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Notes

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Forum

Blueschist-bearing metamorphic core complexes in the Qiangtang block reveal deep crustal structure of northern Tibet: Comment and Reply

COMMENT

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Kapp et al. (2000) proposed that the metamorphic rocks in the middle Qiangtang are similar to the Franciscan melange, which was underplated to the Qiangtang block and was subsequently exhumed by detachment faulting, and that these processes occurred during Late Triassic–Early Jurassic southward subduction of oceanic lithosphere. However, these recognitions are not consistent with many facts. Three main questions are listed as follows.

1. The entirety of the metamorphic belt is not similar to melange. The metamorphic rocks include interbeds of marble, carbonaceous slate, and thin coal layers, and ripple marks are preserved in some marble beds. The strata in the metamorphic belt could be divided into sequences holding lateral continuity within a certain area (XZBGM, 1993; Ye et al., 2001). This characteristic stratigraphy is different from the melange described by Hsü (1968, 1974). Kapp et al. (2000) said that basic and ultrabasic blocks exist in the schist. This is not compatible with the facts. There are many basic rocks in the metamorphic belt, but they are dikes of diabase or gabbro, not exotic blocks. They do not show the characteristics, such as pinch and swell and boudinage structures, and orientation of elongate clasts (Closs, 1982). Additionally, some basic rocks are intercalated basalt or metamorphic basic rock (Ye et al., 2001). Ultrabasic rocks are mainly sporadic intrusions and some schlierens. According to Deng et al. (1996), these rocks do not contain Opx, olivine, and pyroxene, do not have deformational structures, possess high amounts of Al_2O_3, CaO, Fe_2O_3 and low amounts of MgO, and amounts of total rare earth elements are as high as 156.5–163.5 μg/g, and belong to the LHEE-enriched type. These features indicate that they did not come from the remains of partially melted upper mantle and were not relative to plate subduction. In addition, in the Qiangtang metamorphic belt exotic blocks of eclogite and high-greenschist, which mark deep-buried metamorphism, do not appear, and lawsonite and jadeite and other typical high-pressure minerals do not appear (Bao et al., 1999).

2. The Qiangtang metamorphic belt cropped earlier than Late Triassic–Early Jurassic, being a source area of the Qiangtang basin. For example, according to Li et al. (2001), in the Gouganjianian Shan, Permian and Upper Triassic strata, respectively, cover the metamorphic rocks and the lower-middle and bottom of these strata all contain conglomerate with rich metamorphic pebbles and some sedimentary ones. The limestone pebble in the Permian conglomerate has Carboniferous-Permian foraminifera, and is dated at 269 Ma by electronic spin resonance method. We sampled Upper Triassic on the southern and northern sides of the metamorphic belt at 16 locations, studied 38 sandstone thin-sections, and found 24 samples having metamorphic (slate, schist, and mylonite) fragments, with relative amounts up to 15–20%. In the contour map of the grain compositions of the sandstones, there appears a high-value belt compatible with the metamorphic belt (Ye et al., 2001). These facts exclude the possibility that the metamorphic belt was cropped until Late Triassic–Early Jurassic, which was thought by Kapp et al. (2000).

3. The age of 200 to 240 Ma gained by Kapp et al. (2000) only represents the time of a later tectonothermal event of the Qiangtang metamorphic belt; nevertheless, there existed an earlier tectonothermal event. According to Ye et al. (2001), in Luguxiang-Longdanshanggou area, five samples of metamorphic gabbro and diabase dikes were sampled and measured to be 314.0 ± 5.0 Ma by Sm-Nd method (Fig. 1A). At the same time, one the of diabase dikes was measured to be 311.8 ± 3.8 Ma by U-Pb method of zircon single grain (Fig. 1B); the two age data are consistent. In Guomori-Gouganjianian area, four samples of metamorphic diabase and basalt were measured to be 299 ± 13 Ma by Sm-Nd method (Fig. 1C); in Qilongwulugou of Shuanghu, five samples of metamorphic basic rocks measured to be 268 ± 5.6 Ma by Sm-Nd method (Fig. 1D). Similarly, there are some more age data. All of these age data indicate that the metamorphic and magmatic rocks in the Qiangtang metamorphic belt were formed and existed there as early as late Carboniferous–Early Permian. Kapp et al. (2000) overlooked the existence of this earlier tectonothermal event, and thus mistakenly explained the nature and timing of the metamorphic belt.

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REFERENCES CITED

Bao, P., Xiao, X., Wang, J., Li, C., and Hu, K., 1999, The blueschist belt in the Shuanghu region, central-northern Tibet and its tectonic implications: Acta Geological Sinica, v. 73 p. 302–314.

Closs, M., 1982, Flow melanges: Numerical modeling and geologic constraints on their origin in the Franciscan subduction complex, California: Geological Society of America Bulletin, v. 93, p. 330–345.

Deng, W.M., Yin, J., and Wo, C.P., 1996, Research on ultrabasic and volcanic rocks in the Chabu-Shuanghu region, Qiangtang: Science in China (Series D), v. 26, p. 296–301.

