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The nature and potential of gold mineralization in Kelantan, Peninsular Malaysia

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Abstract: Available data suggests that in Kelantan primary gold mineralization is associated with argentiferous-auriferous quartz veins, massive sulphide bodies, pyritiferous and carbonaceous metasediments, skarn-type mineralization, and sulphide-bearing volcanic and volcaniclastic rocks. The last two indications are relatively new findings resulting from previous and present drilling activities initiated within the Sok base metal prospect in eastern Kelantan, whereas the presence of geochemically anomalous schist and pyritiferous state is apparent from a recent reconnaissance mapping exercise conducted in central Kelantan. The significance of such auriferous lithologies has added a new dimension to primary gold exploration in Kelantan. Similar pyritised volcanic-sedimentary suites elsewhere will be given due recognition as potential gold targets. Besides, these rocks may be construed as yet another source of detrital gold so common within the streams in Kelantan.

The most significant argentiferous-auriferous massive pyritic lead-zinc sulphide bodies remaining are those at Ulu Sokor. These oxidised bodies show supergene gold enrichment, with the oxidised zones displaying a higher gold tenor than the primary sulphides. Much of the gold in the primary sulphides is locked in pyrite. Results of a recent geochemical and ground geophysical study suggest the likelihood of more extensive mineralization.

Alluvial gold prospecting undertaken recently in Kelantan by local mining companies indicates that the Pulai district and the Sokor drainage basin are the most promising. Based on heavy mineral concentrate evidence, the general area around the defunct tin-tungsten mine at Sungai Yai in western Kelantan also appears to have a favourable gold potential. In general heavy mineral concentrate and stream sediment sampling are cost-effective techniques in identifying auriferous areas.

INTRODUCTION

The state of Kelantan (Fig. 1) has a long-established gold-mining history. Gold was mined from very early times in the Pulai district which forms the southerly extension of an important gold-mining area stretching from the Kelantan-Thailand border (MacDonald, 1967). Late in the last century and at the turn of this century, gold-mining in Kelantan inspired the interest of several European Companies which prospected and worked the Galas, Nenggiri, Pergau, Lebir and Kelantan rivers. The best known was the Duff Development Company Limited which at one time deployed four dredges on the Nenggiri and Galas rivers, after activities at the most promising prospect in Ulu Sokor were terminated. Some 40,000 oz of gold were produced in Kelantan between 1906 and 1912. Subsequently activities waned and some gold was won immediately before and during World War II by local Malays and Chinese panning the tributaries of the Pergau and the western tributaries of the Kelantan river. In more recent times, gold was produced for a short period from the now defunct Katok Batu, Panggong Lalat and Panggong Besar mines in the Gua Musang area.

Interest in gold exploration in Kelantan continues unabated, as attested by the recent and on-going exploratory work revived by major mining companies in the Ulu Sokor and Pulai areas, and along the Galas-Nenggiri rivers. A new promising area, known as the Sok base metal prospect which was first identified in 1978 by the Geological Survey, is currently being drilled-tested for its base and precious metal potential by a local mining company.

In the light of the large volume of data available through these activities, and that generated by the Geological Survey's own findings, it is felt that a summary on the nature of gold mineralization in Kelantan is appropriate. It is hoped that this will broaden the perspective of gold exploration in the state.

