Mapping of Gold In Densely Vegetated Area Using Remote Sensing and GIS Techniques in Pahang, Malaysia

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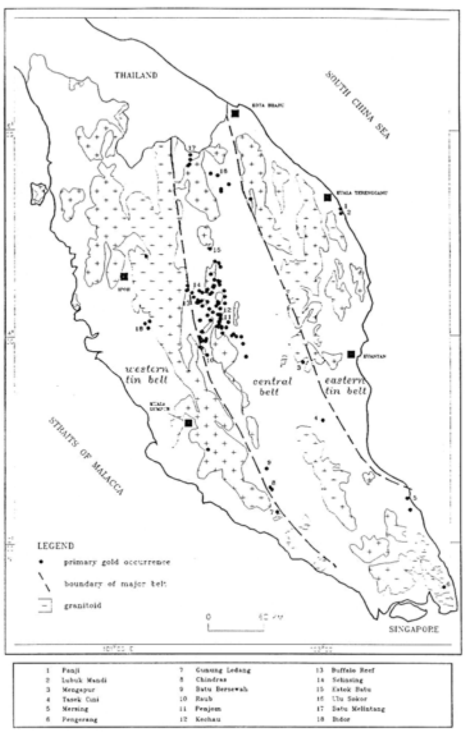
Abstract

The study was carried out for identifying a prospect area for gold (Au) in Penjom-Merapoh, Pahang using remote sensing and GIS techniques. Remotely sensed data including Landsat TM and Radarsat were useful in extracting regional lineament, local fracture patterns, hydrothermally altered rocks as well as providing basic geologic data. Furthermore, airborne radiometric datasets consist of thorium (Th), uranium (U) and potassium (K) were analysed in order to identify the different style of mineralisation as well as to delineate granite bodies. By interpreting K count, alteration associated with mineralisation produces potassium anomalies can be distinguished from particular rocks. The rocks were then taken into account for gold modelling. Statistical analysis of associated elements such as arsenic (As), wolfrum (W), lead (Pb) and cuprum (Cu) were also considered for formulating a model of high prospect area of gold. Each class factor was assigned weightage accordingly based on knowledge and field observation using GIS package. It is found that the abundance of gold not only mapped in the proven location but also extend to the 'untouch' area.

Introduction

The Malay Peninsular has been divided by Scrivenor into three belts, Western, Central and Eastern based originally on the nature of the matellic mineralisation found in each (Gunn, 1994 and Yeap, 2000). This division (Figure 1) has been used up to the present day, but the significant and boundaries of each belt have been a subject of much



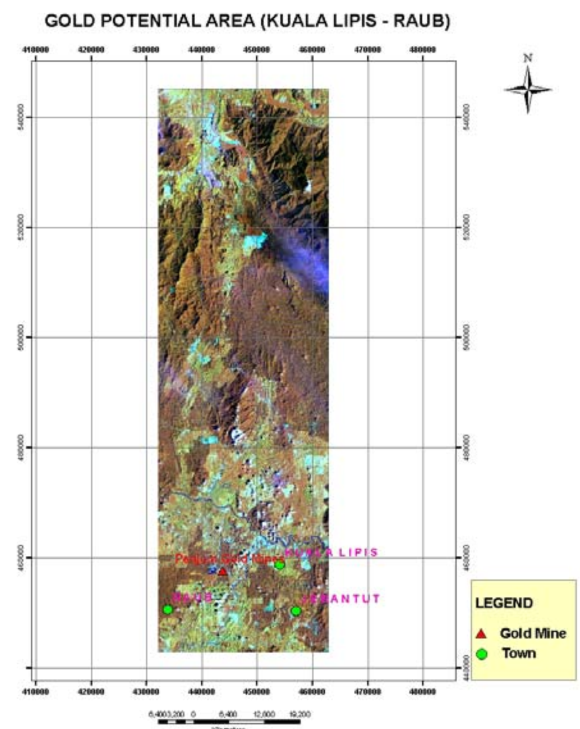


Figure 1: Mineral Belt of Peninsular Malaysia

Figure 2: Study Area

speculation and revision. The majority of primary gold occurrences lie within the Central Belt which characterized by a predominance of gold and base-metal mineralisation, in contrast to the tin-bearing Western and Eastern Belt.

