

ABSTRACT

Air Piau Gold Deposit North-East Peninsular Malaysia was one of an accreted terrain in Malaysia formed during Triassic Indosinian orogeny tectonic event leads to expose a various type of metamorphic rock across this region. Together with the event was the enrichment of gold related to mountain-building process and formation of the Central Gold Belt profoundly refers to orogenic gold clan. This is supported by previous study was carried out by several researchers on Central Belt goldfields of the important role of hydrothermal fluids in the formations of these gold deposits in this region and finally suggest the gold origin point toward orogenic gold type. Meanwhile, new founding of gold prospect at Air Piau in the North-East Peninsular Malaysia remains obscured. In order to answer this deficiency, a research was done by utilized several analytical methods such as petrography, ore microscopy, petrochemical (XRF and ICP-MS), alteration mineralogy (XRD), mineral chemistry (SEM-EDS), heavy mineral concentrations (AAS) and microthermometry of fluid inclusion. From the result, the distribution of metamorphic host rock in Air Piau area was composed of dominantly Chlorite-Biotite-Muscovite schist with several presence of albite, epidote and staurolite minerals (metamorphosed greenschist to amphibolite facies), deformed as fault gouge, cataclasite and metabreccia fault rocks as a product of regional metamorphism during past orogeny event. Together with the exposed of Chlorite-Biotite-Muscovite schist host rock, was network of localized massive quartz-carbonate vein intrusion. There are three type of hydrothermal vein recognized in the Air Piau area which namely V1: the veins observed following the S1 metamorphic foliation, V2: the veins observed crosscutting the S1 metamorphic foliation and V3: brecciated vein observed follows the S1 metamorphic foliation veins. Both V1 and V3 which believed the early generations of quartz veins were strongly controlled by the foliation and deformation structure and

normally to be found as massive, laminated, some brecciated (V3) and parallel foliation of the host rock. Whilst, V2 vein having cross cutting relationship with the metamorphic host rock. The sulfide mineral found inside all types of mineralized veins, contain abundant of pyrite with minor amount of chalcopyrite and arsenopyrite. From the atomic absorption spectrometry (AAS) result, geological anomalies pointing toward the occurrence of gold mineralization in Air Piau area was overwhelming. Based on the analysis, it is known that the concentration of element in each sample ranging 0.003-3.584 ppm of Au, 21-137 ppm of As, 0.1-1.3 ppm of Ag, 2-71 ppm Cu, 1-10 ppm Zn, and 2-100 ppm Pb. The hydrothermal alteration in Air Piau gold deposit can be recognized as; (i) Propylitic (by the presence of albite-chlorite- calcite-sericite minerals) and (ii) Argillic (by the presence of quartz-clay minerals; montmorillonite and smectite). As for the fluid inclusion signature, three samples of mineralized veins (APVI, APV2 and APV3) show vary salinity ranging between 4.5 to 10.9 wt. % NaCl equiv. The mineralised veins of APV01 and APV02 indicates higher temperature range between 220 to 380°C and low average salinity recorded (<10 wt. % NaCl equivalent) making them comparable to orogenic Au deposits. In addition, the gold mineralization salinity-temperature data of ore- forming fluids show metamorphic fluid as one possible source of fluids. In contrast with APV03 mineralised vein that showed low Th (180 to 240°C) and their average salinity 6.9 wt. % NaCl equivalent. Moreover, another trend noticed the most of salinity-temperature data of fluids in APV03 sample show magmatic-meteoric mixing origin. From the field observations, there is a spatial association of igneous rocks and sedimentary/metasedimentary rocks at the Air Piau gold deposits. The igneous rocks appear in the form of intrusion (e.g; andesite, granitoids and pegmatite) at this deposit. The spatial association of these igneous rocks at Air Piau gold deposits strongly suggested that a magmatic contribution is possible to the ore-forming fluids.

