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Editorial: Frontiers in Southeast Asian geosciences, volume II

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Editorial on the Research Topic
Frontiers in Southeast Asian geosciences, volume II

Introduction

Southeast Asia exhibits profound geological complexity arising from the intricate interplay of diverse tectonic processes and magmatic phases. The region is dominated by multiple subduction zones, which have been pivotal in the collisional growth of continental Southeast Asia, consequently giving rise to pronounced seismicity and volcanic activity across various epochs (Hall, 2017; Lai et al., 2021). This dynamic geological setting manifests in the dramatic elevation of land, deep crust exhumation, and basin subsidence. The elucidation of these intricate geological processes is facilitated by the integration of remotely acquired images, seismic data, and multibeam data obtained from oil exploration.

The growing interest in unraveling the geological mysteries of Southeast Asia is driven by the area's unparalleled geo-diversity. The region boasts morphologically diverse features, such as the highlands of Myanmar and Thailand juxtaposed with the valleys and lowlands of Borneo, surrounded by some of the world's highest mountain ranges (e.g., the Himalayas, Karakoram, Tibet). Noteworthy geological structures, like the collision zone of the Indian continent and the Pacific Ring of Fire, add further complexity. The Precambrian and Archean platforms in China and India, spatially associated with Paleozoic magmatic and metamorphic rocks in Thailand, Malaysia, Myanmar, Vietnam, and Sumatra, encompass some of the oldest formations on Earth. In contrast, the region is bounded by the relatively younger island arcs of Indonesia and the Philippines, which are characterized by numerous Cenozoic fluvial and marine deposits. Adding to this complexity are unexplored areas with extensive rainforests and limited accessibility that contribute to the region's general understudy compared to other areas.

This volume serves as a continuation of a prior Research Topic of articles (Tsikouras et al., 2021) and aims to provide the latest insights into the regional geological setting of Southeast Asia. The region's rich geoscientific diversity, along with its occasionally enigmatic geological formations, hosts some of the most economically significant deposits and formations. Moreover, it houses substantial petroleum reserves, highlighting its critical role in global economic and social contexts and emphasizing the allure and urgency of studying Southeast Asian geology. This volume highlights critical issues in Southeast Asia, as reflected in the content of the published work. These include the evaluation of metals and other earth resources, connecting paleoclimatic evolution to climate change and mainly

understanding the geological controls behind hazards such as volcanic eruptions, seismicity, and the associated disasters such as landslides and tsunamis that affect the safety of large populations in the region.

Petrogenetic studies

Fanka and Tadhai studied lithium-bearing pegmatites and associated granitic rocks in southern Thailand, particularly in the Phang Nga area. These rocks, linked to tin deposits in the SE Asian tin belt, are characterized by lepidolite pegmatites and various types of granitic rocks with a peraluminous S-type granite affinity. The geochemical characteristics, including the enrichment of large-ion lithophile elements; the depletion of Ba, Nb, and Ti; and rare earth element patterns, suggest a regional setting related to the Sibumasu–West Burma and West Burma–Indo-Burma collisions during the Cretaceous to Eocene. The lithium-bearing pegmatites in this region have a relatively high average lithium grade compared to other lithium-bearing pegmatites globally.

Pratama et al. investigated the magma storage conditions beneath the Krakatau volcano across three periods: Old Krakatau, Young Krakatau, and Anak Krakatau. The research utilizes geochemistry, rock magnetism, and petrology to infer the evolution of magma storage conditions. Findings reveal that the Old and Young Krakatau magma storage regions were shallow (within the upper 3 km) with more differentiated magmas, while Anak Krakatau's storage is deeper (up to 26 km) with less differentiated and hotter magmas. The study suggests that a complex magma plumbing system persisted throughout Krakatau's evolution, with implications for understanding past, present, and potential future volcanic hazards.

Paleoclimatic evolution

Liang et al. investigated the Holocene paleoclimatic evolution of the Beibu Gulf, focusing on the eastern part and exploring the mineralogical, geochemical, and geochronological features of sediments from that area. Rare earth element distribution, source analysis of clay minerals, and illite crystallinity reveal the area broadly outlined by Hainan, Taiwan, Luzon, Red River, and Pearl River as the province of these sediments. The study provides insights into climatic variations and identifies three climatic stages during the Holocene, where dry and cold periods alternated with humid and warm seasons. The research emphasizes the potential of illite crystallinity as a proxy indicator for reconstructing regional surface chemical weathering processes in response to global climate change.

Geomorphology and geophysics

Putra and Chenrai applied geomorphic indices to assess the relative tectonic activity of the strike-slip basins along the Northern Sumatran Fault, utilizing six indices: mountain front sinuosity, valley width-to-height ratio, stream length-gradient, index of basin shape, asymmetric factor, and hypsometric integral. Results indicate alternating moderate and high tectonic activities along the fault, with a northward decrease from very high to moderate activity in its northern part. The spatial variation in tectonic activity aligns with seismicity and GPS velocities, suggesting persistent long-term tectonic deformation in the Northern Sumatran Fault until recently.

Dahrin et al. focused on the Sianok segment of the Great Sumatran Fault and employed magnetic and gravity modeling to understand its subsurface structures. Ground magnetic measurements, combined with the Bouguer anomaly map, reveal shallow magma chambers beneath Maninjau Caldera, Mount Marapi, and Mount Singgalang-Tandikat. The analysis identifies magnetic anomalies caused by thick andesite deposits and Permian metamorphic rocks, while negative gravity anomalies in Maninjau Caldera suggest a collapse-related accumulation of lighter rocks. The models confirm the presence of exposed and unexposed Permian metamorphic rocks, highlighting the importance of understanding the subsurface structures for potential disaster assessment in the Sianok segment.

Methodological advances

Kodama explored the limitations of the traditional assumption in paleomagnetism that a sample is a magnetic dipole when using a spinner magnetometer. For samples with inhomogeneous magnetization or irregular shapes, non-dipole components become significant, affecting the measurement of remanent magnetization. The study introduces a theoretical method based on an offset dipole model and a multipole expansion analysis, comparing the results with experimental data from a new type of high-resolution spinner magnetometer. This approach allows for quantifying the contribution of non-dipole components and assessing the dipolarity of a sample, providing a valuable diagnostic tool for obtaining more reliable data, particularly in tectonically active regions with complex geological histories.

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Conflict of interest

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