EARLY PERMIAN ALKALINE INTRUSIONS OF WESTERN TIEN SHAN: A TERMINATION OF HERCYNIAN POST-COLLISIONAL MAGMATISM?

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The Tien Shan orogen formed during the late Paleozoic (Hercynian) collision between the Precambrian microcontinents of Karakum and Tarim in the south and the early Paleozoic Kazakhstan continent in the north (Zonenshain et al., 1990; Şengör et al., 1993). The western Tien Shan is composed of three major tectonic units or terranes: (1) the Northern Tien Shan, the deformed margin of the Paleo-Kazakhstan continent; (2) the Middle Tien Shan, a Late Paleozoic volcano-plutonic arc; and (3) the Southern Tien Shan, an intensely deformed fold and thrust belt formed during the final closure of the Paleo-Turkestan Ocean. These east-west trending linear terranes are cut by the NW trending Talas-Fergana Fault with a total dextral offset of about 200 km (Fig. 1). Voluminous late Paleozoic granitoid series of western Tien Shan formed during two episodes of subduction in Silurian – early Devonian and middle – late Carboniferous. Subduction-related magmatism was followed by the early Permian post-collisional magmatic pulse (Konopelko et al., 2017). Subduction-related magmatic series are spatially bound to the Middle Tien Shan terrane, which developed as a northern active margin of the Turkestan Ocean, while the post-collisional magmatism affected the whole western Tien Shan across terrane boundaries. In the Middle Tien Shan the post-collisional magmatic pulse followed the supra-subduction magmatism successively without interruption in time, while in the Southern Tien Shan, which developed during the late Paleozoic as a southern passive margin of the Turkestan Ocean, the post-collisional magmatic pulse was preceded and followed by more than 50 Ma long amagmatic periods (Fig. 2).

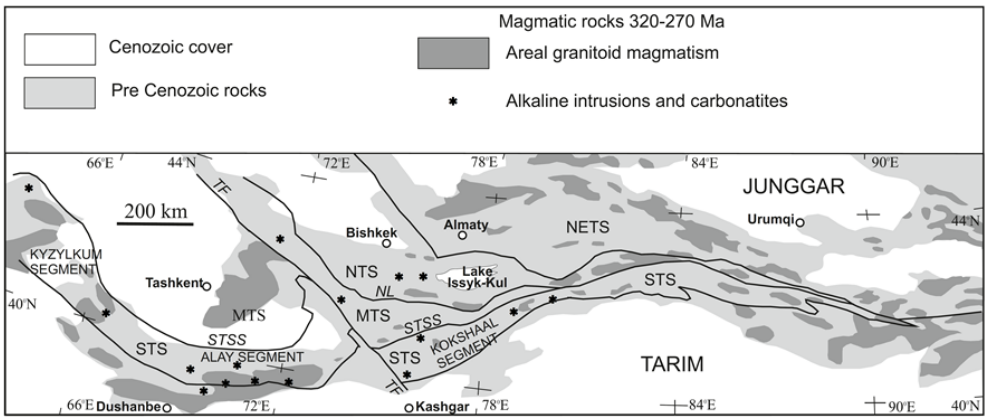

Figure 1. Principal terranes of the Tien Shan belt and distribution of late Paleozoic granitoids and alkaline intrusions. Abbreviations: NTS — Northern Tien Shan, NETS — North-Eastern Tien Shan, MTS — Middle Tien Shan, STS Southern Tien Shan, NL—Nikolaev Line, STSS—Southern Tien Shan Suture, TF—Talas - Fergana strike–slip fault.

Intrusions of alkaline rocks and carbonatites form a regionally developed suite in the Middle and South Tien Shan terranes where they associate with post-collisional granitoids and minor mafic rocks (Fig. 1). Several alkaline and carbonatitic intrusions of the area, such as Dara-i-Pioz, Akkulen, Chagatai and Karashoho intrusions, are known for their peculiar rock types and rare mineral assemblages (Fig. 3), which made them a focus of numerous mineralogical and petrographic studies (e.g. Shinkarev, 1966; Faiziev et al., 2010). However emplacement ages of the alkaline rocks and carbonatites remain poorly studied and their tectonic setting is still debated (e.g. Vrublevskii et al., 2018). In this work we review published single grain zircon ages of four alkaline intrusions and discuss them in combination with ages of associated granitoids in order to constrain the timing of the