PRIMARY GOLD MINERALIZATION

Auriferous quartz veins

The argentiferous-auriferous quartz lodes in the Ulu Sokor area (Fig. 1) are

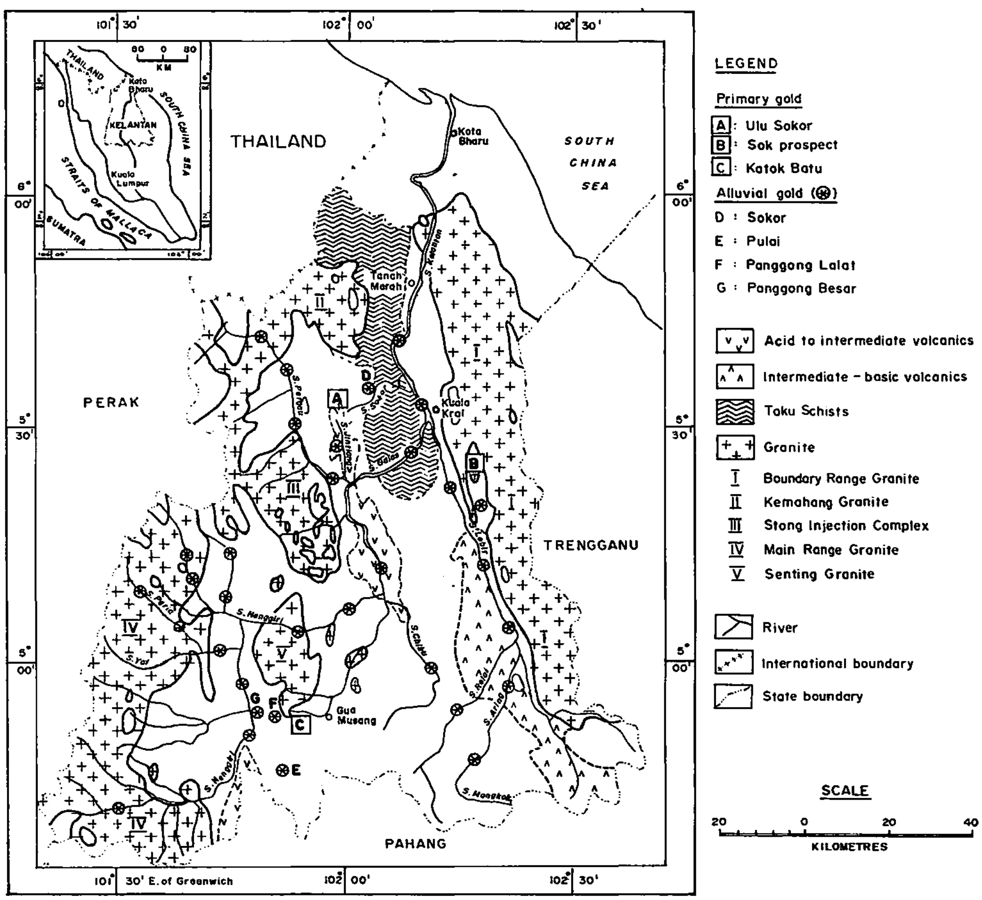

Fig. 1. Important gold-bearing areas, Kelantan

probably the best documented examples of this type of primary gold mineralization in Kelantan. Comprehensive accounts can be found in MacDonald (1953–61), MacDonald (1967), Smith (1969) and Rajah (1970).

The earliest recorded prospecting at the Ulu Sokor area was carried out by the Duff Development Company Limited, commencing in 1903. Although gold and silver results were encouraging other considerations compelled the company to abandon this prospect in 1907. The Geological Survey revisited the area in 1924 and again in 1951.

Among the more important gold-quartz veins (Fig. 2) are:-

1. Dangerfield's Lode, a 0.6 m wide quartz vein, highly mineralized in pyrite and arsenopyrite, cutting through sheared rhyolite porphyry. Tonnage was estimated at 25,000 tons, averaging 6.4 g/T Au and 28.3 g/T Ag.

2. Rixen's No. 1 and 2, characterised by innumerable quartz stringers, some with pyrite, in schistose rhyolite intercalated with minor phyllite and schist. One quartz sample assayed 25.5 g/T Au.

3. Paveglio's Find, indicated by quartz stringers in sheared pyritiferous tuff.

4. Clark's Lode, consisting of quartz veins, stringers and lenses in an interbedded phyllite-volcanic sequence. The Duff Company claimed that Clark's Lode contained 5,000 tons of ore that assayed 5.7 g/T Au and 28.3 g/T Ag.

5. New Discovery, a pronounced shear zone in pyritiferous phylite containing quartz veins. Channel samples taken across the shear zone averaged 4.1 g/T Au.

