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Discovering of high potential zones for gold mineralization using remote sensing satellite data: Mersing, Johor Bahru, SE Malaysia

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Abstract. Mersing is a highly prospective region for gold mineralization in the state of Johor Bahru, which is located on the south-eastern coast of Peninsular Malaysia. The Malaysian Geological Survey identified a widespread geochemical anomaly that follows the north-west regional structural trend running for more than 30 kilometres, commencing near the beach at Kampung Sri Pantai running inland toward the Mersing town. The presence of widespread quartz veining within the highly deformed metasediments, sulphide mineralization and free gold showing in the vein material, and the evidence of substantial alluvial mining and processing activities indicate that the Mersing region has potential to host primary gold mineralization. To date, the area has not been systematically explored using recent remote sensing technology and geological investigations for its primary gold potential and no production details are available. Whilst there are few geological studies in the Mersing, comprehensive remote sensing investigation for identification of high potential zones of gold mineralization in this region is largely lacking. In this study, the application of recently launched remote sensing data such as Sentinel-1and Landsat-8 OLI/TIRS data for locating high potential zones for gold mineralization in Mersing region have been evaluated. High potential zones of gold mineralization associated with the intersection of N-S, NE-SW, NNW-SSE and ESE-WNW faults and curvilinear features in shearing and alteration zones were detected and accurate and up to date structural and geological maps for the region were produced. Results indicate that systematic image processing techniques could be implemented to recently launched satellite data for geological structures and lineament analysis and hydrothermal alteration mapping at both regional and district scales. This investigation provided useful information for gold discovery in tropical environments using integration of remote sensing satellite data.

1. Introduction

The identification of geological structures and lineament analysis using remote sensing imagery are always considered complementary for any precious metals exploration program (Pour and Hashim, 2015a,b). Malaysia is a highly prospective region for gold and polymetallic mineralization and it has a long history of widespread gold, tin, iron and tungsten mining throughout the country. Mersing is located on Eastern Tin Belt of Peninsular Malaysia, in state of Johor (Fig. 1). Gold has been reported in two distinct settings in the area, quartz veins in the Permo-Carboniferous shale sequences and placer type overlying Jurassic conglomerates that contain Ag < 2%. The results show mesothermal sediment-hosted quartz-vein is a major type of gold mineralization indicated by the presence of pyrite, arsenopyrite and galena which is the common type in many other parts of Malaysia. Other minor components are ultramafic/mafic rock type and red-bed type unconformity (palaeo-placer) related mineralization (Styles et al., 1994). The original Malaysian Geological Survey identified a widespread geochemical anomaly that follows the north-west regional structural trend running for more than 30 kilometers, commencing near the beach at Kampung Sri Pantai running inland toward the Mersing Gold town. The presence of widespread quartz veining within the highly deformed metasediments, sulphide mineralization and free gold showing in the vein material, and the evidence of substantial alluvial mining and processing activities indicate that the Mersing region has high potential to host primary gold mineralization. To date, the area has not been systematically explored using recent remote sensing technology for its primary gold potential and no production details are available. The objective of this investigation is to delineate in detail the major lineaments and curvilinear and hydrothermal alteration zones using remote sensing technology as high potential regions for gold mineralization in Mersing Johor state, Peninsular Malaysia.

Figure 1. Location of Mersing in the state of Johor, Peninsular Malaysia

2. Materials

In this investigation, a level 1T (terrain-corrected) Landsat-8 OLI image was obtained through the US Geological Survey Earth Resources Observation and Science Center (http://earthexplorer.usgs.gov) for southern part of Peninsular Malaysia. The image data (LC81250592013178LGN01) (Path/Row 125/59) were acquired on June 27, 2013. The image data cover Johor Bahru state and the scene has 8.33 percent cloud cover. A Sentinel-1 SAR image was also acquired from Sentinels Scientific Data Hub (scihub.copernicus.eu), covering Mersing region and surrounding areas. The data were processed using the ENVI (Environment for Visualizing Images) version 5.2 and Arc GIS version 10.3 software packages.

