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Discussion

Comment on “Characteristics and dynamic origin of the large-scale Jiaoluotage ductile compressional zone in the eastern Tianshan Mountains, China” by X.W. Xu, T.L. Ma, L.Q. Sun and X.P. Cai [Journal of Structural Geology 25 (2003) 1901–1916]☆

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1. Introduction

In a recent paper, Xu et al. (2003) presented their study on the Jiaoluotage ductile compressional zone (JDCZ) in the eastern Tianshan Mountains, China. Xu et al. (2003) proposed a model of the geodynamic evolution of the JDCZ and stated that during the Carboniferous, the Tarim paleo-ocean plate was subducted beneath the Jungar plate, resulting in the separation of the middle Tianshan terrane from the Jungar plate and the formation of the middle Tianshan arc and Jiaoluotage back-arc basin. Although we do not dispute their main conclusions related to the ductile deformation, we disagree with Xu et al.'s model of the geodynamic evolution of the JDCZ. In this paper, we will discuss the following issues:

(1) Was the central Tianshan (named the middle Tianshan by Xu et al. (2003)) separated from the Jungar plate?
(2) When and how did the central Tianshan arc form?
(3) Was Jiaoluotage a back-arc basin during the Carboniferous?
(4) The model of the geodynamic evolution of the JDCZ.

2. Was the central Tianshan separated from the Jungar plate?

Up to now, no Precambrian rocks have been observed in or around the Jungar basin (Allen et al., 1993b; Charvet et al., 2002; Li et al., 2000). Only the Paleozoic volcanics, volcaniclastics and granitoids crop out in the northern margin of the Tianshan and the eastern Jungar (Feng et al., 1989; Carroll et al., 1990; Laurent et al., 2003). In contrast, the Precambrian basement rocks and Sinian tillites occur widely in the central Tianshan and the northern margins of the Tarim. In the eastern segment of the central Tianshan, Precambrian orthogneisses, migmatites, schists, amphibolites, schists and marbles are exposed in northern Kumux–Maanqiao, Tucileike, Weiya and Xingxingxia areas (BGMRX, 1993; Fig. 1). In the western segment, Precambrian amphibolite facies metamorphic rocks, carbonates, clastic rocks and minor tillites crop out predominantly in Wenquan, Nalati, Baluntai, Borohoroshan and Haxiliagendaban–Bingdaban regions (Gao et al., 1998). On the northern margins of Tarim, the Sinian (Vendian or latest Proterozoic) neritic–littoral clastic rocks, carbonates and tillites were also observed (Ma et al., 1993), which lie disconformably on the Precambrian basement (called the Aksu Group) in the Kelpin region (Nakajima et al., 1990). From the Cambrian to Early Ordovician, passive continental margin sediments were deposited along both the northern margin of the Tarim block and the central Tianshan belt, which were characterized by carbonate rocks, cherts and terrigenous coarse clastic rocks. There are no Carboniferous volcanic rocks in the eastern segment of the central Tianshan. These facts demonstrate that the Tarim block and the central Tianshan might have been consolidated before the Ordovician. So far, there is no evidence to support the conclusions by Xu et al. (2003). We suggest that a southward-dipping oceanic subduction took place from