In year 1980, the Department of Minerals and Geoscience Malaysia (JMG) with the aid of Compagnie Generale de Geophysique, a company from Canada undertaking an heliborne spectrometric and magnetic survey in Central Belt for metallic potential study. The survey was carried out by flying north-south lines every 600 m with a nominal terrain clearance of 122 m (Cambon, 1994). It covers a total of 32,000 km^2 area from

Benta in Pahang to Gua Musang in Kelantan. The dataset consists of magnetic as well as radiometric airborne survey including thorium (Th), uranium (U) and potassium (K). The study was concentrated on the uranium favorable granite and volcanic rocks for identifying prospect metallic minerals in both lithologies. However, no major anomaly observed from the data analysed.

In 1991, an expert from IAEA came to Malaysia before he found that the data have some error and cannot be used for analysis. The data were then reprocessed by the Bureau de Recherches Geologiques et Minieres (BGRM) and as a result, several radiometric anomalies were delineated in the granitic environment. In 1993, based on the anomalies found, JMG was formed a team for undertaking detail geological mapping of the granite including granite sampling, stream sediment geochemistry and ground scintillometry survey. The aims of the mapping were to identify the uranium deposits in granitic rock and to correlate the radiometric anomalies with geology of the area. The result, however, concluded that granitic rock in Central Belt is not favorable for formation of uranium deposit (Cambon, 1994).

Furthermore, under collaboration project between MACRES and JMG signed in 2002 the same site was selected for gold mineralisation study. The radiometric and geochemistry datasets available were analysed together with remote sensing data in order to determining mineralisation area. According to Bonham-Carter (1994), remote sensing has proven valuable for mineral exploration in at least four ways. They are:

1. Mapping regional lineaments along which groups of mining districts may occur
2. Mapping local fracture pattern that may control individual ore deposits
3. Detecting hydrothermally altered rocks associated with ore deposits
4. Providing basic geologic data

As gold mineralisation in Malaysia is related to the structure and tectonic setting of the region (Yeap, 2000), the use of remotely sensed data were very useful.

Objectives

There are three objectives of this project,

a) to study the ability of remote sensing data for mineral mapping in vegetated tropical area

b) to develop methodology for mineral potential mapping in Pahang using remotely sensed, radiometric and geochemistry datasets

c) to identify the prospect gold mining area and its extend using GIS technologies

Study Area

The study area covers from Penjom in the south to Merapoh in the north (Figure 2). This regional project area was selected because of the operative mining activities in the area and the wealth of geo-science and radiometric datasets available. In geological contact, the area is underlain essentially by Permian rocks in western and southern regions which consists of phyllite, limestone, slate, and schist and intercalated by volcanic rock (Ab. Halim, et al., 2006). The northeastern region, on the other hand, underlain by Triassic rocks consists of interbeded sandstone, siltstone and trace of volcanic rock. These formations were regionally metamorphosed with showing slight to intermediate deformation while formations surrounding the granite bodies were having contact metamorphism.

Furthermore, volcanism activity in this area is believed occurred during Permian to Lower Triassic. Two major granitic bodies identified are the Benom Complex in south region, and Damar East (Bukit Tujuh), which is smaller size, in the north. Compositionally, the granite range from acidic and calc-alkaline granite to granitoid and diorite. Folding is repetitive with dominant north-south to north-northwest regional trends and the most outstanding tectonic feature is the Bentong-Raub suture.

