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Timing the closure of the Jilin-Heilongjiang Ocean: Constraints from zircon, apatite and titanite U-Pb dating of the Heilongjiang Complex in NE China

YUAN-YUAN LI[1], QIONG-XIA XIA[1], ZHOU JIANBO[2], ER-LIN ZHU[1], ZHAO-YA LI[1], XING-HAO ZHANG[1] AND XIN-YUE GUO[1]

[1]School of Earth and Space Science,University of Science and Technology of China
[2]College of Earth Sciences, Jilin University

The timing of the Paleo-Asian Ocean closure, the onset of Paleo-Pacific Ocean subduction, and the transition between these events remains highly controversial. The Ji-Hei high-pressure metamorphic belt (Ji-Hei HP Belt), formed following the closure of the Jilin-Heilongjiang Ocean (Ji-Hei Ocean), provides well-preserved evidence of this transitional tectonic process. We present whole-rock geochemical data and multi-mineral U-Pb geochronology for Yilan blueschists within the Ji-Hei HP Belt. Whole-rock major and trace elements indicate the protoliths of Yilan blueschists were alkaline basalts formed in an ocean island setting. The youngest concordant zircon U-Pb ages for the Yilan blueschists obtained at 262 ± 3 Ma, constraining their protolith age to the Late Permian. Based on the occurrence and composition, two generations of apatite are identified: Ap-I yields a U-Pb age of 185 ± 13 Ma, dating its formation during prograde subduction to the peak blueschist facies in the Early Jurassic; Ap-II yields a U-Pb age of 165 ± 10 Ma, representing retrograde metamorphism during exhumation in the Middle Jurassic. Integrating these results with published chronological data from the Ji-Hei HP Belt indicates that the Ji-Hei Ocean opened during the Early to Middle Permian (288–260 Ma), with subduction initiating in the Late Permian to Early Triassic (260–230 Ma). Driven by westward subduction of the Paleo-Pacific plate, further subduction of the Ji-Hei Ocean occurred from the Early Triassic to Early Jurassic (230–185 Ma), culminating in the amalgamation of the Jiamusi-Khanka Block with the Songliao Block.