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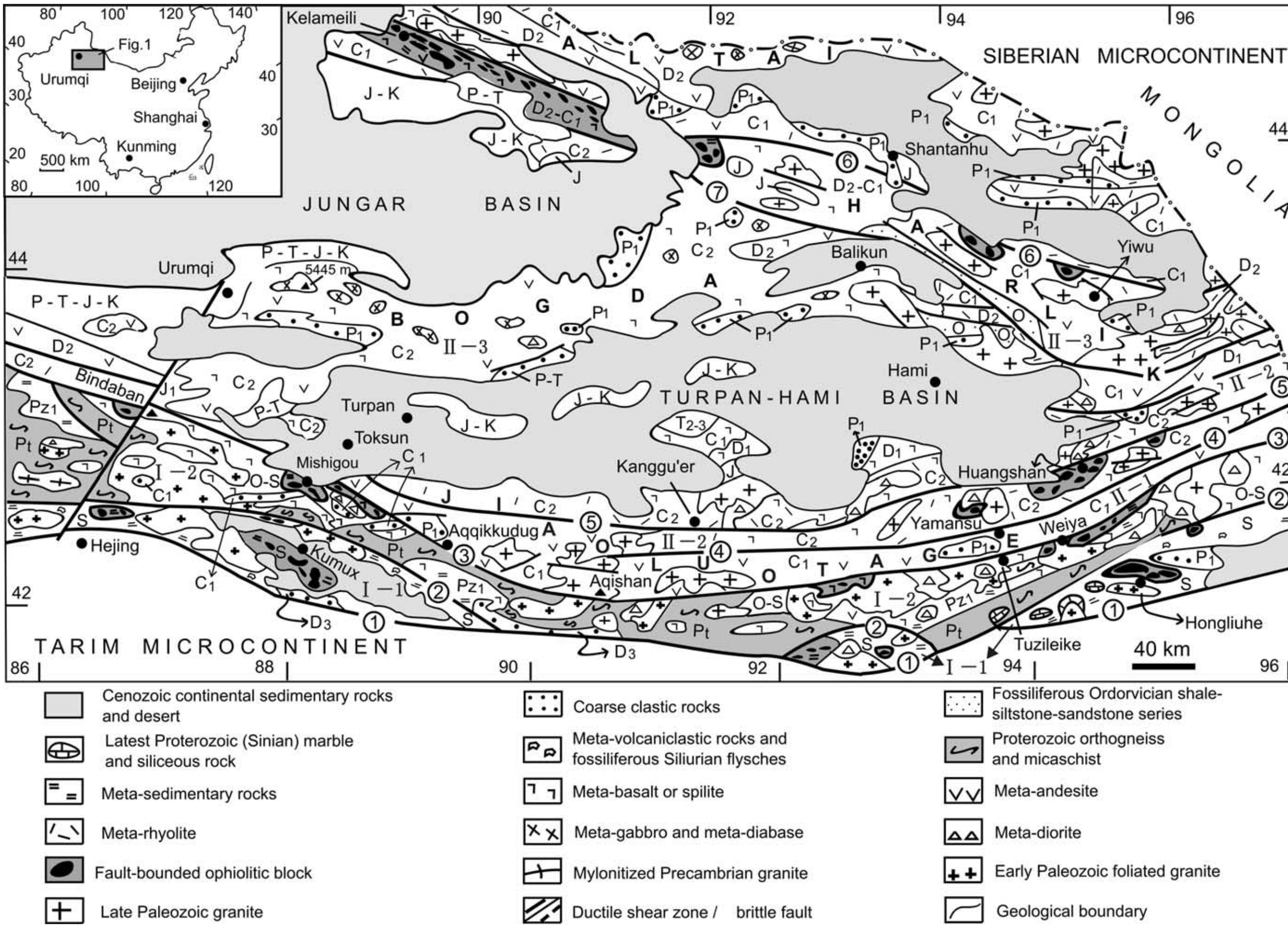

Fig. 1. Simplified geological map of the east Tianshan range (modified from Shu et al. (2002)). ① northern marginal fault of Tarim; ② southern marginal fault in central Tianshan; ③ Aqqikkudug–Weiya suture zone; ④ Aqishan–Yamansu fault; ⑤ Kangguer–Huangshan fault; ⑥ Karamaili–Yiwu suture zone; I–1 Kumux–Hongliuhe suture zone; I–2 central Tianshan Early Paleozoic volcanic arc with the Precambrian basement; II–1 Aqishan–Yamansu Devonian–Carboniferous volcanic arc; II–2 Kangguer–Huanshan Carboniferous inter-arc basin; II–3 Bogda–Harlik Devonian–Carboniferous volcanic arc.

the Middle Ordovician to the Middle Siliurian along the Aqqikkudug–Weiya zone (named North Tianshan Suture Zone by Laurent et al. (2003)), forming the central Tianshan arc and the southern Tianshan back-arc basin that led to the separation of the central Tianshan from the Tarim block (Ma et al., 1993; Zhu et al., 1993; Gao et al., 1998; Charvet et al., 2002).