Gold Mininig Activities in Pahang

The state of Pahang has been the major gold producer in Peninsular Malaysia and has a long gold-mining history. Lee, et al. (1986), reported that gold mining activities in Pahang became comparatively important after 1884 with opening of Penjom Gold Mine and Raub Australian Gold Mine. The total production of gold bullion from Pahang for the period 1889 to 1985 is reported to be at least 36 tonnes. This present 88% of the total production in Peninsular Malaysia. Currently, the Penjom Gold Mine located in the study area is the highest production of gold in Malaysia with concentration about 6.0g/tonne.

Methodology

Image Processing

The Landsat TM scene 126/57 and 126/58 dated Jan 18, 1996 over the area were used in this study. Except for band 6 (thermal band), the Landsat TM data were mosaic and corrected to fit the Rectified Skew Orthomorphic (RSO) Malaysian Projection. The correction technique used was image-to-image registration with twenty-one well-distributed and identified ground control points selected including road intersections and bridges. The images were then enhanced to improve the appearance of the image before undertaking band combination in red, green and blue (RGB).

A number of band combinations were manipulated using ERDAS Imagine software packages in order to obtain the best color composite. Through consideration of all the result, the RGB color combination of band 4,5,3 is the most appropriate combination for visual interpretation for the study. This combination provides a good definition of the landform and also different color shades for different types of vegetations. Therefore, geological features such as regional lineament and local fracture pattern as well as granite body were easily identified from the image.

Radiometric Analysis

The processed radiometric survey datasets consists of K, Th and U used in this project was provided by JMG in display format (Figure 3) as well as an ASCII format. Since the display format could not be used for further analysis, the researcher decided to work only on the ASCII format data. The data which is in tabular form, consist of northing, easting, count of K, count of Th, count of U and total count. The count of each element was mapped using Krigging technique in ArcGIS software package in order to understand the different style of mineralisation throughout the study area.

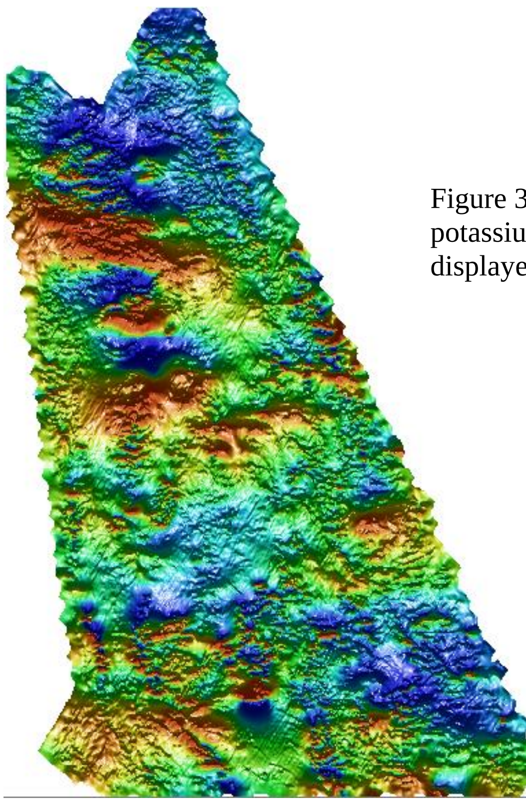


Figure 3 : Radiometric data consists of potassium (K), thorium (Th) and uranium (U) displayed in R,G,B respectively

As uranium deposit in granitic rock is not our interest, the study was then concentrated on the count of Th and the count of K. Th is known as a non-mobile element generated from granitic rock although the rock has been weathered for years and years. Therefore, the concentration of Th as shown in Figure 4 was used in this study for delineating granite bodies. According to Ab.Halim (2005), a corridor between 2 and 5 km from granite bodies in Central Belt is a zone with high concentration of gold. The zone, however, does not pertinent for other type of rocks.

