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Structural mapping using PALSAR data in the Central Gold Belt, Peninsular Malaysia

Amin Beiranvand Pour *, Mazlan Hashim

Institute of Geospatial Science & Technology (INSTeG), Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor Bahru, Malaysia

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ABSTRACT

The Central Gold Belt (CGB) of Peninsular Malaysia has been investigated to map structural elements associated with gold mineralization using the Phased Array type L-band Synthetic Aperture Radar (PALSAR) satellite remote sensing data. Gold mineralization in this belt is structurally controlled and associated with steeply dipping faults and fold hinges. Adaptive local sigma and directional filters were applied to PALSAR data for tracing structural elements associated with gold mineralization. Structural features along the Bentong–Raub Suture Zone have been identified as highly potential areas for gold prospecting. Four sets of lineaments trending N–S, NE–SW, NNW–SSE and ESE–WNW were identified. Results of this study demonstrate the applicability of PALSAR remote sensing data to assist gold exploration in the CGB particularly in reducing costs related to exploration for epithermal and polymetallic vein-type mineralization in tropical environments.

1. Introduction

The identification of geological structures and lineament analysis using remote sensing imagery are always considered complementary for any precious metals exploration program in arid and semi-arid regions (Abdelsalam et al., 2000; Kusky and Ramadan, 2002; Pour and Hashim, 2011, 2012a,b, 2013; Ramadan et al., 2001; Sabins, 1999). However, in tropical environments, the application of remote sensing data for geological structure mapping has been much more limited (Hashim et al., 2013), because of the persistent cloud coverage, limited bedrock exposures, and vegetation. Preliminary studies by Pour et al. (2013, 2014) and Pour and Hashim (2014) in the Bau gold mining district, Sarawak, East Malaysia, on the island of Borneo demonstrated the applicability of satellite remote sensing imagery for mineral exploration in tropical environments. These studies suggest that more investigation is required to test the application of remote sensing data for locating potential gold exploration targets in the Central Gold Belt (CGB) of the Peninsular Malaysia. Many gold mines and prospects in the Peninsular Malaysia are located in the Central Gold Belt (CGB) (Ariffin, 2012; Ariffin and Hewson, 2007; Scrivenor, 1931; Yeap, 1993). Gold mineralization in this belt is structurally controlled. The CGB is a highly potential region for prospecting gold exploration targets along the major lineament structures using remote sensing technology. To date, this gold belt has not been tested using recent generations of very high resolution satellite remote sensing imagery.

Synthetic Aperture Radar (SAR) is an active microwave remote sensing system which can acquire data regardless of day or night, cloud, haze or smoke over a region. SAR image data provide information different from that of optical sensors. Clouds are reasonably transparent to microwave providing measurements with almost any weather conditions. SAR images have been used for geological mapping in glaciated and vegetated terrain, structural geology investigations related to the search for mineral deposits and hydrocarbon traps, and studies of geologic hazards (Abdelsalam and Stern, 2000; Abdelsalam et al., 2000; Kusky and Ramadan, 2002; Pettinato et al., 2013; Pour and Hashim, 2014; Pour et al., 2013, 2014; Raharimahefa and Kusky, 2009; Ramadan et al., 2001; Singhroy, 1992; Thurmond et al., 2006; Zandbergen, 2008). Radar transmits and detects radiation with wavelengths between 2.0 and 100 cm, but typically at 2.5–3.8 cm (X-band), 4.0–7.5 cm (C-band), and 15.0–30.0 cm (L-band) (Campbell, 2007; Spatz, 1997; Woodhouse, 2006). Longer wavelengths optimize the depth of investigation of the radar signal and allow radar to have complete atmospheric transmission. Generally, the approximate depth of penetration is equal to radar's nominal wavelength. L-band can observe the forest's underlying surface features as well as the canopy because of its penetration capability (Abdelsalam et al., 2000; Henderson and Lewis, 1998; Shimada and Isoguchi, 2002). Thus, in tropical environments, L-band SAR data provide the possibility of obtaining more useable geological structure information from the ground than shorter wavelengths.

This research presents a remote sensing approach for geological structure mapping in tropical environments. The objectives of this study are (1) to map structural elements associated with gold mineralization in the Central Gold Belt of the Peninsular Malaysia using the

* Corresponding author. Tel.: +60 7 5530666; fax: +60 7 5531174.
E-mail addresses: beiranvand.amin80@gmail.com, a.beiranvand@utm.my (A.B. Pour), mazlanhashim@utm.my, profmhashim@gmail.com (M. Hashim).

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Phased Array type L-band Synthetic Aperture Radar (PALSAR) satellite remote sensing data at both regional and local scales and (2) to establish a cost-effective exploration approach for prospecting epithermal and polymetallic vein-type mineralization in tropical environments using PALSAR data.

2. Geological setting

Peninsular Malaysia forms an integral part of the Southeast Asian continental core of Sundaland and comprises two tectonic blocks/terranes, the Sibumasu Terrane in the west and the Sukhothai Arc (East Malaya Block) in the east, which were assembled by the Late Triassic (Metcalfe, 2011, 2013a,b). Sibumasu and East Malaya are separated by the Bentong–Raub Suture Zone, which includes a tectonic mélange with ribbon-bedded cherts, schists, and minor ophiolites that represent Palaeo-Tethys remnants (Hutchison, 1975, 2009; Metcalfe, 2000). More than 90% of the plutonic rocks in the Peninsular Malaysia are granitic. The granitoids can be divided into two belts, a West Malaya Main Range S-Type group of granitoids that yield Late Triassic to earliest Jurassic, and an eastern Malaya group of dominantly I-Type granitoids with a range of ages from early Middle Permian to early Late Triassic (Searle et al., 2012; Sevastjanova et al., 2011).