Quartz veining and pyritisation are particularly prevalent within the belt of acid to intermediate fragmentals and flows around the Ulu Sokor prospect (Fig. 2). This volcanic belt extends southwards into the previously worked Jintiang drainage and beyond, where strong pyrite mineralization and quartz veining have also been noted locally. Prospecting at the Jintiang area in 1974 by Osborne-Chappel likewise indicated the presence of large vein quartz and massive quartz boulders. Assay results of selected vein quartz samples were reported to be all less than 0.5 g/T Au. Although the free gold present in the streams was thought to be derived from these veins, the company did not disregard the possibility of some other source (Osborne-Chappel, 1974). Within the adjacent Taku Schists, rutile-bearing quartz veins are known to contain trace amounts of gold (MacDonald, 1967).

Gold-quartz veins carrying minor amounts of chalcopyrite, arsenopyrite, galena and sphalerite constituted the ore mined at Katok Batu, near Gua Musang. The mineralized zone is located at a shale-sheared granite porphyry contact. The quartz veins are mainly within the sheared contact zone, but some extend into the adjacent shale (Yin, 1965). Similar occurrences of auriferous quartz veins in sheared intrusives have been noted earlier in Pahang by Richardson (1939, 1950), and have also been extensively documented by Boyle (1979).

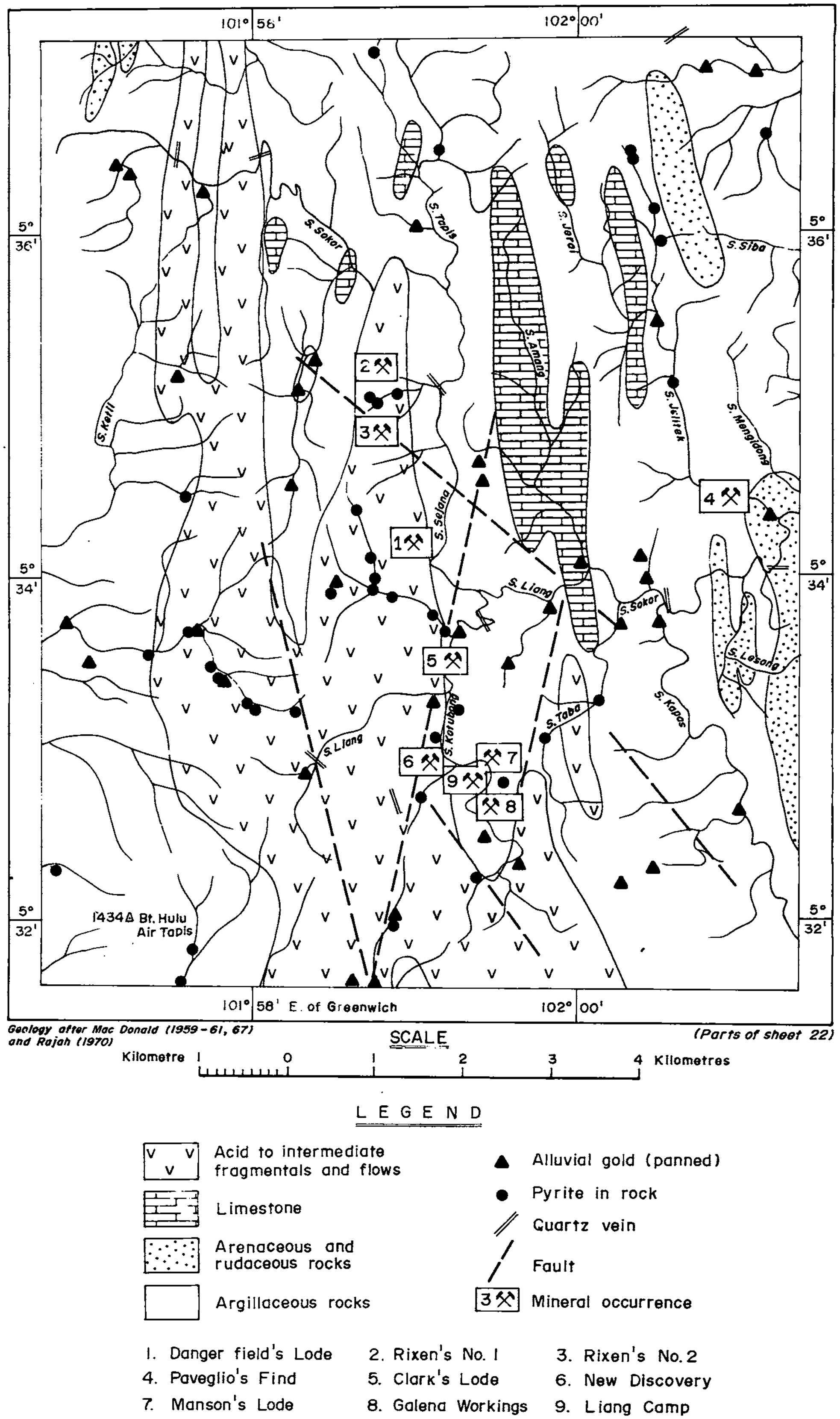

Fig. 2. General geology of the Ulu Sokor area.

A recently-recognised base metal target in eastern Kelantan called the Sok prospect (Fig. 1), shows promising gold-silver potential. This prospect, encompassing part of the Boundary Range Granite and the adjacent volcanic-sedimentary rocks, was detected through the Central Belt Project geochemical sampling programme, and possesses features suggestive of an important porphyry-type Mo-Cu system (Chu, 1983). Exploratory drilling conducted by the Geological Survey during 1981–1982, and the present drilling programme undertaken by Malaysia Mining Corporation (MMC) indicate significant gold and silver values from sulphide-bearing quartz-calcite veinlets ramifying brecciated biotite hornfels and meta-tuff. The common sulphides are pyrrhotite, pyrite, arsenopyrite and galena. Drill core samples of brecciated quartz veins in granite are also found to be auriferous and argentiferous.

Elsewhere, investigations of former gold-bearing ground, particularly in the Gua Musang area, have likewise repeatedly refered to the presence of quartz veins and their importance as likely mineralizers (MacKay and Schnellman, 1967; Aw, 1975).

