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Petrology and Geochronology of Igneous and Metamorphic Rocks from the Inthanon Zone: Implications for the Tectonic Evolution of Northwestern Thailand

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The Inthanon zone of northwestern Thailand comprises numerous plutonic rocks within a metamorphic basement which displays a multi-stage magmatic and metamorphic history starting in the Early Mesozoic. The latest activity occurred during the Cenozoic extensional phase which led to the development of various rift basins (e.g., Chiang Mai basin) but also exhumed the Inthanon zone by low-angle detachment faults. We provide P–T estimates and geochronological data (monazite and zircon) from metamorphic rocks, along petrographic, geochemical and zircon U–Pb age data of granitoids to reconstruct their tectonic history.

The sampled granitoids are biotite granite, syenite/monzonite, and hornblende granite. The biotite granite is a peraluminous S-type granite belonging to the high-K calc-alkaline to shoshonitic series. In contrast, syenite/monzonite and hornblende granite are metaluminous with shoshonitic affinity. The biotite granite and syenite/monzonite have comparable REE patterns: elevated LREEs, a negative Eu anomaly, and a flat HREE profile. The hornblende granite is enriched in LREEs compared to HREEs and lacks a negative Eu anomaly. Zircon U–Pb geochronology dates the biotite granite at 217–210 Ma, the syenite/monzonite at 70–65 Ma, and the hornblende granite at around 21 Ma.

Metamorphic rocks consist of orthogneiss and paragneiss, some garnet-bearing. The orthogneiss shows a mylonitic texture with large K-feldspar augen and contains intercalated of foliated garnet leuco-granites with a zircon U–Pb age of ~40 Ma. Ti-in-biotite geothermometry indicates temperatures of 650–700 °C. Notably, two distinct populations of zircon ages are identified: one around 200 Ma with a high Th/U ratio (>0.1), interpreted to represent the protolith age, and one around 80 Ma with a low Th/U ratio (<0.1). The garnet-bearing paragneiss shows two garnet growth episodes. The garnet core reflects medium-grade metamorphism (0.7–0.8 GPa; 530–570 °C) and yields a monazite age of ~230 Ma, while the rim, formed under upper amphibolite facies (0.4–0.5 GPa; 640–670 °C) at about 80 Ma. Monazite in the matrix shows complex zoning, suggesting recrystallization and re-precipitation during multiple stages of metamorphism, with a primary age population around 230 Ma and sporadic clusters indicating lead loss at about 80 Ma.

Our data indicate that northwestern Thailand underwent several tectonic events. The first event in the Late Triassic is associated with widespread plutonism and an initial medium P–T regional metamorphic phase related to the Sukhothai-Sibumasu collision. This was followed by a widespread upper amphibolite facies overprint and granitic emplacement in the Late Cretaceous, linked to the collision between the Sibumasu and West Burma blocks. Additionally, our data reveal a late Eocene–Oligocene metamorphic event including the intrusion of small magmatic body resulting in upper amphibolite facies to lower granulite facies metamorphism associated with large-scale shearing, as evidenced by the Mae Ping and Three Pagodas shear zones.

Session: *Pangeo workshop: Regional Geology*

Keywords: *Thailand; Western Gneiss Belt; U–Pb dating*