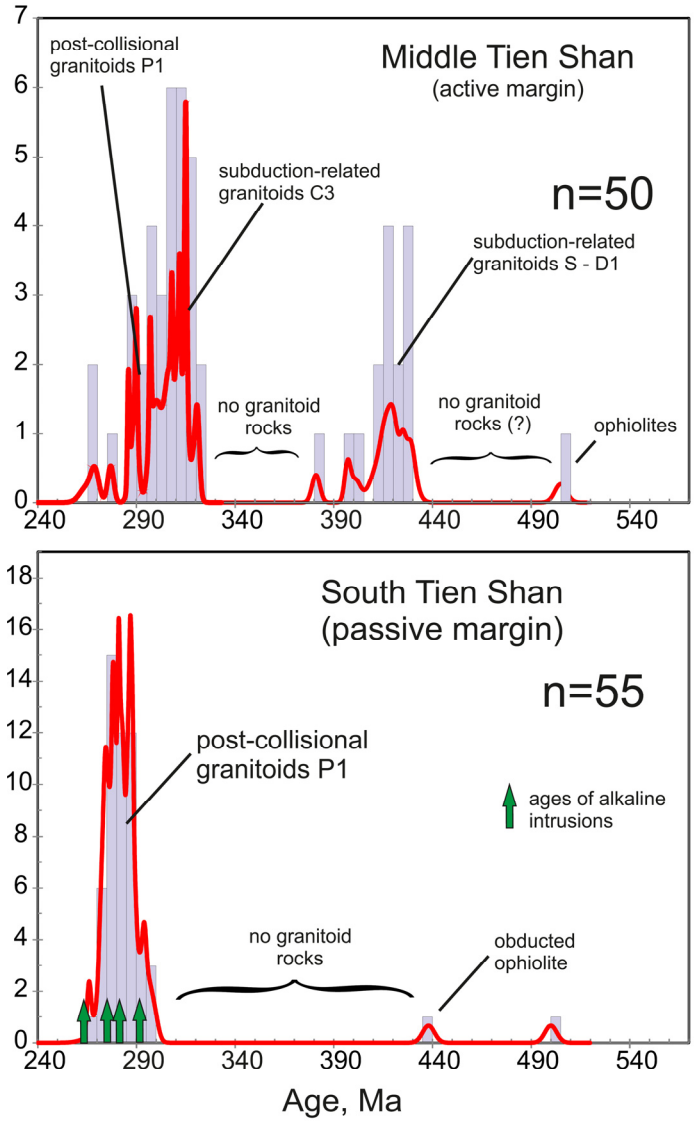

Figure 2. Histograms showing distribution of ages of late Paleozoic subduction-related and post-collisional granitoid intrusions at former active and passive margins of the Turkestan Ocean. Ages of alkaline intrusions are shown for comparison. Compiled from Seltmann et al. (2011), Dolgopolova et al. (2017), Konopelko et al. (2007, 2017, 2018).

alkaline magmatism within the frame of Hercynian collisional events in the western Tien Shan orogenic belt.

The geochronologically investigated alkaline rocks include alkaline syenites from the Akkulen (Fig. 3) and Surteke intrusions, located to the east of the Talas-Fergana Fault, nepheline syenite from the Dara-i-Pioz intrusion, representing the alkaline rocks of the Alai range, and the granite vein crosscutting diamondiferous mafic alkaline rocks of the Karashoho pipe in Kyzylkum desert. Alkaline syenites of the Akkulen massif were emplaced in the Middle Tien Shan while three other intrusions represent alkaline suites of the South Tien Shan terrane. Zircon grains from the Akkulen, Surteke and Karashoho rocks were dated by SHRIMP-II in VSEGEI and yielded ages 292 + 1 Ma, 284 + 1 Ma and 276 + 4 Ma, respectively. Zircon grains from the Dara-i-Pioz syenite were dated at 267 + 2 Ma utilizing LA-ICP-MS in the Natural History Museum, London, UK. These ages were published separately by Seltmann et al. (2011), Dolgopolova et al. (2017) and Konopelko et al. (2017) and are discussed here collectively for first time. The obtained ages of four alkaline intrusions are presented on histograms showing distribution of ages of late Paleozoic subduction-related and post-collisional granitoids at former active and passive margins of the Turkestan Ocean (Fig. 2). As seen in Fig. 2, the ages of alkaline intrusions generally correspond to the early Permian and match well the ages of post-collisional intrusions elsewhere in Tien Shan. Thus, emplacement of alkaline magmas was