Argentiferous-auriferous massive sulphides

The Ulu Sokor area, besides being endowed with significant gold-quartz veining, contains important base metal mineralization (Fig. 2). Between 1966 and 1970 the Eastern Mining and Metals Company (EMMCO) undertook a detailed exploration programme culminating in diamond drilling which aggregated 2,966 m. To date two notable argentiferous and auriferous massive Pb-Zn sulphide bodies occurring as epigenetic replacements within brecciated limestone and along limestone-phyllite contacts have been well established (MacDonald, 1967; Smith, 1969; Rajah, 1970). These are:-

1. Manson's Lode, expressed on the surface by limonitic and manganiferous gossan. The ore body is a poly-metallic massive sulphide manto, consisting of galena and sphalerite which is enveloped by a pyritic shell composed mainly of disseminated pyrite and pyrrhotite. Tonnage estimations were:

   (a) 163,160 tons primary Pb-Zn sulphides assaying 193.9 g/T Ag and 3.1 g/T Au.

   (b) 33,920 tons pyrite assaying 46.2 g/T Ag and 2.7 g/T Au.

   (c) 101,160 tons oxidised material assaying 91.3 g/T Ag and 4.2 g/T Au.

2. Galena Workings, somewhat similar to Manson's Lode but smaller. Tonnage estimate shows 60,810 tons primary Pb-Zn sulphide assaying 145.5 g/T Ag and 1.8 g/T Au.

Between these two sulphides bodies is a pyritised and oxidised zone called Liang Camp which has been estimated to contain 18,400 tons of combined sulphide and secondary oxides assaying 56.7 g/T Ag and 4.9 g/T Ag. Other minor base metal sulphide occurrences, in the form of pyrite-rich veins and mineralized boulders, are widespread. Most of these are argentiferous and auriferous.

Studies by Rajah (1970) on the mineralogy of samples taken from the Manson'

Lode indicated that the pyrite contains both gold and silver. Chemical analyses of pyrite drill core samples returned maximum values of 5.2 g/T Au and 249.8 g/T Ag. However, no free gold or silver minerals were detected in polished sections. Of particular note is the high gold content of the gossans capping Manson's Lode where a peak value of 33 g/T Au has been noted. Such high gold values in the gossan, and the fact that the gold tenor of the oxide ore is higher than that of the primary ore body suggests supergene gold enrichment following oxidation (Boyle, 1979). Galena and sphalerite contain appreciable silver, and argentite has been reported in the deposit.