The suggestion ore model for Air Piau gold deposit in where extensive deformation (brittle-ductile and shearing zone), metamorphism and magmatic events that created the favourable environment for source and trap of gold mineralisation. The source rocks are Permian-Triassic sedimentary to meta-sedimentary rocks and the heating chamber that induced the hydrothermal fluids is the Late Triassic Kemahang granite body that intruded under the sedimentary to meta-sedimentary rock, whilst structures which allow the deposition of gold are sheared and faulted rocks originating from depth. The hydrothermal fluids and organic matter in the shales reacted and produced CO₂-rich fluids that mixed with gold-bearing fluids to precipitated gold by reduction of gold bisulfide complex. As deformation evolved, fluid moved and deposited gold in mostly metasedimentary fault rocks. It has been found that, mostly all the quartz veins containing ore minerals in has been found together with graphite minerals as probably played a role of a seal rock that favoured the trapping and deposition of Au. Regionally, the Air Piau gold deposit shares geologically similarities (in term of tectonic setting, geological structures controlled, host rock, ore mineralogy) with many other sediment/metasediment-hosted, orogenic gold deposits in Peninsular Malaysia such as Tersang, Selinsing and Penjom. Furthermore, Air Piau gold deposit characteristics as discussed before supported the theory related with orogenic gold from various researchers (e.g., Groves *et al.*, 1998; Goldfarb *et al.*, 2005; Dubé and Gosselin, 2007; and Wilkinson, 2001). However, a number of inferences on classified Air Piau gold deposit model as orogenic gold deposit remains speculative in the absence importance data like ore geochemistry data (Hg, Sb and Te element concentrations).

Keyword(s): Air Piau, Central Gold Belt, Peninsular Malaysia, orogenic gold, greenschist facies, quartz-carbonate vein.

ABSTRAK

Mendapan Emas Air Piau Semenanjung Timur Laut Malaysia adalah salah satu medan yang bertambah di Malaysia yang terbentuk selama peristiwa tektonik orogen Indosinian Trias yang mengarah untuk mengekspos berbagai jenis batuan metamorf di seluruh wilayah ini. Bersamaan dengan acara tersebut adalah pengayaan emas terkait proses pembangunan gunung dan pembentukan *Central Gold Belt* yang secara mendalam mengacu pada klan emas orogenik. Hal ini didukung oleh penelitian sebelumnya yang dilakukan oleh beberapa peneliti di wilayah ini tentang peran penting fluida hidrotermal dalam formasi endapan emas tersebut di wilayah ini dan akhirnya menunjukkan titik asal emas menuju jenis emas orogenik.

Sementara itu, prospek penemuan emas baru di Air Piau di Semenanjung Timur Laut Malaysia masih tertutup. Untuk menjawab kekurangan tersebut maka dilakukan penelitian dengan menggunakan beberapa metode analisis seperti petrografi, mikroskop bijih, petrokimia (XRF dan ICP-MS), alterasi mineralogi (XRD), kimia mineral (SEM-EDS), konsentrasi mineral berat (AAS) dan inklusi cairan mikrotermometri.

Dari hasil penelitian, sebaran batuan inang metamorf di wilayah Air Piau tersusun atas sekis dominan Chl-Bt-Ms dengan beberapa keberadaan mineral albite, epidote dan staurolite (metamorfosis greenschist menjadi fasies amfibolit), terdeformasi menjadi batuan patahan kataklasit dan metabreccia sebagai produk metamorfosis regional selama acara orogeni masa lalu. Bersama-sama dengan tereksposnya batuan induk sekis Chl-Bt-Ms, terjadilah jaringan intrusi vena kuarsa-karbonat masif lokal. Ada tiga jenis urat hidrotermal yang dikenal di wilayah Air Piau yaitu urat V1, V2 dan V3 yang dicirikan oleh hubungan silang dan komposisi mineralnya. Baik V1 dan V3 yang percaya bahwa generasi awal urat kuarsa sangat dikendalikan oleh struktur foliasi dan deformasi dan biasanya ditemukan sebagai tersegmentasi, sigmoidal, terputus-putus dan sejajar dengan

