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Counterclockwise *P–T* evolution of the Aghil Range: Metamorphic record of an accretionary melange between Kunlun and Karakorum (SW Sinkiang, China)

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ABSTRACT

This paper describes the metamorphic evolution and the tectonic significance of the Aghil Range, a poorly known terrane located between Kunlun and Karakorum north of K2 in the framework of western Tibet. The Aghil Range consists of different units separated by syn- to late-metamorphic thrusts and post-metamorphic faults of similar attitude; among other units, the Surukwat Complex is a composite sequence of thrust sheets trending WNW–ESE and steeply dipping SSW showing a general increase of metamorphic grade from lower to higher structural levels.

P–T pseudosections and conventional thermobarometry of metapelites at the top of the Surukwat Complex tightly constrain the *P–T* path of this highest-grade metamorphic portion of the Aghil Range. The prograde path is characterized by an early increase in both *P* and *T* and by a later, nearly isothermal, increase in *P*, from $500<T<530$ °C and $0.25<P<0.40$ GPa to $580<T<600$ °C and $0.80<P<0.90$ GPa. The peak metamorphic event is constrained at $550<T<590$ °C and $0.77<P<0.91$ GPa. The retrograde path is characterized by decompression associated to a slight cooling to $T\sim500$ °C and $P<0.5$ GPa. Altogether, the petrology of the studied rocks suggests a *P–T* path with a narrow counterclockwise shape. The studied sequence could represent the result of the early subduction of an accretionary complex, interpreted further eastward according to a melange underthrusting model.

As concerning the tectonic setting of this terrane, a number of geologic and petrologic similarities link the Aghil Range and the central Qiangtang metamorphic belt, suggesting that the Aghil Range is the possible NW extension of the Qiangtang microplate separating Kunlun from Karakorum.

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1. Introduction

The tectonic setting of western Tibet is complex and characterised by a number of blocks, terranes, sutures and major crustal faults. The Aghil Range is a problematic terrane located within this sort of "geopuzzle" between west Kunlun to the north and Karakorum to the south. Detailed geologic studies in this area are few, confined east of the Aghil Range itself and mostly written in Chinese (e.g. Ding et al., 1996; Pan, 2000). Moreover, petrologic studies of the metamorphic basement rocks are virtually nonexistent. Although poorly known, this is a key area in order to understand the tectonic history of the westernmost side of Tibet, and to correlate the various terranes identified eastwards and westwards (e.g. Tapponier et al., 1981; Şengör, 1984). A geological reconnaissance in the Aghil Range from the Yarkand valley to the north, to the Shaksgam valley to the south, was carried out in 2006 with the following aims: (i) to understand the geologic setting and tectonometamorphic evolution of this poorly known terrane, and (ii) to compare its geology and petrology with that of the central Qiangtang terrane, in order to understand if they belong to a coherent single terrane as suggested by large scale tectonic reconstructions (e.g. Gaetani et al., 1990, 1991, 1993; Zanchi, 1993).

2. Geological setting

The studied area is located in a complex geological contest at the north-western termination of the Tibetan Plateau, north of the Karakorum Fault, where different blocks made of metamorphic and unmetamorphosed slivers are tectonically juxtaposed (Fig. 1). In the western Tibetan Plateau four terranes are conventionally distinguished, though poorly characterized, from north to south: Kunlun, Songpan-Ganzi (Tianshuihai) flysch complex, Qiangtang, and Lhasa terranes, each one separated by east striking suture zones of late Paleozoic to Mesozoic age (Chang and Zheng, 1973; Dewey and Burke, 1973; Allègre et al., 1984; Dewey et al., 1988; Matte et al., 1996, Yin and Harrison, 2000).

The metamorphic basement of the western Tibetan Plateau mainly outcrops at the core of a kilometric long anticlinorium structure in the central Qiangtang metamorphic belt (CQMB) (Kapp et al., 2000, 2003; Zhang et al., 2006). Its tectonic significance is debated and two alternative models are proposed: (i) CQMB may represent a Paleo-