A geochemical orientation study conducted over the Ulu Sokor area by the Geological Survey in 1979 indicated the usefulness of Ag and As in stream sediments as pathfinders for gold mineralisation (Chu and Muntanion, 1983). Not only were the gold-quartz occurrences highlighted by Ag and As, but Manson's Lode and the Galena Workings were similarly delineated. Stream sediment Pb and Zn values were naturally anomalous within the environs of these two sulphide bodies. Soil Pb, Zn and Ag values displayed strong geochemical contrast over both zones. It is worthy to note that the soil sampling programme has, in addition, demarcated a geochemically significant but untested area west of Liang Camp (Fig. 3) where a subsequent geoelectric survey

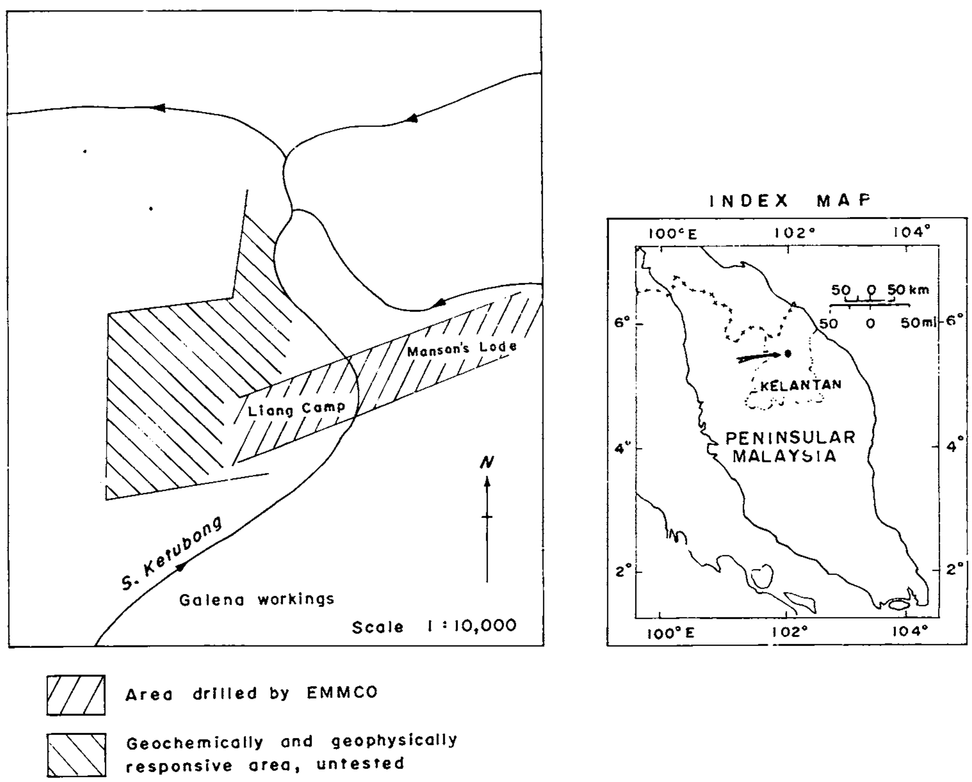

Fig. 3. Untested area west of Liang Camp.

indicated a favourable geophysical response (Robertson Research, 1981). This untested sector displays a geochemical contrast comparable to that noted over Manson's Lode, and if proved significantly mineralized, will certainly elevate the potential of the Ulu Sokor area.

In the Sok prospect, drilling results show the existence of several small, massive sulphide veins in graphitic quartz-biotite hornfels. Comprising mainly pyrrhotite and arsenopyrite, with lesser galena, pyrite and chalcopyrite, these veins assay up to 3 g/T Au and 260 ppm Ag. Exceptionally high Bi and As values are recorded.