Furthermore, the alteration rock for gold is highly related with the count of K (Roston, 2006).   From the analysis result, it is show that the lowest count of K is 6.22 and the highest is 142.16, represented in blue and red color, respectively (Figure 5). By comparing with the lithological map, the distribution of K throughout the study area mostly found in sedimentary rock and also in certain zone of granitic rock.

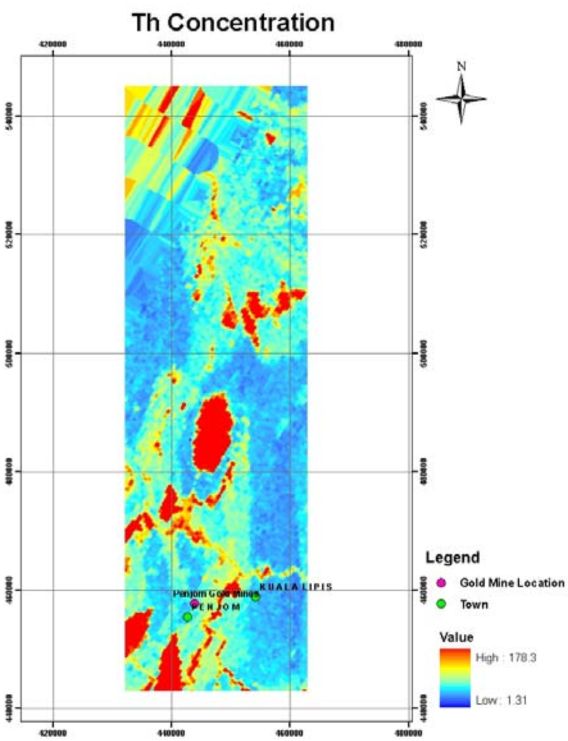


Figure 4: Map of Concentration of Potassium (Th)

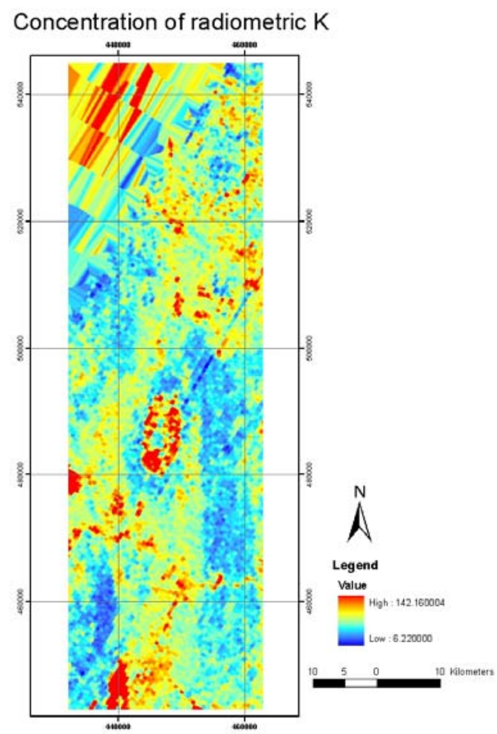


Figure 5: Map of Concentration of Potassium (K)

GIS Analysis

The main GIS processing has included gold-associated minerals occurrence, lineaments, fault, and lithology.   Study by Gunn in 1994 found that four major elements present in the so call highly gold-associated minerals in stream sediment samples in Penjom and Raub area are arsenic (As), wolfrum (W), lead (Pb) and cuprum (Cu). These four elements, therefore, were analysed using Krigging method in ArcGIS and consequently, used as parameters for gold potential modeling.   Figure 6 shows that high As, which represented in red color shade concentrated in mid to south region and north-east region, within the sedimentary rock and the concentration of W (Figure 7), on the other hand, high in sedimentary rock in the central and northwestern regions.