Mineralisasi batuan induk. Sedangkan vena V2 memiliki hubungan lintas potong dengan batuan induk metamorf. Mineral sulfida yang ditemukan di dalam semua jenis urat termineralisasi, mengandung banyak pirit dengan sedikit kalkopirit dan arsenopirit. Dari hasil spektrometri serapan atom (SSA), anomali geologi yang mengarah pada terjadinya mineralisasi emas di kawasan Air Piau sangat besar. Berdasarkan hasil analisis diketahui bahwa konsentrasi unsur pada setiap sampel berkisar antara 0,003-3,584 ppm Au, 0,1-1,3 ppm Ag, 2-71 ppm Cu, 1-10 ppm Zn, dan 2-100 ppm Pb. Mineral alterasi biasanya tersebar di seluruh batuan di luar batas butir mineral primer, dengan sebagian atau seluruhnya merusak tekstur primer batuan induk. Mineral ini dapat menginterpretasikan pola perubahan di Deposit Emas Air Piau; (i) Albite-Chlorite- Calcite-Sericite (Propylitic) dan (ii) Quartz-Clay; montmorilonit dan smektit (Argillic).

Sedangkan untuk tanda inklusi cairan, tiga sampel urat termineralisasi (APV1, APV2 dan APV3) menunjukkan salinitas bervariasi berkisar antara 4,5 hingga 10,9% berat setara NaCl. Urat termineralisasi APV01 dan APV02 menunjukkan kisaran suhu yang lebih tinggi antara 220 hingga 380°C dan salinitas rata-rata rendah yang tercatat (<10% berat setara NaCl) membuatnya sebanding dengan endapan orogenik Au. Selain itu, data suhu salinitas mineralisasi emas dari cairan pembentuk bijih menunjukkan fluida metamorf sebagai salah satu kemungkinan sumber fluida. Berbeda dengan urat termineralisasi APV03 yang menunjukkan Th rendah (180 sampai 240°C) dan salinitas rata-rata setara NaCl 6,9% berat. Selain itu, tren lain mencatat bahwa sebagian besar data suhu salinitas cairan dalam sampel APV03 menunjukkan asal pencampuran magmatik-meteorik. Dari pengamatan lapangan, terdapat asosiasi spasial batuan beku dan batuan sedimen / metasedimen pada endapan emas Air Piau. Batuan beku muncul dalam bentuk intrusi (misalnya; andesit, granitoid dan pegmatit) pada deposit ini. Asosiasi spasial batuan beku ini di endapan emas Air Piau sangat menunjukkan bahwa kontribusi magmatik mungkin terjadi pada cairan pembentuk bijih.



Sebagai kesimpulan, mineralisasi emas di Air Piau berlangsung di dalam batuan metasedimen derajat rendah yang terbentuk selama tumbukan blok Sibumasu di bawah blok Timur-Malaya Indochina melalui Permian hingga Trias Akhir. Jadi, sistem busur pulau ini terdiri dari batuan sedimen dan meta-sedimen disertai deformasi ekstensif (zona getas-ulet dan geser), peristiwa metamorfisme dan magmatik yang menciptakan lingkungan yang menguntungkan untuk sumber dan perangkat mineralisasi emas. Batuan sumbernya adalah batuan sedimen Permian-Trias hingga batuan meta sedimen dan ruang pemanas yang menginduksi cairan hidrotermal adalah badan granit Kemahang Trias Akhir yang menyusup di bawah batuan sedimen hingga meta sedimen, sedangkan struktur yang memungkinkan pengendapan emas dicukur dan batuan sesar yang berasal dari kedalaman.

Kata kunci: Air Piau, Central Gold Belt, Semenanjung Malaysia, emas orogenik, fasies sekis hijau, urat kuarsa-karbonat.