3. When and how did the central Tianshan arc form?

The Middle Ordovician basalt, andesite, dacite, rhyolite, greywacke and Silurian flysch crop out in the central Tianshan. The Ordovician–Silurian meta-volcanic sedimentary rocks are in contact with the Precambrian basement by ductile faults (Shu et al., 2002). The diorite in Tucileike (Fig. 1) gives a Rb–Sr whole-rock age of 460 ± 11 Ma (Yang, 1988) and the andesite in southern Aqishan yields a Rb–Sr isochron age of 477 Ma (Lu, unpublished data, in: Ma et al., 1993). Early Carboniferous red molasses, sandstone, mudstone, marlite and limestone are unconformably overlaid on the Ordovician meta-volcanic rocks or Silurian flysch layer (Charvet et al., 2001; Shu et al., 2002). No Carboniferous volcanic rocks occur in the eastern segment of the central Tianshan, unlike Xu et al.'s depiction (Xu et al. (2003) and their Fig. 18). Xu et al. (2003) proposed that a northward-dipping oceanic subduction along the southern margin of the central Tianshan created the late Paleozoic central Tianshan arc during the Carboniferous. Kinematic and chronological research, however, suggests that a southward-dipping oceanic subduction took place along the Aqqikkudug–Weiya zone during the Ordovician and produced the early Paleozoic central Tianshan arc (Ma et al., 1993, Shu et al., 2000).

4. Was Jiaoluotage a back-arc basin during the Carboniferous?

We do not agree with Xu et al.'s (2003) proposal that the Jiaoluotage is a back-arc basin resulting from a northward-dipping subduction of the Tarim paleo-ocean plate during the Carboniferous. Xu et al. (2003) did not present the Paleozoic rock assemblages of Jiaoluotage. In fact, two Paleozoic tectonic units were recognized in Jiaoluotage. (1) Aqishan–Yamansu unit: the Devonian–Late Carboniferous island-arc type volcanic and volcaniclastic rocks are predominantly exposed in the Aqishan–Yamansu and Dananhu areas. They are mainly andesite, dacite, dacitic rhyolite, rhyolite, rhyodacite, andesitic breccia and andestic tuff, and have been dated by whole-rock Rb–Sr isochron at 290±5 Ma for andesite and 300±13 Ma for rhyolite (Li et al., 1998) and by whole-rock Sm–Nd isochron at 416±120 Ma for basalt (Rui et al., 2002). The chemical composition and the REE distribution patterns of the volcanic rocks show that they are calc–alkaline (Ma et al., 1993). (2) Kangguer–Huangshan unit: this unit lies between the Aqishan–Yamansu and the Bogda–Harlik Devonian–Carboniferous volcanic arcs. This Middle Carboniferous inter-arc basin is evidenced by the following geological facts: (a) the Early Carboniferous sedimentary facies in the Kangguer–Huangshan unit exhibit an environmental evolution from shallow water (fluvial) to deep water (flysch) containing radiolarian cherts, which reveals the spreading and extension of the basin (Guo and Ma, 1990); (b) the Middle Carboniferous bimodal volcanic rocks exposed in the Kangguer unit indicate a rifting environment (Zhu et al., 1996); (c) a large Alaskan-type mafic–ultramafic complex was emplaced along the Kangguer fault (Ma et al., 1993; Zhu et al., 1996; Charvet et al., 2002), and was dated by Sm–Nd isochron at 308.9±10.7 Ma (Li et al., 1998). These geological data indicate that Kangguer–Huangshan unit