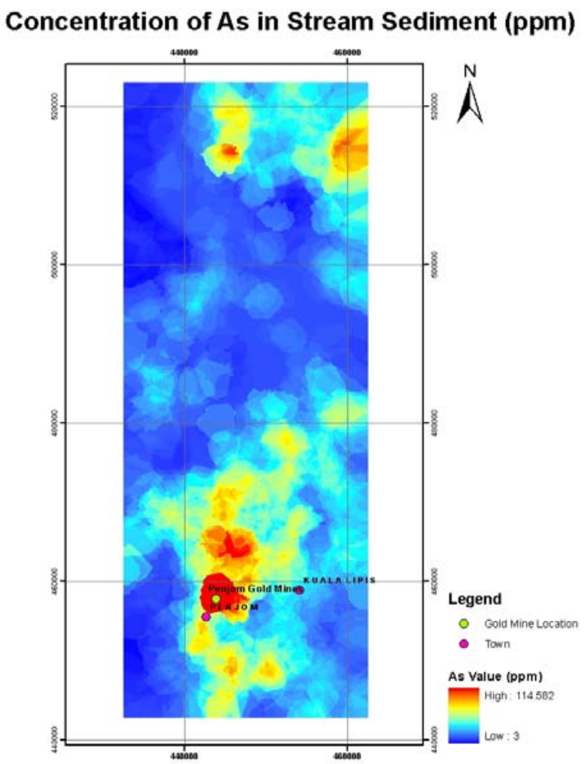


Figure 6: Concentration of Arsenic (As) in stream sediment sample

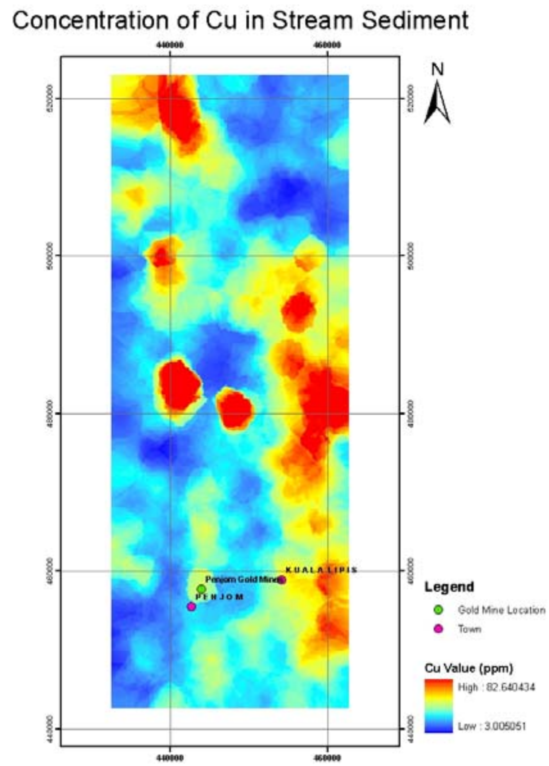


Figure 7: Concentration of Cuprum (Cu) in stream sediment sample

Based on Gunn et al.,(1994), Cambon, (1994), Lee et al., (1986) and knowledge and field observation by JMG staff, only lineament and faults at north-south trending (± 30°) have significant to the abundance of gold in hardrock in Central Belt. Hence, the lineament at other trendings were not considered in this study. The selected lineament, which identified from visual interpretation of R,G,B 4,5,3 were proximated (buffer) for three classes within 0 to 2 km distance. Moreover, the analysis of lithology involved the proximity of granitic rock within 0 to 5 km from the body. The rock was identified from geological map as well as Th radiometric analysis. All the datasets created have been used to generate a GIS model pertaining to gold exploration.

Gold Potential Modelling

The initial modeling methodology used in this study described by Bonham-Carter (1994) as a knowledge-based driven approach for multiple map overlay. To establish the model, the input map was given same weight but map classes on each input map were assigned at different rating. The weighting for each map class was based on author's judgment together with many references from previous study, where the highest score is 10 and the least is 1. The highest weightage of lineament, for example is the zone between 1 to 2 km from the line, while for granite buffer the zone from 2 to 5 km radius from the body is the highest weightage (Figure 8). The parameters involved and weighting for each class is described in Table 1.