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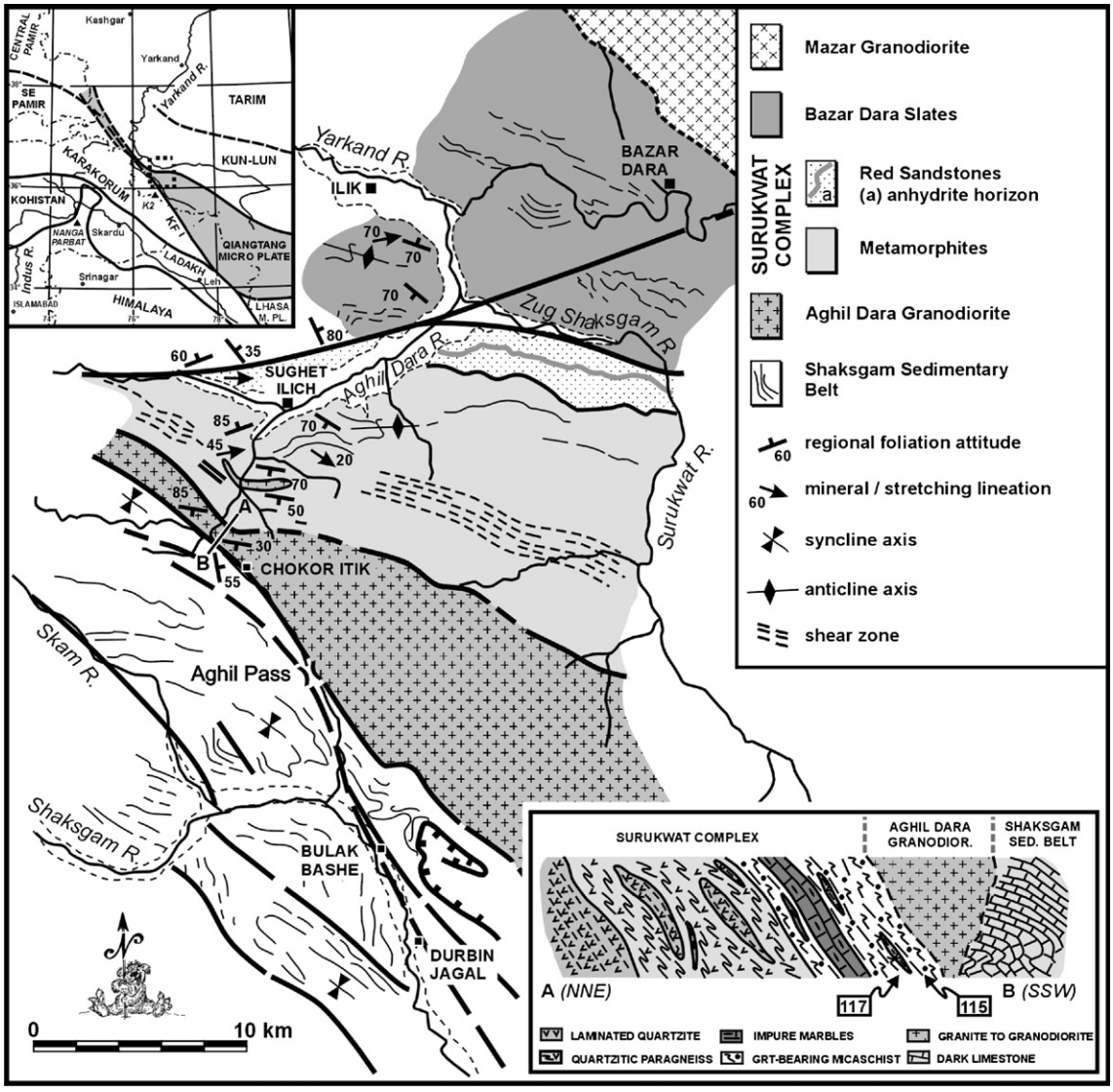

Fig. 1. Geologic map of the Aghil Range, between Kunlun (Yarkand River) and Karakorum (Shaksgam River), modified after Gaetani et al. (1991). Top left inset shows the tectonic framework of NW Himalaya from Islamabad to Kashgar. The geologic link between the Aghil Range (dotted rectangle) and the western termination of the Qiangtang microplate is discussed in this paper (KF = Karakorum Fault). Bottom right inset shows a schematic geologic cross-section of the uppermost structural level of the Surukwat Complex and its contact with the Aghil Dara Granodiorite and the Shaksgam Sedimentary Belt (not to scale), as inferred in the middle–upper Aghil Dara Valley, NW of Chokor Itik (line A–B). Approximate location of studied samples is also given.

Tethyan suture and the Qiangtang terrane may thus consist of two distinct crustal fragments, a southern portion of Gondwanan affinity and a northern portion of Cathasyan affinity (*in situ suture zone model*; Li et al., 1995; Zhang, 2001; Zhang et al., 2006); (ii) CQMB may be an early Mesozoic melange occurring in the footwall of Late Triassic–Early Jurassic domal low-angle detachment faults, and may thus represent the Songpan-Ganzi flysch subducted under a single Qiangtang terrane of Gondwanan affinity (*melange underthrusting model*; Kapp et al., 2000, 2003; Kapp, 2001). Independently from its tectonic interpretation, it is noteworthy that metamorphic rocks cropping out in the CQMB belong to an accretionary melange and experienced variable metamorphic imprints up to epidote–blueschist ($P>10$ kbar, $T\approx500$ °C) and epidote–amphibolite facies ($P\approx11$ kbar, $T\approx660$ °C) (Kapp et al., 2000, 2003).

While a number of tectonic, geochemical and geochronologic studies have been published across west Kunlun from Yecheng to Mazar and the Yarkand and Karakash rivers eastwards (Matte et al., 1996; Mattern and Schneider, 2000; Wang, 2004; Xiao et al., 2005), very little have been done west of this transect, i.e. where the Aghil Range is located (e.g. Gaetani et al., 1991). According to most of the large scale geological reconstructions (Gaetani et al., 1990, 1993; Zanchi, 1993), the Aghil Range is located at the north-western termination of the Qiangtang terrane and shows strong sedimentary affinities with SE Pamir (Gaetani, 1997). The NE–SW geological transect examined in this paper, from the Yarkand valley to the north to the Shaksgam valley through the Surukwat valley and the Aghil Pass to the south, goes through different geologic units, separated by syn- to late-metamorphic thrusts and post-metamorphic faults of similar attitude. From north to south these units are: Bazar Dara Slates, Surukwat Complex, Aghil Dara Granodiorite and Shaksgam Sedimentary Belt (Gaetani et al., 1990 and Fig. 1).

The Bazar Dara Slates are best exposed along the Yarkand valley as an unmetamorphosed to very low-grade metasedimentary sequence of sandstones, siltstones and slates, steeply dipping towards SSE, locally intruded by undeformed granitic bodies and dykes. Located south of a major subvertical fault striking WSW–ENE, the Surukwat Complex is a composite sequence of thrust sheets and strongly squeezed eradicated anticlines trending WNW–ESE and steeply dipping SSW. In this unit, apart from few non-metamorphic slivers, a general increase of metamorphic grade is evident southward from lower to higher structural levels (Rolfo

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