Based on stratigraphical and structural differences the Peninsular Malaysia is divided into three geological belts: the Eastern Tin Belt, Central Gold Belt, and Western Tin Belt that are bounded by major fault zones (Hutchison, 1975; Khoo and Tan, 1983) (Fig. 1). The Central Belt of the Peninsular Malaysia is well-known as the Gold Belt (Scrivenor, 1931; Yeap, 1993). The Central Gold Belt (CGB) consists mainly of Permo-Triassic, low-grade metasediments, deep to shallow marine clastic sediments and limestone with abundant intermediate to acid volcanics and volcaniclastics, deposited in a paleo-arc basin (Metcalfe, 2002, 2011, 2013a,b). The belt coincides with the Bentong–Raub suture, which is a deep rooted 13 km wide north–south trending tectonic zone (Cocks et al., 2005; Tan, 1996). The CGB is bounded by the Bentong–Raub Suture Zone to the west and the Lebir Fault Zone to the East (Campi et al., 2002). The north–south trending Bentong–Raub Suture extends from Thailand through Raub and Bentong to the east of Malacca, Peninsular Malaysia (Fig. 1). This suture represents the main Palaeo-Tethys Ocean that was destroyed by collision between the Sibumasu and Sukhothai continental terranes of Southeast Asia (Metcalfe, 2000).

Major faults in the Peninsular Malaysia strike N–S, NNW–SSE, NW–SE, WNW–ESE, E–W, ENE–WSW and NE–SW and have undergone complex repeated movements, including microstructure evidence for both sinistral and dextral movements along many strike-slip faults (Shuib,

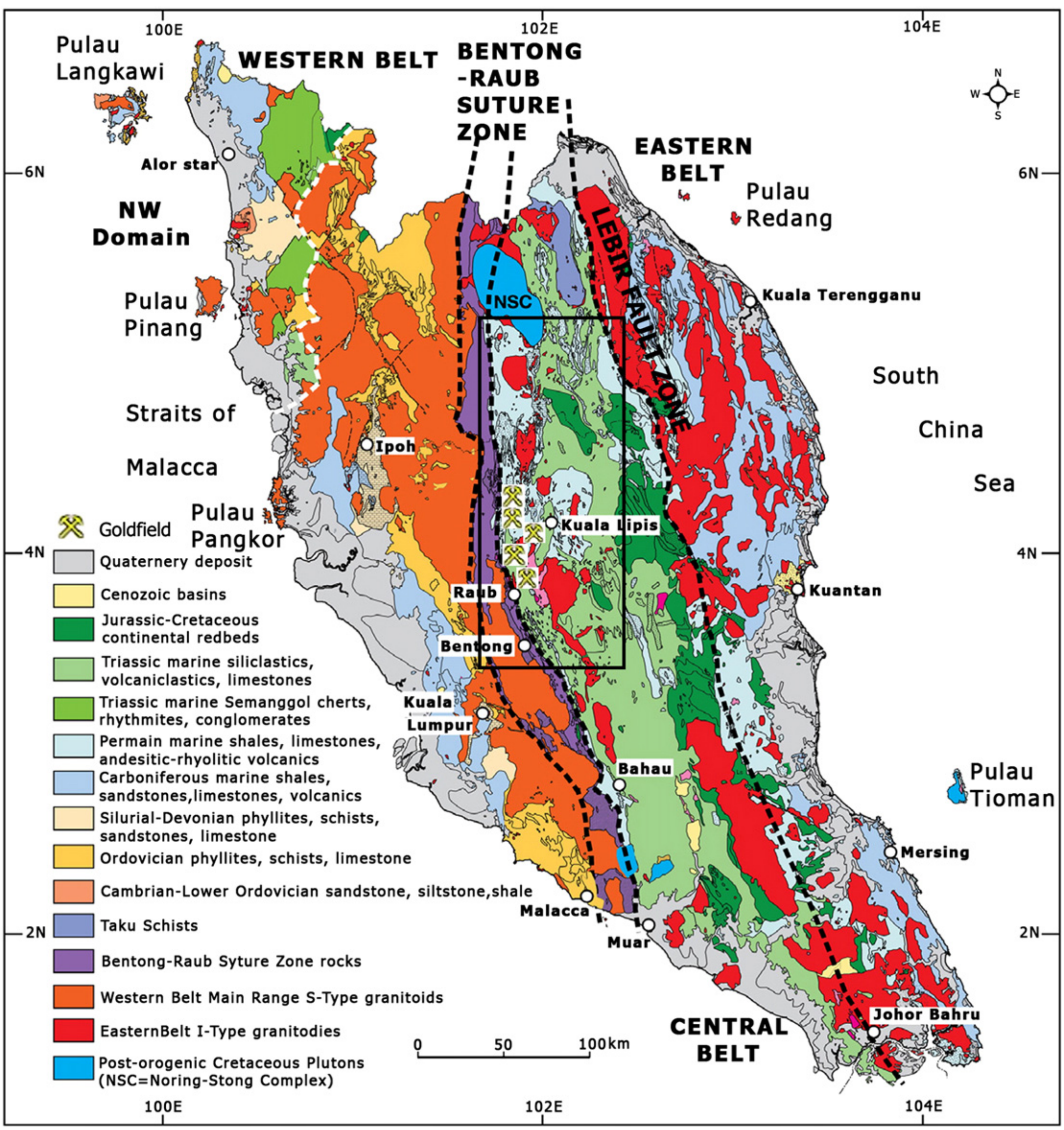

Fig. 1. Simplified geological map of the peninsular Malaysia. Modified from Metcalfe (2013a). Study area is located in black rectangle.