.83
3	158.1	- 0.4	0.714	52.17	5.83
4	183.4	- 0.4	0.714	107.32	10.75
5	183.1	- 0.5	0.895	107.32	10.75
6	233.7	- 0.5	0.895	329.99	29.69
7	249.7	- 0.6	1.077	446.29	39.11
8	257.3	- 0.6	1.077	513.716	44.48
9	297.9	- 0.6	1.077	1016.90	82.52

about 240°–250°/45°–60° (Fig. 2). According to Gan (1981), the sulphides were deposited under water in a Kuroko-type environment and is regarded as syngenetic volcanogenic-sedimentary in origin.

Gold mineralization in quartz veins

Kecau Tui

The Kecau Tui gold mineralization occurred in sheared quartz zone and quartz veins in limestone wall rock. The mineralization is structurally controlled by right lateral fault and sheared zone (200°–220°/70°) and tensional fractures 290°–310°/80°. Wall rock alteration that envelopes the quartz veins is dominated by K-feldspar, muscovite – carbonate. Associated sulphide minerals observed are abundant galena and traces of pyrite, chalcopyrite and a silver-grey sulphide identified by Cheang & Zulkifli (1988) as tetrahedrite. Gold occurs as free gold and in crystal lattices of the tetrahedrite. In this mine gold abundance is unrelated to galena occurrence as gold grains are observed in clean, milky-white, galena-free part of the quartz, and gold is not observed in galena-rich veins.

Fluid inclusion study from quartz veins associated with gold mineralization gave a temperature range 150–300°C with a salinity of 0.7–1.1 wt% and the depth of formation from 50–1,000 m (Table 1). This information gives the type deposit of gold mineralization in Kecau Tui as sheared quartz sulphide and carbonate gold deposits (Fig. 3).

Tersang

The gold mineralization in Tersang occurs in sheeted quartz veins trending generally 300°/70° and stock work system (Fig. 3). Mineral associations observed are pyrite, chalcopyrite and arsenopyrite although Lee *et al.* (1986) mentioned the occurrence of scheelite and cinnabar. The country rocks for gold mineralization in Tersang are volcano-clastic and sedimentary rocks. Wall rock alterations are silicification, argillization and minor chloritization usually near quartz vein. Geochemical analysis of a sample showed high copper (Cu) and minor lead (Pb), zinc (Zn) and silver (Ag). Fluid inclusion analyses of a quartz vein showed gold deposition took place at a temperature range of 200–285°C, salinity 0.9–1.1 wt%, and depth from 200 m to 850 m (Table 2). From the available data, type deposit for Tersang gold mineralization is interpreted as sheeted

Table 2. Fluids inclusion analysis from quartz vein in Tersang (Sampel : HFL 08/01).

No.	Th °C	Tm °C	NaCl wt%	D (m)	P (bar)
1	211.5	- 0.6	1.077	208.01	19.5
2	211.5	- 0.6	1.077	208.01	19.5
3	228.7	- 0.6	1.077	298.14	27.07
4	238.0	- 0.5	0.895	358.46	32.02
5	238.0	- 0.5	0.895	358.46	32.02
6	248.0	- 0.6	1.077	433.22	38.06
7	285.5	- 0.6	1.077	833.28	69.01

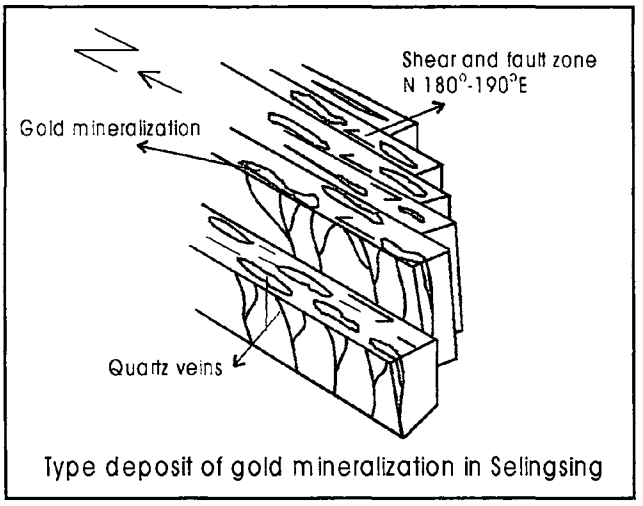

Figure 5. Type deposit model of gold mineralization in Selinsing, Pahang.

quartz veins and stockwork with sulphides (Fig. 4).

Selinsing

Mineralization in Selinsing occurs in right lateral fault zone, about 10–20 m wide trending 185°/80°. The dominant thickness of quartz veins in the fault and sheared zones range from 2 cm to 20 cm. The sulphide minerals in the vein are mainly pyrite with traces of chalcopyrite and galena. A narrow alteration envelope is dominated by K-feldspar, albite or muscovite (sericitization). Wall rock alterations are silisification, argillization and chloritization. Gold mineralization was not observed in the wall or country rock. Fluid inclusion in quartz veins associated with gold mineralization contain salinity of 0.5–1.1 wt%, formation temperature range of 150–290°C and depth of formation at 100–850 m (Table 4). Based on above data gold deposit in Selinsing is of sheared quartz sulphide type (Fig. 3).

Penjom

In Penjom gold mineralization occurrs in quartz vein, sheared and lateral fault zones in bedrocks composed of volcanic and sedimentary rocks which in some places are carbonaceous. The volcano-clastics and sedimentary sequence is cut by microgranite and dacite intrusion, known locally as felsite. Major structural trends are aligned in N-S (355°-005°) and NE-SW (035°–045°) and controlled the gold mineralization.

