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The Barrovian and Granulite Metamorphism in the Chinese Altai: Separate or Shared Tectono-Metamorphic Histories?

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The prolonged accretionary history of the Central Asian Orogenic Belt (CAOB) has resulted in considerably complicated deformation and metamorphism patterns which remain not well understood. As a key element of the CAOB, high-grade metamorphic rocks of particular interest to understand the major tectonic process, has not been well investigated, because they were commonly thought to be some exotic Precambrian blocks with isolated tectono-thermal histories. However, many of they have recently been recognized as components of Early Paleozoic arcs or accretionary complexes. As a consequence, whether these high-grade metamorphic rocks shared the same thermal-tectonic process with the neighboring lower-grade rocks or they experienced completely different thermal histories as previous thought is one of the most fundamental questions that we have to face. Since high-grade rocks can generally provide pivotal information to reconstruct the crustal evolution, the resolution of the tectonothermal history of the high-grade rocks in the CAOB is a paramount step for the reconstruction of the complicated history of the region. In this respect, the Altai orogenic belt is an area of specific interest.

The Altai Orogen is a typical orogenic belt situated in the central CAOB and features various lithological elements of Paleozoic age. It has been the subject of many scientific studies, especially for its geochronological and geochemical features, but much less work has been done on its structural and metamorphic evolution. Rocks exposed in the southern Altai range (the Chinese Altai) generally exhibit typical barrovian metamorphic features, passing from sericite, through biotite, garnet, staurolite, to kyanite zones. Besides, some rock outcrops show clear high-grade metamorphic features at granulite facies conditions. The barrovian metamorphism is believed to be the product of crustal overthickening during major orogenic process. However, the tectonic significance of high-grade metamorphic rocks has not been well investigated, because they were generally assigned as exotic entities with isolated thermal histories. Recent studies have indicated that the granulite facies rocks were most likely high-grade counterparts of the barrovian rocks, since they have very similar geochemical compositions, isotopic signatures and protolith ages. Moreover, our primary study has demonstrated that the granulite facies metamorphism took place during Middle Devonian, coeval with the intensive arc magmatism in the region. This implies some genetic links between the granulite metamorphism and the regional lower-grade barrovian metamorphism. Due to the lack of structural and geochronological constraints, the mechanism and relationship of these metamorphic sequences remain poorly understood. It is therefore considered timely to develop a comprehensive systematic study of this crucial question to provide a better understanding of the underlying process.

In the present study, we integrate structural geology, metamorphic petrology, isotopic geochronology and phase equilibrium modeling to understand the tectono-thermal history of the region. Field structural investigation reveals that the major *S-L* fabrics developed in the granulite facies metamorphic rocks have exactly the same attitudes as those developed in the lower-grade barrovian rocks. Geochronological studies constrain the major fabrics in both kinds of rocks developed during mid-Devonian. Micro-structural investigation on both kinds of rocks show similar prograde metamorphic history featured by clockwise *P-T* path evolution. Phase equilibrium modeling

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in the MnNCKFMASH system indicates that the development of major fabrics in the barrovian metamorphic rocks mainly recorded the notable increase of pressure and that in the granulite-facies rocks was featured by the significant increase of temperature. The pressure increase could attribute to the progressive crustal thickening that may be correlated to the accretionary regime of the southern Altai in the mid-Devonian and the high temperature conditions most likely imply a significant heat input from the deep depth, consistent with the syn-chronologically emplacement of juvenile magmas on a large scale. Our study indicates the development of granulite facies metamorphism was genetically linked with that of the barrovian metamorphism and suggests that the crustal thickening during the orogenic process of the Altai region was accompanied by large heat input.

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Key words: CAOB; Altai Range; Barrovian metamorphism; Granulites metamorphism; Tectonothermal model; Phase diagram.