Hsü, K.J., 1968, Principles of melanges and their bearing on the Franciscan-Knoxville paradox: Geological Society of American Bulletin, v. 79, p. 1063–1074.

Hsü, K.J., 1974, Melanges and their distinction from olistostromes: Society of Economic Paleontologists and Mineralogists Special Publication 19, p. 321–333.

Kapp, P., Yin, A., Manning, C.E., Murphy, M., Harrison, T.M., Spurlin, M., Ding,

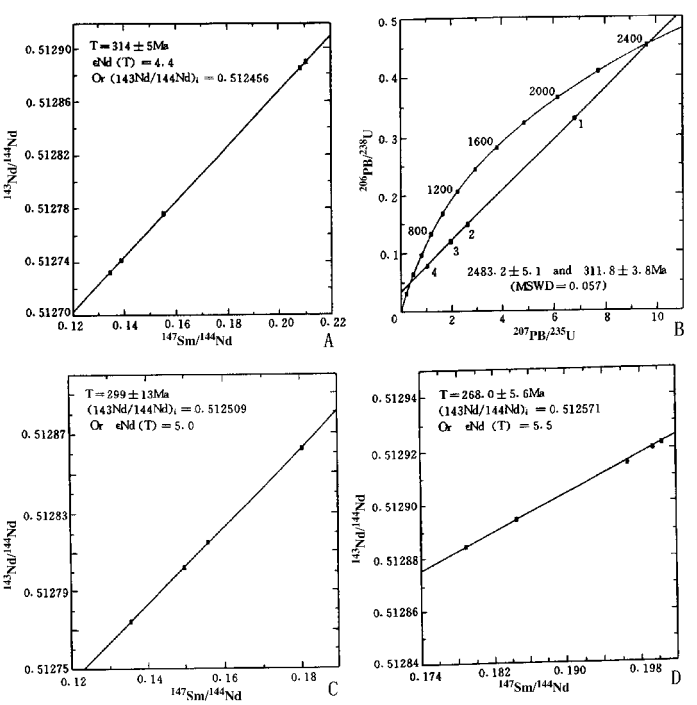

Figure 1. Isotopic age graphs of the metamorphic rocks in central Qiangtang (from Ye et al., 2001).

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L., Deng, X.G., and Wu, C.M., 2000, Blueschist-bearing metamorphic core complexes in the Qiangtang block reveal deep crustal structure of northern Tibet: Geology, v. 28, p. 19–22.
Li, Y.T., Luo, J.N., Lu, H.L., Xu, W.K., and Wu, R.Z., 2001, Stratigraphy of the Tibetan Plateau: Beijing, Science Press, in press (in Chinese with English abstract).
Ye, H.F., Xia, B.D., Liu, C.Y., Li, C., and Wang, Y.C., 2001, Tectonics and basin evolution of the Tibetan Plateau: Beijing, Science Press, in press (in Chinese with English abstract).
XZBGM (Xizang Bureau of Geology and Mineral Resources), 1993, Regional geology of Xizang autonomous region, China: Beijing, Geological Publishing House, 707 p. (in Chinese with English summary).

REPLY

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Xia et al. argue that the Qiangtang metamorphic belt does not include melange and was exhumed prior to early Mesozoic time, in contrast to the conclusions of Kapp et al. (2000a). While many of the data they cite may be valid, we show that the interpretations presented are either incorrect or highly questionable.

In their first point, Xia et al. argue that the blueschist-bearing melange of Kapp et al. (2000a) is neither melange nor exhibits ''typical high-pressure minerals.'' Figure 1 shows strongly foliated and lineated blueschists that encapsulate tectonic lenses of marble within the central Qiangtang metamorphic belt near Rongma village. These schists were mapped previously as lithostratigraphic units and assigned ages ranging from pre-Devonian to Triassic (Cheng and Xu, 1986; Liu, 1988; Deng et al., 1996). Qiangtang metamorphic rocks do include relatively undeformed sequences of strata, but they occur as large tectonic inclusions in melange (Kapp, 2001). A blueschist from the base of the exposure shown in Figure 1 contains the assemblage: garnet + glaucophane + chlorite + phengite + epidote + plagioclase + titanite + rutile + ilmenite + quartz. Multiequilibria calculations using mineral compositional data obtained from this sample yield intersections at 13.5 ± 1.5 kbar and 500 ± 50 °C, which lie within a narrow *P-T* (pressure-temperature) range constrained from garnet-phengite thermobarometry and the reaction albite = jadeite + quartz (Kapp et al., 2000b). Ongoing thermobarometric studies of Qiangtang amphibolites and blueschists from the Shuang Hu and Gangma Co areas also yield pressures in excess of 10 kbar.