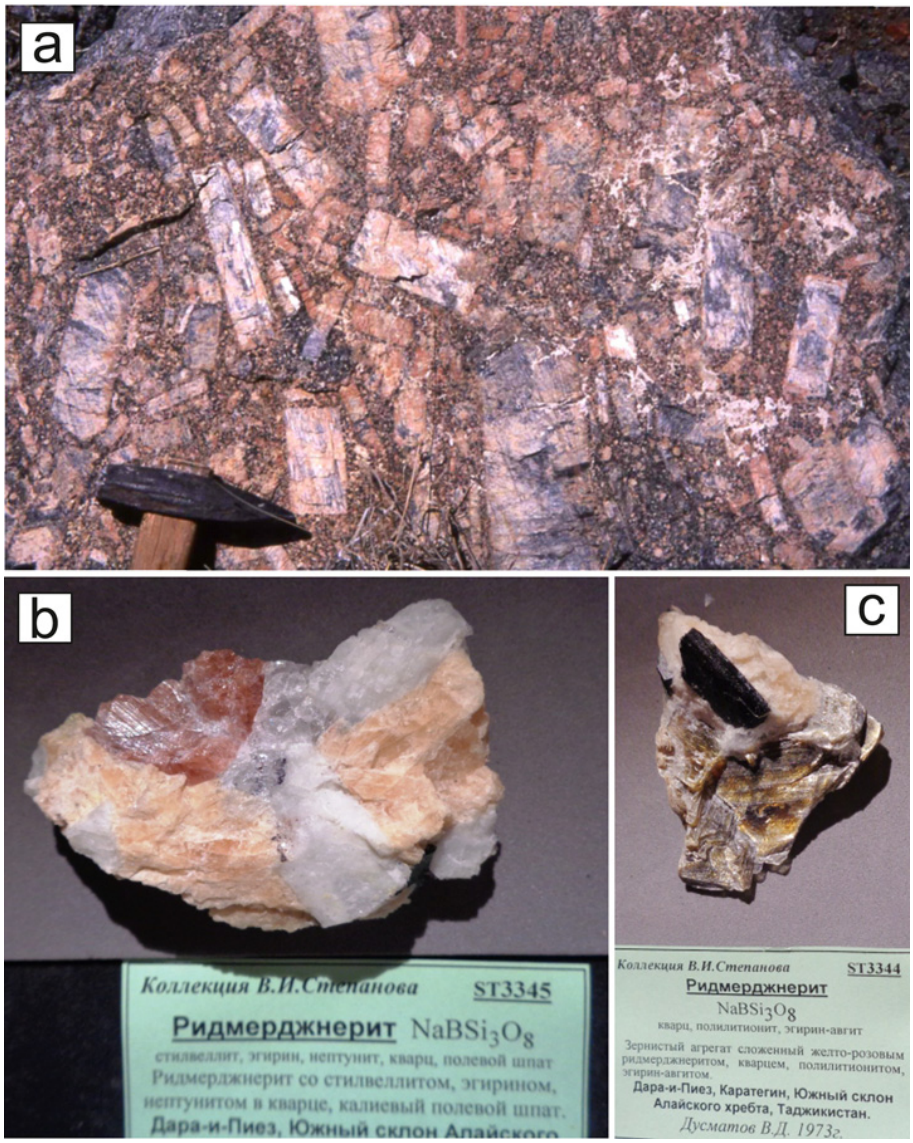

Figure 3. Specific rock types and rare mineral assemblages characteristic for alkaline intrusions of western Tien Shan: a – Kfs-megacrystic syenite with interstitial nepheline from the Akkulen intrusion; b and c – reedmergnerite $NaBSi_3O_8$ (yellowish cream-colored aggregates) from the Dara-i-Pioz intrusion. Photographs b and c represent samples from Fersman Mineralogical Museum, Moscow (http://geo.web.ru/druza/l-Dara-i-Pioz.htm).

probably triggered by the post-collisional processes and was unrelated to Permo-Triassic intraplate extension, as it was suggested by some authors (e.g. Vrublevskii et al., 2018).

To explain the geodynamic setting of Hercynian post-collisional intrusions Konopelko et al. (2007) proposed a model of post-collisional plate-scale displacements based on the model for the San Andreas fault in California (Teyssier and Tikoff, 1998). According to this model, after the late Carboniferous collision, the Tien Shan was affected by trans-crustal strike–slip motions that created a number of regional faults including the Talas-Fergana fault, which was active since early Permian (Fig. 1). It is suggested that transfer of displacement from the mantle to the upper crust was accommodated in the lower-middle crust by flat-lying detachment zones. This transpressional system provided suitable conduits for ascending asthenospheric material and influx of heat into the crust. Mantle-derived melts triggered melting of various crustal protoliths and emplacement of compositionally diverse post-collisional granites. In this scenario coeval alkaline magmas originated as a result of interaction between ascending asthenospheric material and lithospheric keels of accreted continental blocks with Precambrian basements.

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