Argentiferous and auriferous skarn

Argentiferous skarn-type sulphide mineralization is known from the Sg. Mangkok area in southeast Kelantan (Aw, 1972; 1973). Comprising fine-grained pyrite, chalcopyrite, galena and sphalerite associated with garnet, vesuvianite, chlorite, quartz, chalcite and siderite, samples of mineralized skarn analysed returned less than 0.5 g/T Au, although Ag values peaked at 20 g/T.

What appears to be a larger and more promising area of mineralized skarn development is located within the Sok base metal prospect. Sporadic but mineralized garnetiferous skarn zones are evident in the contact aureole comprising hornfels, slate, phyllite and meta-volcanics. Mineralization in these zones occurs as disseminations and fracture-fillings consisting of pyrite, chalcopyrite, pyrrhotite, galena, arsenopyrite, molybdenite, sphalerite. Scheelite is occasionally noted. No visible gold or silver minerals are discernable, but some mineralized sections have returned encouraging gold and silver values and analyses. A positive and significant Cu-Au and Bi-Au relationship is established.

Auriferous volcanics, volcaniclastic rocks and metasediments

Besides the skarns, several meta-andesite, meta-tuff and metamorphosed tuffaceous sediment intersections from the Sok prospect are evidently auriferous, as indicated by the geochemically high gold values which run into several ppm. Pyrite and pyrrhotite are ubiquitous within these anomalous sections, while quartz stringers are rarer. This conforms to the general descriptions of disseminated gold mineralization in volcaniclastic beds (Boyle, 1979). Several rusty gold colours have subsequently been obtained on panning crushed samples of pyritiferous tuff from the area (Malaysian Mining Corporation, per. comm.). Within the property and even slightly further south, heavy mineral concentrates panned from streams draining andesitic fragmentals contain a few gold flakes. Indications of free gold in streams draining sedimentary-volcanic rocks have also been noted by Santokh Singh (1963) to the south of Ulu Sokor.

These findings substantiate the views of Richardson (1939, 1950) and Santokh Singh (1977), who have related gold mineralization in Peninsular Malaysia to volcanic exhalatives. Furthermore these results underline the significance of the extensive, commonly pyritised, volcanic-sedimentary belt in central Kelantan as a favourable gold exploration area. By implication, these rocks will themselves be the source of the gold, and as they become structurally deformed and metamorphosed, dilatant zones will be created and filled by the more mobile constituents of the rocks, including quartz, pyrite, arsenopyrite, gold, silver (Boyle, 1979). The gold-quartz veins in the Ulu Sokor area and others within this belt could well have originated in this manner, although the classic igenous-source concept has invariably been invoked.

Other lithologies found to be geochemically anomalous in gold include metamorphosed carbonaceous sediments in the Sok prospect, and pyritised schist samples from central Kelantan.

ALLUVIAL GOLD

Alluvial gold mining has been the mainstay of the gold mining industry in Kelantan. Most streams in Kelantan contain some gold. In recent years an evaluation of the potential of the auriferous alluvium within the Pergau, Sokor, Jintiang, Chiku, Nenggiri and Galas drainage areas has been revived by several local mining enterprises. Currently the only area in Kelantan that is being actively evaluated is the former gold-mining district in Pulai. Prospecting results indicate that this area and the Sokor river are the most promising. A few tributaries of the Pergau river, thought to have good potential (MacDonald, 1967), were found to be sub-economic.

Little is known of the nature of alluvial gold in Kelantan. Work by the Malaysian Mining Corporation in the Pulai district and the Galas-Nenggiri rivers shows that generally gold distribution is confined to the basal gravelly horizons where the gravels are commonly within the 20–50 mm range, although clasts up to 60 mm in diameter have been concentrated (Choo and Spykerman, 1982). The gold particles, some in nugget form, are associated with the clay-sand matrix. Experimental evidence deduced by the company reveals that sampling using the 6-inch rather than a 4-inch Banka reflects better the representative tenor of the ground. It is perhaps pertinent to indicate at this juncture the importance of bedding, bedrock jointing and fracture in influencing the localization of the pay-dirt, and hence evaluation. Richardson (1947) noted that at two alluvial gold mines in north Pahang the gravel pay-dirt and residual quartz-rich detritus containing gold are invariably concentrated within fissures and solution gullies incised into the limestone bedrock. Boyle (1979), made references to alluvial gold being trapped in natural riffles in streams beds and also being concentrated in the fissures of sheared, fractured and shattered bedrock. While commenting on the proposed dredging operations in the Kelantan, Galas and Nenggiri rivers, MacDonald (1967) suggested the possible deployment of a powerful dredge capable of digging into the top one or two feet of the decomposed bedrock. Clearly the nature of the bedrock assumes a critical role in the exploration and exploitation of alluvial gold, and the importance of sinking exploratory bore-holes and pits beyond 'false bottoms' down to bedrock cannot be over-emphasised.