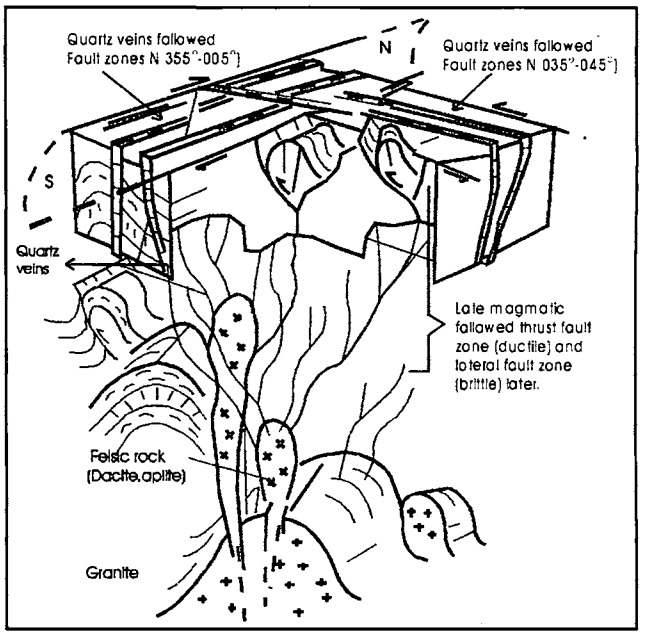

Figure 6. Type deposit model of gold mineralization in Penjom and Raub, Pahang.

Intensive alteration observed around the quartz veins, intrusive rock and fault zone are silicification, argillization and chloritization. Two styles of gold mineralizations are reported, viz., quartz sulphide and carbonate-base metal type. The quartz-sulphide type is associated with coarse pyrite and arsenopyrite (Kidd, 1988) whereas the carbonate-base metal type contains galena, sphalerite and carbonate mineral in the quartz veins. The carbonate-base metal type is the main gold mineralization event and it overprinted the earlier quartz-sulphide mineralization. Fluid inclusion analysis of a quartz vein associated with gold mineralization shows a salinity range of 1.8–4.8 wt%, temperature range of 190_270°C and depth range of 100–700 m. Based on the data obtained, the type deposit of gold mineralization in Penjom is interpreted as sheared quartz vein sulphide and carbonate gold deposits (Fig. 6).

Raub

The gold mineralization in Raub occurs in quartz shear zone, sheeted quartz vein and quartz breccia. The most dominant is the quartz shear zone, 20–200 cm wide with quartz sheets of 2–15 cm thick. The sulphide minerals in the quartz vein are pyrite, arsenopyrite, stibnite, scheelite and traces of chalcopyyrite and cerussite. There is a narrow alteration envelope developed is dominated by K-feldspar, albite or muscovite (seritization). Reconnaissance fluid inclusion study of a Raub vein sample showed the hydrothermal solution involved has a salinity range of 0.5–1.6 wt% NaCl, with a temperature range of 180–330°C and depth of formation range of 100–1,500 m. (Table 4). The quartz veins are controlled by reverse fault generally trending 120°/50° and 360°/80° trending lateral fault (Richardson, 1939).

Table 3. Fluids inclusion analysis from quartz vein in Selinsing (Sampel HFL 07/01).

No.	Th °C	Tm °C	NaCl wt%	D (m)	P (bar)
1	151.1	-	-	-	-
2	151.1	-	-	-	-
3	181.8	- 0.3	0.534	102.79	10.35
4	181.8	- 0.3	0.534	102.79	10.35
5	240.3	- 0.4	0.714	374.00	33.28
6	240.7	- 0.3	0.534	377.08	33.53
7	261.3	- 0.4	0.714	551.15	47.44
8	261.3	- 0.3	0.534	551.15	47.44
9	287.0	- 0.4	0.714	853.62	70.54
10	287.0	- 0.6	1.077	853.62	70.54

Table 4. Fluids inclusion analysis from quartz vein in Raub (Sampel : HFL 05/01).

No.	Th °C	Tm °C	NaCl wt%	D (m)	P (bar)
1	181.8	- 0.3	0.534	102.79	10.35
2	181.8	- 0.3	0.534	102.79	10.35
3	191.8	- 0.3	0.534	132.13	12.94
4	191.8	- 0.4	0.714	132.13	12.94
5	225.1	- 0.4	0.714	277.76	25.34
6	225.1	- 0.4	0.714	277.76	25.34
7	266.0	- 0.9	1.627	599.42	51.20
8	273.7	- 0.3	0.534	684.23	57.73
9	325.0	- 0.9	1.627	1547.5	119.30
10	325.0	- 0.9	1.627	1547.5	119.30

Wall rock alterations recognized are silisification, argillization and chloritization. Based on the above data gold deposit in Raub area is interpreted as quartz sulphide type (Fig. 6), however Richardson (1939) suggested that the mineralization is somewhat related to the nearby Late Triassic Kajang granite.

CONCLUSION

Field observations and mineralogical studies in most of the localities indicates that gold is present in quartz veins (sheeted, sheared and brecciated) in association with volcanic intrusion and sulphide minerals. Gold mineralization is structurally controlled and accompanied by intensive wall-rock alterations. Temperature for gold mineralization in the Central Belt ranges about 150–350°C, with formation depth 100–700 m and fluid salinity of 0.5–4.8 wt% NaCl. Type deposits are usually quartz veins sulphide and carbonate gold deposits (Penjom, Raub, Selingsing, Tersang dan Kecau Tui). The type of deposit in Sokor is volcanic massive sulphide.

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