3. Methods

The Landsat-8 data were converted to reflectance using the Internal Average Relative Reflection (IARR) method. This algorithm is recommended for mineralogical mapping as a preferred calibration technique, which it does not necessitate to have the prior knowledge of samples that collected from the field (Ben-Dor et al., 1994) To suppress and separate the erroneous effects of vegetation in hydrothermal alteration mapping and unveiling the lithology of the tropical terrain band ratio was implemented on specific spectral indices of ETM^+ data. Vegetation index (band ratio of 4/3), clay minerals index (band ratio of 5/7), ferric iron oxide index (band ratio of 3/1), and ferrous iron oxide index (band ratio of 5/4) were used. The presence of speckle in Synthetic Aperture Radar (SAR) images reduce the detectability of ground targets, obscures the spatial patterns of surface features, and decreases the accuracy of automated image classification. Therefore, it is necessary to treat the speckle by filtering the data before it can be used in various applications (Sheng and Xia, 1996). To fulfill the aim of this study, the median spatial convolution filter was used for noise removal and smoothing the SAR images. The median filter is a particularly useful statistical filter in the spatial domain, which effectively remove speckle (salt and pepper noise) in radar images without eliminating fine details. The RGB color composites additive primary colors allow the assignment of three different types of information (e.g image channels) to the three primary RGB colors. The color composite facilitates the interpretation of multichannel image data due to the variations in colors based on the values in the single channels. The RGB technique was applied to Landsat-8 OLI image and Sentinel-1 SAR image of Mersing, Johor. Directional filters were used to enhance specific linear trends in the resultant image. Four principal Directional filters: N-S, E-W, NE-SW, and NW-SE with a 7*7 kernel size were applied. Filters were chosen to highlight the main lineament directions in the Mersing area of the Peninsular Malaysia. Directional filter angles were adjusted as N-S: 0°, E-W: 90°, NE-SW: 45°, and NW-SE: 135°. North (up) is zero degrees and the other angles are measured in the counterclockwise direction. 7*7 kernel matrix was selected to enhance semi-smooth and smooth/rough features. Image Add Back value was entered 40%. The Image Add Back value is the percentage of the original image that is included in the final output image. This part of the original image preserves the spatial context and is typically done to sharpen an image.

4. Results and discussion

Figure 2 shows RGB colour-composite of band ratio of 5/7, band ratio of 5/4 and band ratio of 4/3 for Johor state. The RGB colour-composite yields an image showing vegetation cover and area with low vegetation cover. High vegetated regions are appeared as yellow colour, while the area with less vegetation ground manifest as blue colour.

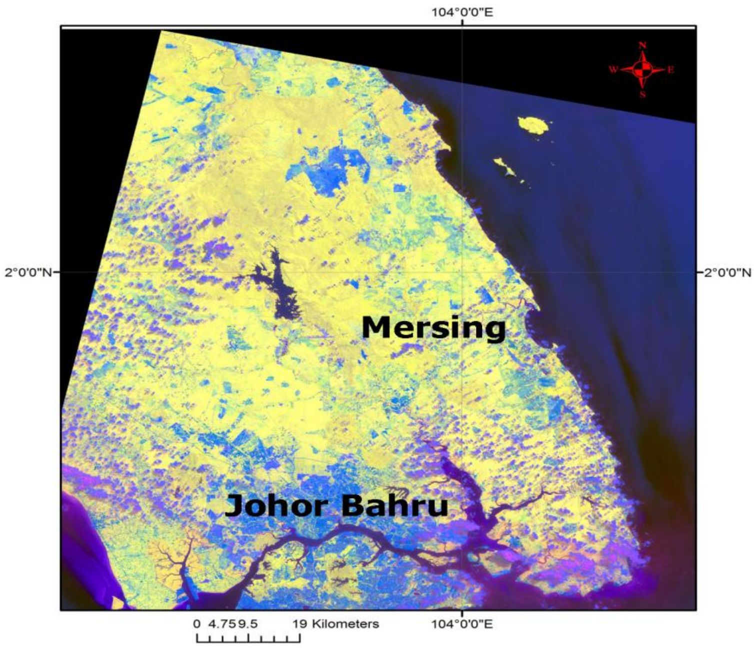

Figure 2. RGB colour combination of band ratio of 5/7, 5/4 and 4/3 for Johor state