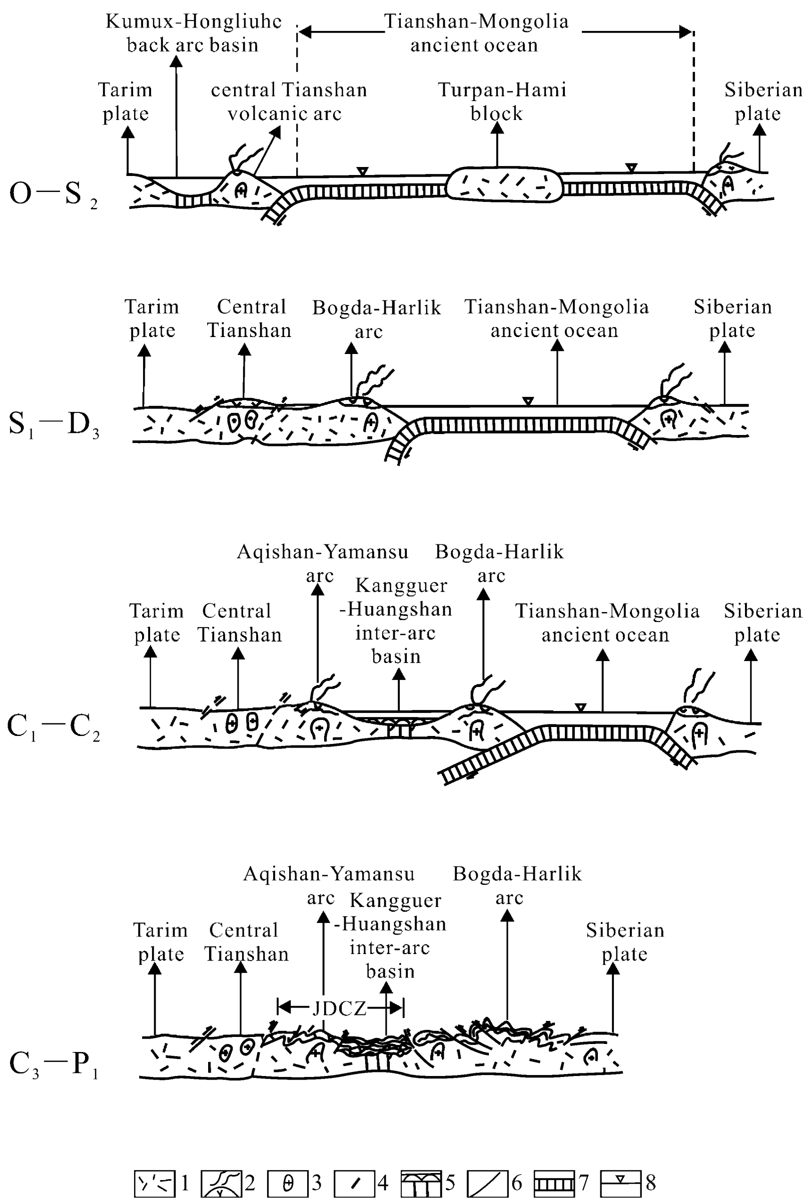

Fig. 2. Model of Paleozoic tectonic evolution of east Tianshan: (1) continental crust; (2) island arc; (3) granites; (4) ophiolite; (5) mafic–ultramafic rocks; (6) fault; (7) oceanic crust; (8) sea surface.

represents an inter-arc basin between Aqishan–Yamansu and Bodga–Harlik island-arcs.

