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Postcollisional magmatism in the South Tien Shan Variscan Orogenic Belt, Kyrgyzstan: Evidence for high-temperature and high-pressure collision

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Abstract

The South Tien Shan Collisional belt consists of two segments divided by the largest in the Central Asia Talas-Fergan diagonal dextral strike-slip fault. The narrow eastern (Kokshal) segment, where the Late Carboniferous collision was followed by continental subduction of the Precambrian Tarim platform beneath the Caledonian Kazakh continent, is characterized by overthickened (60–65 km) crust and ultrahigh-pressure (coesite eclogite) regional metamorphism. The Permian postcollisional magmatism is represented there by a small volume of relatively 'cool' two-mica peraluminous leucogranites, moderate volumes of K-rich calk-alkaline (transitional from I- to S-type) granites and several large plutons of A-type rapakivi granites. The latest could have formed by a two-step process involving: (1) syncollisional submersion of the Tarim platform granulitic basement into the mantle accompanied by considerable heating of the source rocks, (2) 'rapid' postcollisional exhumation accompanied by decompression and extensive high-degree of melting. In the western (Alay) segment, which is much wider, the collision was not followed by continental subduction. The thickness of crust decreases westward dramatically (from 60 to 45 km). The Alay segment is characterized by the high-temperature/low-pressure regional metamorphism and significant volume of Permian shoshonitic/ultrapotassic magmatism, connected with postcollisional strike-slip tectonics. The shoshonitic magmatism is indicative of lithosphere delamination and input of mantle-derived melts and heat into the crust. In contrast to the Kokshal segment, the postcollisional granitic magmatism in the Alay segment is represented by relatively 'hot' cordierite- and sillimanite-bearing strongly peraluminous (S-type) granites, locally rooted in the high-temperature/low-pressure metamorphic rocks and large volume of calc-alkaline (I-type) granitoides of mixed (crust-mantle) origin.

Keywords: Granites; Plate collision; Tien Shan; Kyrgyzstan

1. Introduction

There is significant diversity among the continental collision orogenic belts. They are distinguished mainly by the thickness of continental crust, type of regional metamorphism and proportion of mantle-/crust-derived melts in collision-related magmatism. According to the concept of a 'duality of orogens' introduced by Zwart (1967) and developed by Sylwester (1998), two contrasting types of collisional orogens are distinguished: high-pressure as opposed to high-temperature collisional orogens. A full spectrum of transitional orogens exists between those contrast types. In high-pressure orogens (Alps and Himalayas) with crust extremely thickened by thrust stacking to more than ~50 km, high and ultrahigh-pressure regional metamorphism preceded granitoid magmatism (Scharer et al., 1986; von Blanckenburg, 1992; Gebauer et al., 1997). Syncollisional in situ radiogenic heating is the main source for crustal anatexis, which may have resulted from postcollision

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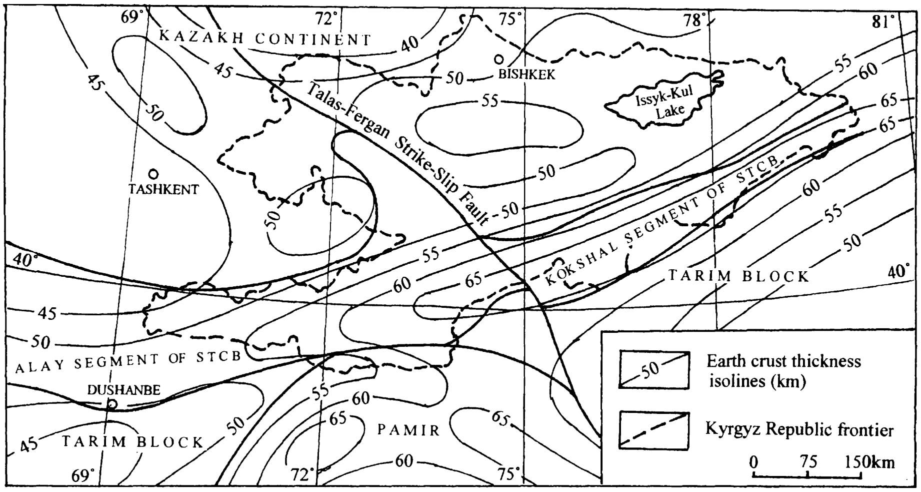