Figure 3 shows RGB colour-composite of VH, VV and VH+VV polarization channels for Johor state. The RGB colour-composite was produced a map of structural details and geomorphological information for Johor state. N-S, NE-SW, NNW-SSE and ESE-WNW structural trends in Mersing region could be seen easily. High altitude regions with rough pattern are manifested as light green colour. Areas with low altitude smooth to semi-smooth pattern and less structural features are appeared gray to light purple colour. Figure 4 is an image map of VH polarization channel associated with lineament feature detected in the Mersing area. High potential zones of gold mineralization associated with the intersection of N-S, NE-SW, NNW-SSE and ESE-WNW faults and curvilinear features in shearing and alteration zones were detected and accurate and up to date structural map for the region was produced (Fig 4).

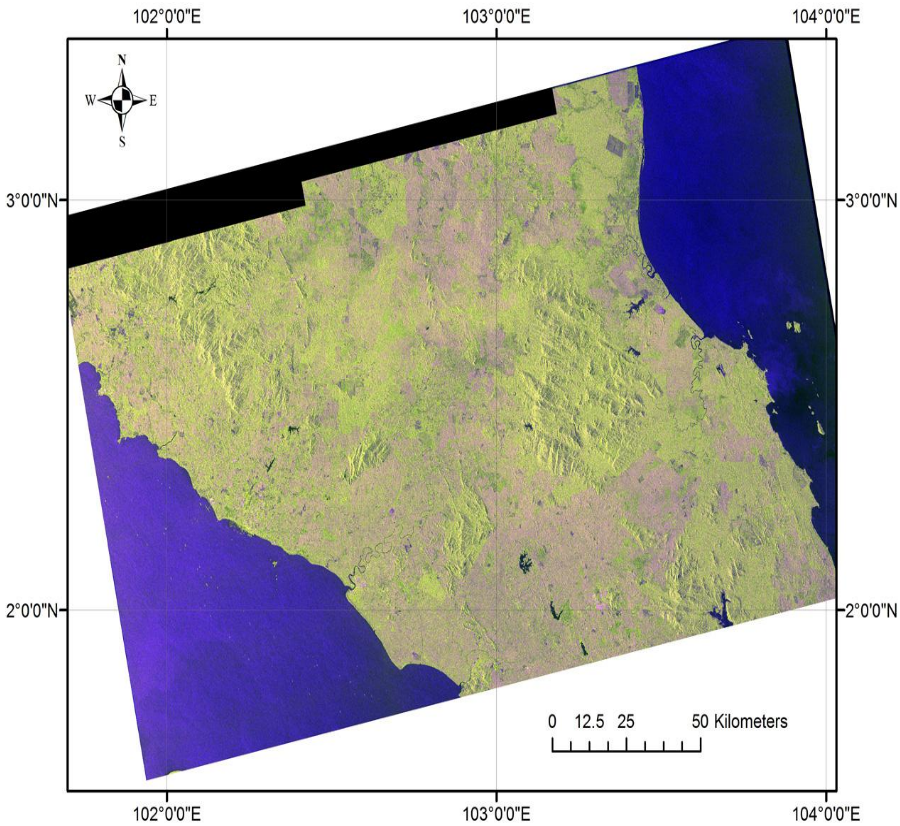

Figure 3. RGB colour combination (VH, VV and VH+VV polarization channels) of Sentinel-1 SAR scene covering Johor state.

N-S and NE-SW trending lineament systems are clearly extensive in the region. Most of longer lineaments are concentrated in the NS direction. N-S-trending, normal-slip faults parallel to the Bentong-Raub Suture Zone trend are defined by an obvious, west facing fault escarpment. This NS trend is similar to the orientation of the Bentong-Raub Suture Zone (Fig. 4). Some NW trending lineaments are associated with normal faults. A particular attention is carried in the NW-SE and NE-SW strike slip faults which can be often conjugated. Indeed, in this region they are respectively sinistral and dextral showing a maximal directed constraint N-S. In the radar image, strike-slip faults mark sharp boundaries; the planar fabric on either side is either sharply truncated or sheared off. Most of the known gold deposits are located along of splay faults in the CGB, which are confined within brittle-ductile share or brecciated zones. Major N-S and NE-SW orientations and strike-slip faults with sharp boundaries are revealed in Figure 4.

