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Early Paleozoic exhumation and granite intrusion in the Kokchetav HP/UHP massif: geochronological and petrological constraints

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The Kokchetav Massif in northern Kazakhstan has attracted the widespread attention of the geoscientific community ever since the discovery of coesite and metamorphic microdiamonds as inclusions in garnet, clinopyroxene and zircon crystals of the high- and ultrahigh pressure (HP/UHP) rocks of the Kokchetav Massif. Subduction of the microcontinental basement rocks of the Kokchetav Massif metamorphosed them under HP/UHP conditions. Peak conditions were attained in the Early Cambrian, around 535 Ma ago. Subsequent rapid exhumation in the Early Paleozoic positioned these HP/UHP rocks in the shallow crust and subjected them to retrograde metamorphism. The diamondiferous rocks are mainly constrained to the western part of the Kokchetav Massif, especially to the Kumdy-Köl UHP unit, and were the prime focus of many previous studies. The central and eastern parts of the Kokchetav Massif are less understood and comprise several petro-tectonic metamorphic units of medium to high pressure. These are composed primarily of Paleoproterozoic granitic-gneiss, Neoproterozoic garnet-kyanite-sillimanite-biotite schists with boudins of amphibolite and Cambrian mylonitized granitic-gneiss with boudins of eclogite. These petro-tectonic units are separated by fault zones bearing garnet-quartz-muscovite and quartz-muscovite schists. We performed a new mapping survey in the central Kokchetav area. In addition we sampled mica schists in several units in the central Kokchetav Massif for

geochronological and geochemical analyses: the Berlyk, the Saldat-Köl and Kulet units. Also samples along one of the major fault zones delineating the Berlyk unit, the Chaglinka fault zone, were collected. The Changlinka fault zone forms one of the most important unit boundaries within the whole of the Kokchetav Massif. Muscovite ^{40}Ar/^{39}Ar dating of the Chaglinka and Berlyk mica schists yields consistent Early Ordovician plateau and isochron ages of 479-487 Ma (7 samples). Muscovite ^{40}Ar/^{39}Ar ages for Saldat-Köl mica schists are slightly younger (4 samples) and range between 477 and 479 Ma with a single sample yielding an age of 483 Ma. A muscovite schist sample from the Kulet unit exhibits an even younger ^{40}Ar/^{39}Ar age of 473 Ma. An additional sample of garnet-bearing schist of the southeastern Daulet unit on the other hand gives an anomalous high age of 547 Ma. It is not clear at the moment of writing how this age relates to the consistent Early Ordovician ages for the areas north of the Daulet unit and peak metamorphism ages reported earlier by several other authors. However, the Early Ordovician ages we obtained, constrain the timing of retrograde metamorphism during exhumation of the Berlyk, the Saldat-Köl and Kulet units. The results presented here imply that the rocks of these units reached muscovite Ar-retention temperatures of $\sim$350-380˚C in the Early Ordovician when they were exhumed to middle and upper crustal levels. Additional geochronological data were obtained from zircon crystals from granitoids that intrude the Kokchetav Massif, near the village of Zerenda. U/Pb SHRIMP dating of this zircon yields Early Devonian crystallization ages of $\sim$405 Ma. These ages are younger than previously thought and confirm that the metamorphic Kokchetav host rocks were at middle to upper crustal levels at that time.