Granite Buffer

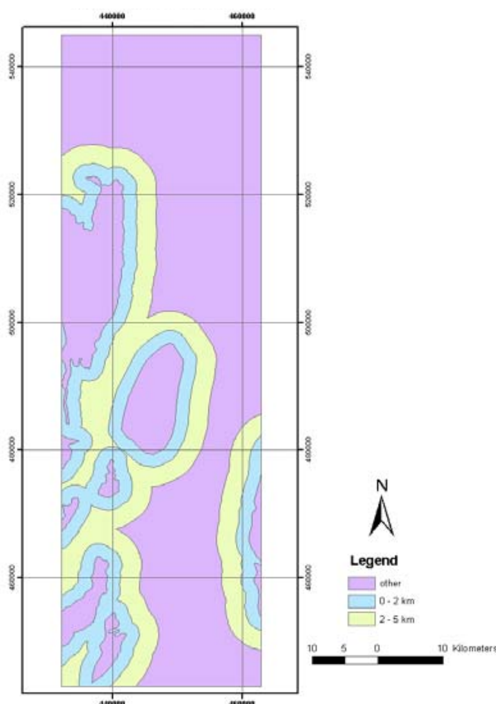


Figure 8: Granite Buffer

Table 1: Parameters Involved and Class Weighting for Gold Potential Modelling

Parameter	Value Assigned
Lithology	Volcanic = 10 Limestone = 8 Sediment = 5 Granite = 1
Lineament Buffer	0 – 1 km = 4 1 – 2 km = 10 else = 1
Granite Bodies Buffer	0 – 2 km = 4 2 – 5 km = 10 else = 1
K count (min =7, max=135)	0 – 50 = 4 50 – 60 = 10 more than 60 = 2
As concentration (min = 3, max = 114)	0 – 20 = 1 20 – 40 = 2 40 – 60 = 4 60 – 80 = 6 80 – 100 = 8 more than 100 = 10
W concentration (min = 5, max=198)	0 – 40 = 2 40 – 80 = 4 80 – 120 = 6 120 – 160 = 8 more than 160 = 10
Cu concentration (min=3, max=83)	0 – 15 = 1 15 – 30 = 2 30 – 45 = 4 45 – 60 = 6 60 – 75 = 8 more than 75 = 10
Pb concentration (min= 3, max= 103)	0 - 20 =2 20 – 40 = 4 40 – 60 = 6 60 – 80 = 8 more than 80 = 8

There were eight factors involved in the modeling consists of lithology, lineament, granite body, count of K, concentration of As, concentration of W, concentration of Pb, and concentration of Cu. The gold potential modelling was computed as the weightage sum overlay of these eight factors. The result of the model was then reclassified into four groups; low, medium, high and very high (Figure 10). The model was validated by superimposed the existing mine as well as field verification. It is found that the Penjom Gold Mine, which is the biggest and highest gold producer in Malaysia located in the very high potential area.   Moreover, several potentially favorable areas that have no existing developed mines fall in the north-south trending, which classified by many researcher as a high prospect gold zone.