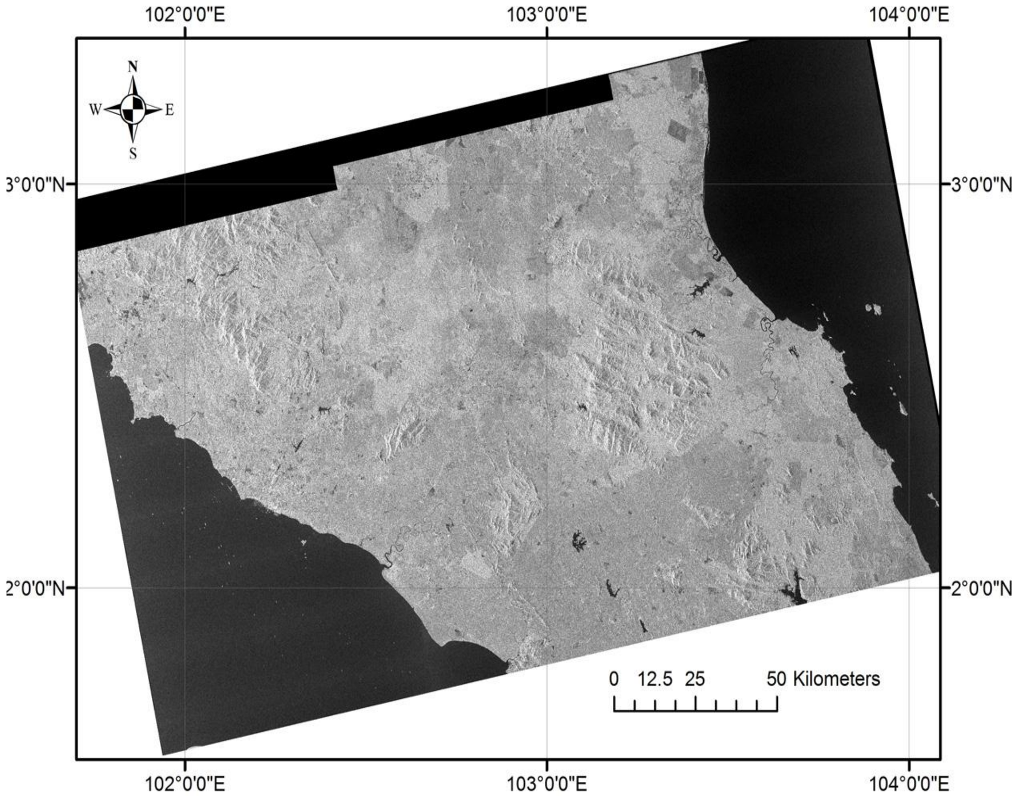

Figure 4. VH polarization channel of Sentinel-1 SAR scene covering Johor state

These structural elements are the most important potential areas for gold targets exploration, especially where fault-related rocks (cataclasite and mylonite) and hydrothermal alteration minerals are mostly found. Figure 4 shows an anticline with NE-SW trending and some curvilinear features in the eastern part of the image. Fold hinges are favorable settings for gold prospecting where they are associated with intensely faulted zones in contact between tonalite and carbonaceous sedimentary rocks. Moreover, meandering stream, which is also high potential area for placer gold exploration.

5. Conclusions

The Mersing region is well suited to evaluation through remote sensing structural analysis and hydrothermal alteration mapping for initial stages of mineral exploration program and prospecting high potential zones of gold mineralization. Remote sensing mapping techniques could be used to delineate areas with high potetail in Mersing region on a detailed scale. This is first time that such innovative research is undertaken in Mersing region, Johor state. Results of this investigation are useful for Ministry of Science, Technology and the Environment and innovation of Malaysia, Ministry of Natural resources and Environment Malaysia, Geological Society of Malaysia (GSM), Geological survey of Malaysia, Minerals & Geoscience Department Malaysia (JMG) Minerals & Geoscience Department Malaysia of Johor state and Monument Mining company.

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