Fig. 1. Map showing the thickness of continental crust in the South Tien Shan collisional belt and adjoining territories (modified after Sabitova, 1989).

decompression melting along some of the deep-rooted thrusts (Sylwester, 1998), though fluid focusing along crustal shear zones (Strong and Hanmer, 1981) and advection or conduction of mantle-derived heat into lower crust (Wickham and Oxburgh, 1987) may also contribute.

In high-temperature orogens (European Hercynides, Lachlan in Australia), the newly formed continental crust is comparatively thin (less then 50 km) and large volumes of peraluminous (S-type) granites are associated with postcollisional high-temperature/low-pressure metamorphism (Sylwester, 1998), which typically can not be produced by in situ radiogenic heating in <50 km thick crust (Thompson and Connolly, 1995). Unlike high-pressure collisional orogens, S-type granites of high-temperature collisional belts are associated with large volumes of contemporaneous calk-alkaline (I-type) postcollisional granites that exhibit evidence for interaction with mantle-derived magmas (Sylwester, 1998; Bonin, 2004).The chemical and mineralogical composition of peraluminous granites is also evidence of mantle-derived heat contribution. In high-pressure orogens, peraluminous granites are represented by a ‘cool’ (<875 °C) two-mica variety that occurs where thick continental crust is crosscut by major shear thrust zones, while in high-temperature orogens, they manifest themselves as ‘hot’ (>875 °C) cordierite–sillimanite varieties locally rooted in high-grade metamorphic rocks (Sylwester, 1998; Barbarin, 1999).

The above-mentioned orogens are not of the same age (Caledonian, Hercynian, and Alpine) and do not refer to the same continents. Therefore, an alternative possibility is that different granitoids can also be related to distinct structural levels of a continental collision-related orogenic belt (Barbarin, 1999). The Himalayas may represent the upper level, while the Lachlan belt will be indicative of the lower one.

In this connection, the South Tien Shan Hercynian collisional belt (STCB) provides an opportunity to check that hypothesis. The belt consists of two segments divided by the Talas-Fergan diagonal dextral strike-slip fault (Fig. 1), the largest in Central Asia. All available geological, geophysical and petrological data below suggest that the eastern (Kokshal) segment of STCB may represent a high-pressure collision orogen, while the western (Alay) segment is related to a high-temperature one. In each of those segments collision-related magmatism has some distinct peculiarities. In this article, the generalized petrological, geochemical and isotopic data concerning collision-related granitoids from both segments of STCB are presented and compared.

2. Geological setting

The South Tien Shan collisional belt, being the south-central portion of the huge Central Asian folding belt, formed as a result of Late Paleozoic collision of the Post-caledonian Kazakh continent with the Precambrian Tarim block (Bakirov et al., 1989; Byske, 1996; Gao et al., 1998; Chen et al., 1999). Before the collisional event, the Kazakh continent to the north (in present-day coordinates) and Tarim to the south had been divided by the Turkestan Ocean. According to Burtman (1997), the northern margin of the Turkestan Ocean was active from the Ordovician until Early Devonian, passive or transform in the Middle and Late Devonian and most of the Early Carboniferous and active again in Serpukhovian time and Late Carboniferous. In contrast, the southern Tarim margin remained passive throughout this time interval.

Along its extent, the Turkestan Ocean closing suture is marked by ophiolitic mélange outcrops (Fig. 2). In some of those outcrops, subduction-related high-pressure/low-temperature (blueschist facies) metamorphism was preserved (Bakirov et al., 1989). The K–Ar age of glaucophane from the Atbashy blueschists is 360 ± 10 Ma (Zamaletdinov, 1994). The ophiolitic mélanges and blueschists are also widespread along that suture in the eastern Chinese part of STCB. Those blueschists occur as small blocks, lenses or