5. The model of the geodynamic evolution of the JDCZ

In the Precambrian, a huge continent, which included Tarim, Yili and Turpan–Hami blocks, already existed in central Asia (Carroll et al., 1990; Ma et al., 1993; Charvet et al., 2001, 2002; Shu et al., 2002, 2003). During the early Cambrian, the E–W-trending Tianshan–Mongolia ancient ocean formed as a result of the rifting between the Tarim and the Yili–Turpan–Hami microcontinents (Shu et al., 2002). Middle Ordovician, southward-dipping oceanic subduction along the Aqqikkudug–Weiya zone (Fig. 2) formed the Early Paleozoic island-arc-type volcanic rocks and granitoids in the central Tianshan (Charvet et al., 2001; Guo et al., 2002; Shu et al., 2002, 2003). As the Tianshan–Mongolia ancient ocean was subducted, the continental crust on the south of the central Tianshan began to extend, creating the Kumux–Hongliuhe marginal sea that separated the central Tianshan from the Tarim (Zhu et al., 1993; Gao et al., 1998; Charvet et al., 2001; Shu et al., 2002). Throughout the Middle Devonian–Middle Carboniferous, the new subduction zone occurred on the north side of the Turpan–Hami block. The Tianshan–Mongolia ocean subducted towards the south along the Karamaili–Yiwu zone, forming the Aqishan–Yamansu, Dananhu and Bogda–Harlik Devonian–Carboniferous volcanic arcs, and then the Kangguer–Huangshan Middle Carboniferous inter-arc basin in the Jiaoluotage region (Figs. 1 and 2). These three tectonic units were named the North Tianshan arc by Windley et al. (1990) and Allen et al. (1993a). During the late Late Paleozoic, collision took place between the northern Tianshan and the southern Siberian active continental margins, resulting in the accretion of the North Tianshan arc towards the central Tianshan and the closure of the Kangguer–Huangshan inter-arc basin, which formed the JDCZ (Fig. 2).

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References

Allen, M.B., Windley, B.F., Zhang, C., 1993a. Paleozoic collisional tectonics and magmatism of the Chinese Tienshan, central Asia. Tectonophysics 220, 89–115.

Allen, M.B., Windley, B.F., Zhang, C., Guo, J.H., 1993b. Evolution of the Turpan basin, Chinese central Asia. Tectonics 12, 889–896.

BGMRX (Bureau of Geology and Mineral Resources of Xinjiang Uygur Autonomous Region), 1993. Regional Geology of Xinjiang Uygur Autonomous Region, People's Republic of China, Ministry of Geology and Mineral Resources. Geological Memoirs, Series 1, No. 32, Geological Publishing House, Beijing, pp. 6–206 (in Chinese).

Carroll, A.R., Liang, Y., Graham, S.A., Xiao, X., Hendrix, M.S., Chu, J., McKnight, C.L., 1990. Junggar Basin, northwest China: trapped Late Paleozoic ocean. Tectonophysics 181, 1–14.

Charvet, J., Laurent, C.S., Shu, L.S., Ma, R.S., 2001. New structural and geochronological data on Paleozoic continental accretion around Junggar block. In: International Symposium and Field Workshop on the Assembly and Breakup of Rodinia and Gondwana, and Growth of Asia, Osaka (Japan). Extended abstract.

Charvet, J., Laurent, C.S., Shu, L.S., 2002. New Insights on the Paleozoic Deformation in Xinjiang, NW China Program and Abstracts PPO-Asia. Hokkaido University, Sapporo, Japan.

Feng, Y., Coleman, R.G., Tilton, G., Xiao, X., 1989. Tectonic evolution of the West Junggar Region, Xinjiang, China. Tectonics 8, 729–752.

Gao, J., Li, M.S., Xiao, X.C., Tang, Y.Q., He, G.Q., 1998. Paleozoic tectonic evolution of the Tianshan orogen, northwestern China. Tectonophysics 287, 213–231.

Guo, J., Shu, L.S., Charvet, J., Laurent, C.S., Sun, S.W., 2002. Geochemical features of the two Early Paleozoic ophiolitic zones and volcanic rocks in the central-southern Tianshan region, Xinjiang. Chinese Journal of Geochemistry 21, 308–321.