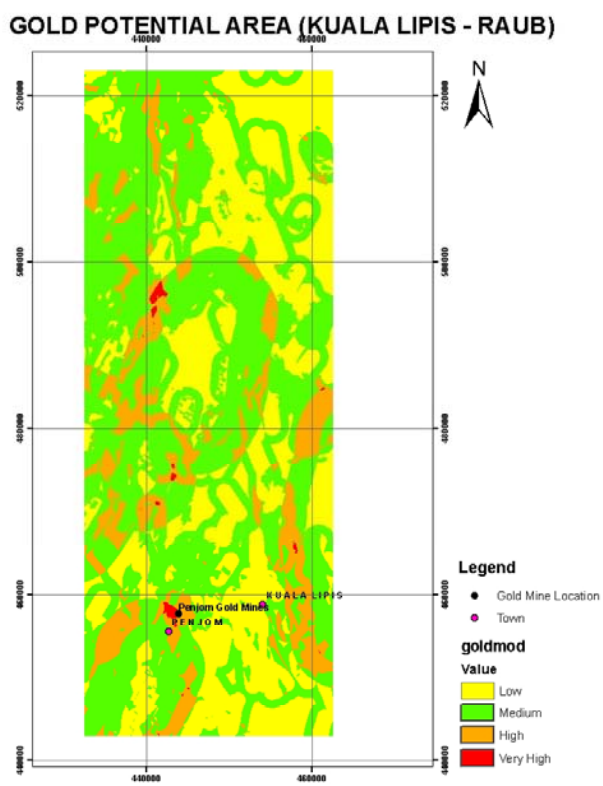


Figure 10: Gold Potential Model

The model developed was then validated by comparing gold (Au) stream sediment records from previous study (Figure 11) as well as field checking throughout the study area. About forty-four stream sediment samples from three different locations were collected for chemical analysis during the visit. Location 1 (Block A) is located in northern part of the study area where twenty samples were collected (Figure 12). The area covered by eighteen years old oil palm estate which underlain by limestone. The second location is Block B, located in mid-south of the study area and thirteen samples were collected. About nine samples were collected from third location, marked as Block C. From the samples analysed, it is found that the highest concentration of gold from these three locations were 141.2 ppm, 456.4 ppm, and 223.9 ppm, respectively.

