



Tectonic evolution of the Mudanjiang Ocean between the Jiamusi and Songnen-Zhangguangcai Range massifs, NE China: Geochronological and geochemical evidence

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The Heilongjiang Complex lies between the Jiamusi (JM) and Songnen-Zhangguangcai Range (SZM) massifs, and it is composed predominately of blueschist, amphibolite, greenschist, serpentinite, mica schist (quartz schist), metasilicalite and marble, providing insights into understanding the tectonic evolution between the JM and SZM. Magmatic zircons of amphibolites from the Yilan area yielded a $^{206}\text{Pb}/^{238}\text{U}$ age of 274 ± 2 Ma, interpreted as the protolith age. The amphibolites yielded the rutile U-Pb ages of 177 ± 11 Ma and 172 ± 5 Ma, reflecting the time when the rocks cooled down to the closure temperature of Pb in rutile. The protoliths of amphibolites from the Yilan area exhibit the geochemical characteristics of tholeiitic series rocks, showing arc affinities. Moreover, zircon U-Pb analysis indicates that the youngest detrital zircons from metasedimentary rocks in the Heilongjiang Complex have concordant $^{206}\text{Pb}/^{238}\text{U}$ ages of ca. 230~180 Ma. And based on the Early-Middle Jurassic metamorphic ages of the Heilongjiang Complex from previous studies, the metasedimentary rocks from the Heilongjiang Complex were deposited during the Late Triassic-Early Jurassic. These data, combined with previous studies on the Heilongjiang Complex and contemporaneous magma-tectonic activities in the JM and SZM, indicate that two paralleled N-S trending Permian magmatic belts were distributed in these two massifs, associated with the evolution of the Mudanjiang Ocean. Taken together, a double-side subduction model is favored for the tectonic evolution of the Mudanjiang Ocean during the Late Paleozoic-Early Mesozoic, and the Mudanjiang Ocean closed during the Jurassic (180-160 Ma).

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