Guo, Z.J., Ma, R.S., 1990. A study on the Late Paleozoic Kangguer inter-arc basin in eastern Tianshan. Journal of Nanjing University (Earth Sciences) 3, 103–113 (in Chinese with English abstract).

Laurent, C.S., Charvet, J., Monie, P., Shu, L.S., 2003. Late Paleozoic strike-slip shear zones in eastern central Asia (NW China): new structural and geochronological data. Tectonics 22 (2), 1009–1032.

Li, H.Q., Xie, C.F., Chang, H.L., Cai, H., Zhu, J.P., Zhou, S., 1998. Study on Metallogenetic Chronology of Nonferrous and Precious Metallic Ore Deposits in North Xinjiang, China. Geological Publishing House, Beijing, pp. 63–210 (in Chinese with English abstract).

Li, J.Y., Xiao, X.C., Chen, W., 2000. Late Ordovician continental basement of the eastern Junggar basin in Xinjiang, NW China: evidence from the Laojunmiao metamorphic complex on the northeast basin margin. Regional Geology of China 19 (3), 297–302 (in Chinese with English abstract).

Ma, R.S., Wang, C.Y., Ye, S.F., 1993. Tectonic Framework and Crustal Evolution of Eastern Tianshan Mountains. Publishing House of Nanjing University, Nanjing, pp. 1–225 (in Chinese).

Nakajima, T., Maruyama, S., Uchiumi, S., Liou, J.G., Wang, X., Xiao, X., Graham, S.A., 1990. Evidence for late Proterozoic subduction from 700 Myr old blueschists in China. Nature 346, 263–265.

Rui, Z.Y., Liu, Y.L., Wang, L.S., Wang, Y.T., 2002. The eastern Tianshan porphyry copper belt in Xinjiang and its tectonic framework. Acta Geologica Sinica 76, 83–94 (in Chinese with English abstract).

Shu, L.S., Chen, Y.T., Lu, H.F., Charvet, J., Laurent, C.S., Yin, D.H., 2000. Paleozoic accretionary Terranes in northern Tianshan, NW China. Chinese Journal of Geochemistry 19, 193–202.

Shu, L.S., Charvet, J., Lu, H.F., Laurent, C.S., 2002. Paleozoic accretion–collision events and kinematics of ductile deformation in the eastern part of the southern-central Tianshan belt, China. Acta Geologica Sinica 76, 308–323.

Shu, L.S., Wang, B., Yang, F., Lu, H.F., Charvet, J., Laurent, C.S., 2003. Polyphase tectonic events and Mesozoic–Cenozoic Basin-range coupling in the Chinese Tianshan belt. Acta Geologica Sinica 77 (4), 457–467.

Windley, B.F., Allen, M.B., Zhang, C., Zhao, Z.Y., Wang, G.R., 1990. Paleozoic accretion and Cenozoic redeformation of the Chinese Tien Shan Range, central Asia. Geology 18, 128–131.

Xu, X.W., Ma, T.L., Sun, L.Q., Cai, X.P., 2003. Characteristics and dynamic origin of the large-scale Jiaoluotage ductile compressional zone in the eastern Tianshan Mountains, China. Journal of Structural Geology 25, 1901–1915.

Yang, H., 1988. The origin, features, distribution, tectonic settings and metallization of grantes in the Eastern Tianshan. Ph.D. thesis, Nanjing University, China, pp. 1–198 (in Chinese).

Zhu, W.B., Wang, C.Y., Ma, R.S., 1993. The study of Kumishi metamorphic terrane in Xinjiang. Geotectonica et Metallogenia 17, 373–383 (in Chinese with English abstract).

Zhu, W.B., Ma, R.S., Wang, C.Y., 1996. Tectonic attribute of Huangshan–Jing'erquan complex in eastern Xinjiang, China. Scientia Geologica Sinica 31, 22–32 (in Chinese with English abstract).