

The warm mature subduction of the old Paleo-Tethyan Ocean in the northern Vietnam

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The eastern Paleo-Tethyan Jinshajiang–Ailaoshan–Song Ma orogenic belt in the Southeast Tibetan Plateau represents the tectonic boundary between the Indochina and South China blocks. Regional Cenozoic lithospheric strike-slip movements caused by the India–Asia collision have modified many of the pristine geological records associated with the Indosinian orogeny. The lack of reliable petrological evidences, particularly of high-pressure (HP) metamorphism, has hindered the tracing of the evolutionary history of the Paleo-Tethyan orogenic belt. We report the mineralogy, geochemistry, geochronology and thermodynamic modelling of eclogite lenses/blocks and their host garnet–phengite schists from the Song Ma Suture Zone of Northwest Vietnam and reveal their protolith origins and metamorphic evolution. The eclogites are geochemically similar to mid-ocean ridge basalt, showing weak depletions in high field-strength elements, positive to slightly negative whole-rock $\epsilon\text{Nd}(t)$ ratios (−1.69 to +5.15). The igneous protolith of the eclogites formed in the late Silurian (425.4 ± 3.6 Ma; igneous zircon dating), which makes them the oldest known mid-ocean ridge mafic rocks in an ancient Paleo-Tethyan Ocean. Various eclogites preserve similar peak mineral assemblages under indistinguishable peak conditions. Their prograde P–T trajectories show a uniform pattern of progressive heating and weak compression along a geothermal gradient of 8–10°C/km, indicating a warm subduction setting at a low angle that contrasts with the cold oceanic subduction recorded in the adjacent Paleo-Tethyan suture zones. Combined with detrital U–Pb ages from previous studies, our geochronological data indicate that the host schists originated from continental crust within the South China Block and underwent a pervasive Triassic HP metamorphism related to the Indosinian orogeny. The eclogites and host schists yielded HP metamorphic ages of 239–234 Ma and retrogressive amphibolite-facies metamorphic ages of 231–229 Ma, suggesting rapid cooling and exhumation from the mantle to the crust. The Song Ma eclogites and their host schists formed when the final ocean closure transitioned to the initial Indochina–South China collision.