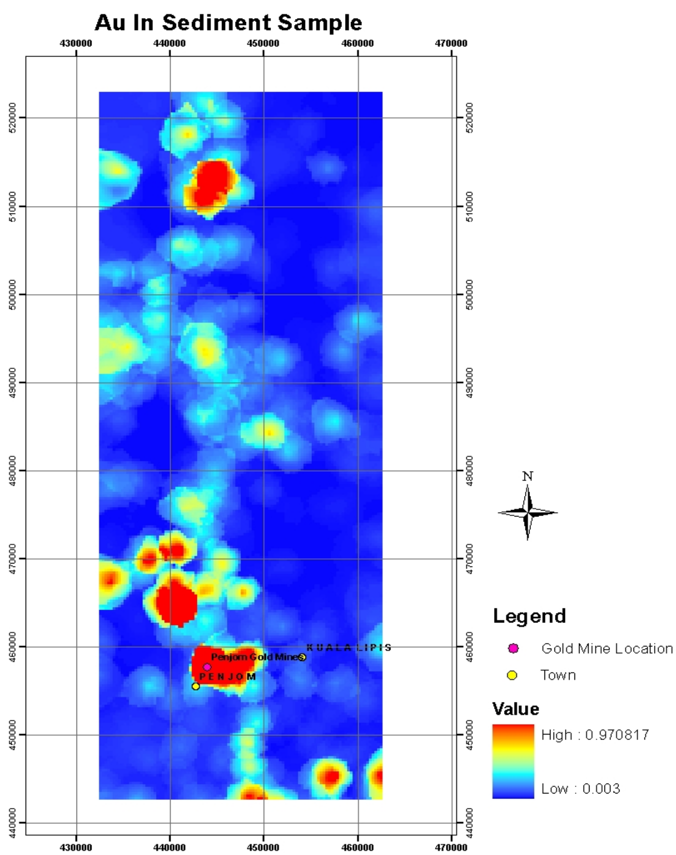


Figure 11: Concentration of Au (gold) in sediment samples from previous study

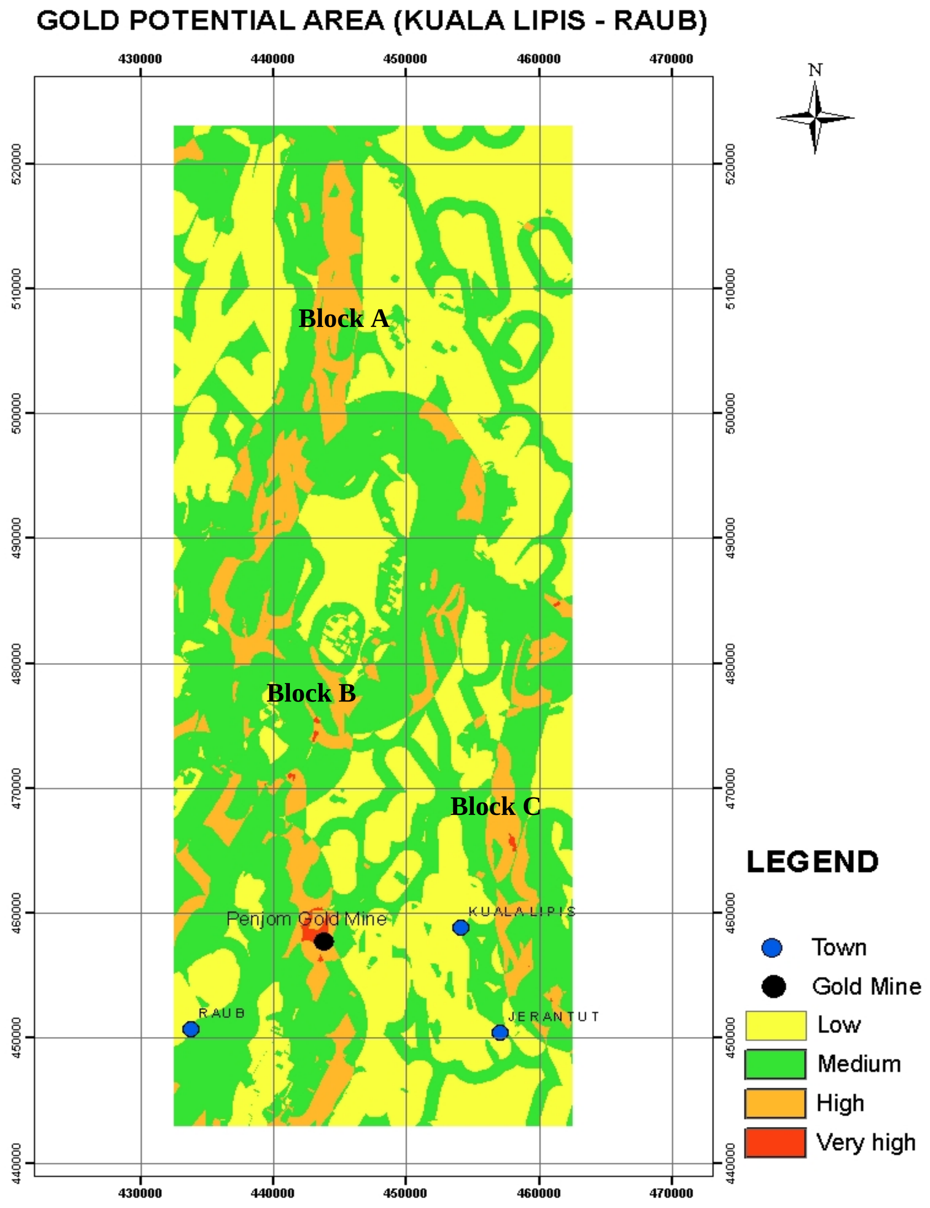


Figure 12: Sample locations for Gold Model verification

Conclusion

Remote sensing data together with radiometric and geochemistry datasets has proven to be a valuable data source for gold exploration. The model developed not only succeed in identifying the most abundance gold deposits i.e the Penjom Gold Mine but also able to recommend possible high potential area which are 'untouch' and have no existing developed mines.

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