The second point of Xia et al. is that the Qiangtang metamorphic belt must have been exhumed prior to early Mesozoic time because it is depositionally overlain by Permian and Upper Triassic strata that include metamorphic clasts. The interpretation of a depositional contact is dubious. Low-angle normal faults between Paleozoic-Mesozoic strata and metamorphic rocks in the Gangma Co and Shuang Hu areas (Kapp et al., 2000a; Fig. 2) were previously mapped as nonconformities (Cheng and Xu, 1986). Also, depositional contacts involving strata older than the latest stages of melange formation can be preserved within large tectonic inclusions in melange (i.e., Hsü, 1968). Finally, observations of metamorphic clasts within Upper Triassic strata strengthen the conclusion of Kapp et al. (2000a) that Qiangtang melange was being denuded during this time in the footwalls of normal faults.

Figure 1. Qiangtang blueschist-bearing melange. Photo taken 10 km northeast of Rongma village (33°06′N, 86°45′E). View is to northwest; relief is 600 m.

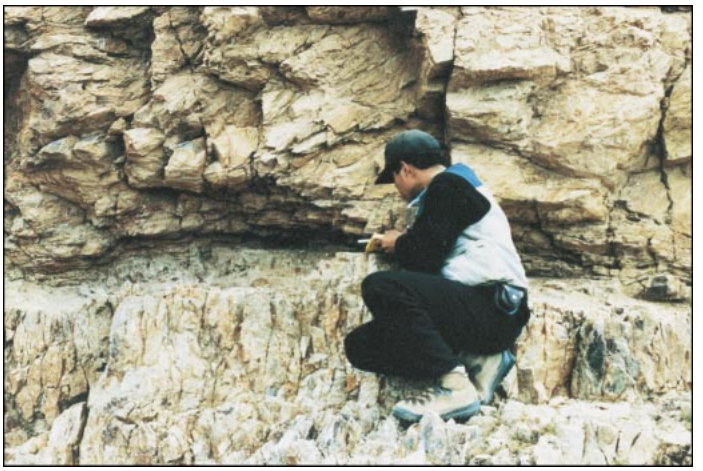

Figure 2. The Falong detachment in the Shuang Hu area juxtaposes metamorphic rocks in the footwall against Triassic strata in the hanging wall. Photo was taken 2 km north of locality 97-6-9-4b (see Fig. 2 of Kapp et al., 2000a). Here, the fault juxtaposes Triassic carbonate in the hanging wall against chloritic breccia in the footwall. Michael Murphy is measuring the orientation of the fault surface.

In their final point, Xia et al. present age data to suggest that Qiangtang mafic rocks formed as early as late Carboniferous–Early Permian. Primary crystallization ages of mafic rocks within melange must predate the age of melange formation. Thus, the presence of late Paleozoic mafic rocks within a melange that is interpreted to have formed during early Mesozoic time would not be surprising. In addition, the analyzed samples may not be metabasites in Qiangtang melange. Rather, they may be mafic sills and dikes that commonly intrude upper Carboniferous Qiangtang strata (Li and Zheng, 1993; Fig. 3 of Kapp et al., 2000a). These intrusions exhibit greenschist-facies mineral assemblages and were emplaced probably during late Carboniferous–Early Permian time as they do not cut Upper Permian strata.

We welcome future tests of the melange underplating hypothesis for the origin of Qiangtang metamorphic rocks. However, these tests should consider the main conclusions of Kapp et al. (2000a) that the Qiangtang metamorphic belt consists of blueschist-bearing melange that formed in a subduction zone and occurs in the footwalls of major Late Triassic–Early Jurassic low-angle normal faults.

REFERENCES CITED

Cheng, J., and Xu, G., 1986, Geologic map of the Gaize region with report: Tibetan Bureau of Geology and Mineral Resources, 369 p. (in Chinese).
Deng, W., Yin, J., and Guo, Z., 1996, Basic-ultrabasic and volcanic rocks in Chagbu-Shuanghu area of northern Xizang (Tibet), China: Science in China (Series D), v. 39, p. 359–368.
Hsü, K.J., 1968, Principles of melanges and their bearing on the Franciscan-Knoxville paradox: Geological Society of America Bulletin, v. 79, p. 1063–1074.
Kapp, P., 2001, Blueschist-bearing metamorphic core complexes in the Qiangtang block reveal deep crustal structure of northern Tibet: Reply: Geology, v. 29, p. 91.
Kapp, P., Yin, A., Manning, C.E., Murphy, M., Harrison, T.M., and Spurlin, M., Ding Lin, Deng Xi-Guang, and Wu Cun-Ming, 2000a, Blueschist-bearing metamorphic core complexes in the Qiangtang block reveal deep crustal structure of northern Tibet: Geology, v. 28, p. 19–22.
Kapp, P., Manning, C.E., Yin, A., and Harrison, T.M., 2000b, Barometry of epidote-bearing blueschists and amphibolites using titanite-rutile equilibrium: Eos (Transactions, American Geophysical Union), v. 81, p. F1380.
Li, C., and Zheng, A., 1993, Paleozoic stratigraphy in the Qiangtang region of Tibet: Relations of the Gondwana and Yangtze continents and ocean closure near the end of the Carboniferous: International Geology Review, v. 35, p. 797–804.
Liu, Z.Q.C., 1988, Geologic map of the Qinghai-Xizang Plateau and its neighboring regions: Beijing, Geological Publishing House, scale 1:1 500 000.