In the Sokor and Jintiang areas a little cassiterite is associated with the detrital gold. Pyrite is more plentiful. Cassiterite, scheelite, xenotime, monazite and gold have been found in heavy mineral concentrates panned from streams draining the Main Range Granite contact zone in west Kelantan and within the environs of the Sok prospect. Traces of gold and scheelite in the heavy mineral concentrates have been detected within the western aureole of the Stong Injection Complex (Chu, 1973) while alluvial gold, tourmaline and rutile are commonly associated in streams draining the Taku Schists.

The most commonly-cited primary source of alluvial gold are the auriferous quartz veins. These are thought to be genetically related to granitoids, even though the gold-bearing ground may be at some distance from the nearest granite outcrop (MacDonald, 1967). This vein-granite association is reported to be obvious in Ulu Pergau, and is certainly the case at Katok Batu (Yin, 1965), whereas within the southern inner margin of the Senting Granite near Gua Musang, significant gold colours have been noted in association with vein quartz fragments (Aw, 1975). At Ulu Sokor, the gold-quartz lodes and the massive sulphides occurrences are no doubt responsible for the alluvial gold within the area, including the important Sokor river. Alluvial gold may also have been derived from sulphide-bearing volcaniclastic and volcanic rocks that abound within central Kelantan. Latest evidence from the Sok prospect strongly support this contention.

CONCLUSIONS

In Kelantan, primary gold mineralization has been traditionally related to argentiferous-auriferous quartz veins and, in the Ulu Sokor area, to massive sulphides as well. However, through the drilling activities undertaken within the Sok base metal prospect, auriferous-argentiferous skarn, auriferous-carbonaceous zones, and metamorphosed acid-intermediate volcanic and volcaniclastic intersections returning encouraging gold-silver values have been encountered. This latter observation, viewed in conjunction with the evidence of detrital gold in heavy mineral concentrates panned from this environment, has far-reaching implications in that the realm of primary gold exploration should now perhaps be extended to include a proper evaluation of similar volcanic-sedimentary suites elsewhere. Moreover, the concept of the host rocks themselves carrying disseminated gold is particularly attractive for the secretion theory (Boyle, 1979) to be invoked as an alternative to hydrothermal emanations to account for the gold-quartz veins present in these rocks, as at Ulu Sokor. There are of course, several well-documented examples of auriferous quartz stringers genetically related to granitoids.

The gold, silver and base metal potential of the Ulu Sokor area may be further enhanced, if the postulated extension of the sulphide zone deduced from the findings of a recently-completed geochemical and ground geophysical orientation survey prove positive. The oxidised zones of the massive sulphide bodies here contain a higher gold tenor than the primary sulphides, suggesting supergene gold enrichment following oxidation. Among the primary sulphide minerals, pyrite apparently contains the highest gold content, hence accounting for the auriferous nature of the gossan cappings.

Most streams in Kelantan contain detrital gold. Besides the auriferous quartz veins and massive sulphide bodies, latest evidence from the Sok prospect suggests that metamorphosed carbonaceous sediments and sulphide-bearing metavolcanic and metamorphosed volcaniclastic rocks may be important sources of alluvial gold. In Kelantan, recent and on-going exploratory work by mining companies indicate that alluvial gold seems to be in workable quantities in the Pulai district and within the

Sokor drainage basin. Gold, scheelite and cassiterite have been noted in heavy mineral concentrates panned from streams draining the Main Range Granite contact zone in western Kelantan. Within this zone at the Yai river, scheelite and cassiterite have been mine in the past, and it is only logical that this general area be investigated for its gold potential.

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