



Tectonic exhumation and boundary structure of the Kokchetav HP – UHP metamorphic belt (Northern Kazakhstan): constraints from $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology

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The Kokchetav metamorphic belt (KMB) is part of the Early Paleozoic orogenic belt of Northern Kazakhstan and constitutes one of the most famous, classical ultra-high pressure (UHP) metamorphic terranes. The KMB mainly consists of gneisses, mica schists and eclogites. These were formed by Cambrian continental subduction and associated metamorphism of the Precambrian Kokchetav microcontinent and subsequent exhumation of fragments of this metamorphosed continental crust. Several subterranean can be distinguished in the KMB: Barchi, Kumdi-Kol, Sulu-Tube, Enbek-Berlyk, Kulet and Borovoe. These subterranean differ not only in rock composition or in genetic pT conditions, but also in the age of the individual metamorphic events, including the timing of peak, and regressive stages. Most geochronological data indicate a Cambrian age of UHP and HP metamorphism and subsequent exhumation of the KMB. However, there is no field evidence of Cambrian geodynamic processes in the region: Cambrian sediments, volcanic rocks, or large magmatic bodies are completely absent in the KMB setting.

The youngest geochronological information in the KMB was obtained on the garnet-mica schists from the Enbek-Berlyk subterranean. The $^{40}\text{Ar}/^{39}\text{Ar}$ ages of the muscovite from these schists lies in the range of 490 to 475 Ma (mainly 480-485 Ma). All $^{40}\text{Ar}/^{39}\text{Ar}$ stepwise heating experiments yield well-defined plateau and isochron ages. This age is considered to represent the time of emplacement of various heterogeneous nappes, including nappes that consist of HP – UHP metamorphic rocks, to upper crustal levels. To the north, the Kokchetav HP – UHP metamorphic belt is bounded by the Northern Kokchetav tectonic zone (NKTZ). This zone includes thin nappes of (1) Palaeo-Mesoproterozoic gneiss of the metamorphic basement of the Kokchetav microcontinent and Neoproterozoic meta-sandstones and dolomites of its deformed sedimentary cover, (2) pre-Ordovician volcanic rocks of island-arc affinity, (3) Early Ordovician turbidities with olistostrome lenses, and (4) gneiss with eclogite boudins. These nappes are tectonically juxtaposed distinctly against unmetamorphosed rocks. The fault zones between the different tectonic units are formed by quartz-muscovite schists. The $^{40}\text{Ar}/^{39}\text{Ar}$ ages of the muscovite from these schists cluster between 492–476 Ma (mainly about 490 Ma). The NKTZ was formed by the Early Ordovician collision between the Kokchetav microcontinent, including the Kokchetav metamorphic belt, and the Stepnyak island-arc. Late Ordovician and Silurian granites cross-cut the internal structural architecture of both the KMB and NKTZ, providing a relative upper age limit.

As a consequence, only the youngest stage of the formation of the metamorphic belt is directly related to a collision event. Comparison of the structural-metamorphic history of the KMB with the regional geological context, indicates that tectonic exhumation of the Kokchetav HP – UHP rocks must be precollisional. In this model, the individual nappes, detached from the underthrusting slab during progressive continental subduction, were exhumated before subduction cessation. The observed imbricated-nappe structure in the field, where UHP and HP rocks are juxtaposed against unmetamorphosed Ordovician sediments and volcanic deposits was formed during subsequent Ordovician collisional deformation events.