DISCUSSION AND REPLY

Age of Initiation of the India-Asia Collision in the East-Central Himalaya: A Discussion

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In their recent article, Zhu et al. (2005) provide new data on the stratigraphy and provenance of the Paleogene terrigenous strata in the Zhepure Shan Range of the Tethyan Himalayas, southern Tibet, using petrographic and geochemical whole-rock and single-grain techniques. Observed changes in the sandstone composition, according to the authors, indicate the onset of the India-Asia collision and the first development of the foreland basin immediately south of the India-Asia suture zone, which occurred at 50.6 ± 0.2 Ma. The authors present valuable new geochemical data for the Paleogene clastic rocks in southern Tibet, including their source areas and tectonic affinity, which they use to interpret the geotectonic history of the Tethyan Himalaya. The aim of the present discussion is to point out several erroneous claims and conclusions made by the authors that have a considerable effect on the interpretation of regional stratigraphy, lithofacies, the closing of the Tethys seaway, and the initiation of the India-Asia collision.

The authors reject most of the conclusions reached by Wang et al. (2002), which were derived from a study of the same stratigraphic sequence at the same location (Qumiba section; for details, see fig. 1). The location of the section, as given in Wang et al. (2002), was based on a Chinese military map, and the location given by Zhu et al. (2005), using a GPS locator, was not correct, but their section is the same one studied by Wang et al. (2002; see fig. 1). The main objective of the Wang et al. (2002) article was to present results of a reconnaissance study of newly found early Tertiary marine strata in southern Tibet and its implications, as the title of the article says, "for closure of Tethys seaway," not for the India-Asia plate collision, as incorrectly implied by Zhu et al. (2005, p. 280).

Lithostratigraphy

Wang et al. (2002) named the exposed ~180-m-thick Paleogene clastics the Pengqu Formation, which conformably overlies the several-hundred-meters-thick shallow-sea Nummulitic limestone of Paleocene through Early Eocene age (Willems and Zhang 1993; Willems et al. 1996). They subdivided the formation into the Enba and Zhaguo Members. The Enba Member is comprised of gray and yellowish green shale intercalated with thinly bedded fine sandstone and rare marls. The Zhaguo Member, overlying the Enba Member with an erosional disconformity, consists of similar lithologies but is reddish and violet in color, with coarser sandstones.

Zhu et al. (2005) described a soil horizon that they placed at the disconformity and used this occurrence as evidence to rename the Enba Member the Youxia Formation and the reddish Zhaguo Member the Shenkeza Formation. According to our field observation, the soil horizon is located within the upper part of the Enba Member, approximately 30 m below the erosional contact separating greenish gray and reddish-colored strata, and there are no pedogenic sediments on the surface at the erosional disconformity. The biostratigraphic data of Wang et al. (2002) suggest a brief hiatus at this erosional disconformity, which is mostly related to the erosional removal of the underlying strata rather

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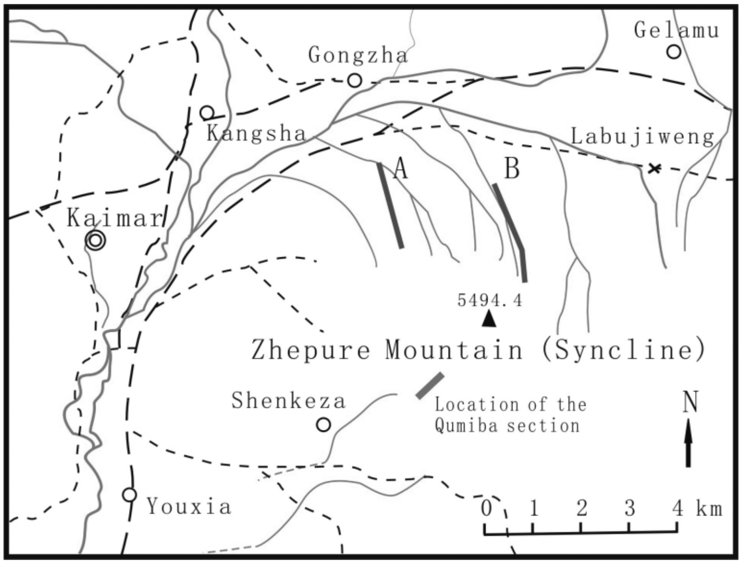

Figure 1. Sketch map showing the Qumiba section locality of the marine terrigenous Upper Eocene in Tingri, Tibet, and a location comparison of the different Gongzha sections referred to by (*A*) Hao and Wan (1985) and Wang et al. (2002) and (*B*) Willems and Zhang (1993) and Zhu et al. (2005). Whichever Gongzha section location is referred to by the different authors, the section and the location of the latest marine noncarbonate sediments are unique; that is, the Qumiba section of Wang et al. (2002) and the Shenkeza section of Zhu et al. (2005) are the same.

than to a nondeposition, as incorrectly postulated by Zhu et al. (2005).

The other reason Zhu et al. (2005) reject the Pengqu Formation is that the Pengqu River valley is about 10–15 km away, while the source of their proposed new name is about 1 km west of the Qumiba section (fig. 1). In fact, the Pengqu River is much more visible in the field and more easily found on maps than the Shenkeza monastery, Shenkeza, and Youxia. Moreover, when we refer to chapter 3.B.5 of the *International Stratigraphic Guide* (Salvador 1994), there are no distance criteria for the naming or revision of a lithostratigraphic unit. Therefore, distance cannot be used as evidence of the need for a new formation name and to reject the Wang et al. (2002) lithostratigraphic system. All we can do for the Enba and Zhaguo members of the Pengqu Formation, in our opinion, is possibly to change the rank of the stratigraphic members once there is enough evidence to make revisions, but the geographic parts of names should remain in any case.

Age

The nannofossil assemblages from the Zhaguo Member contain the youngest fossil assemblages found in southern Tibet, belonging to nannofossil zone NP 20, verified by leading specialists in the United States and Germany. The Wang et al. (2002) late Priabonian age of ~35–36 Ma is the latest date for marine sediments in the Tethys Himalayas yet given. However, Zhu et al. (2005) reject our findings of nannofossils for the reddish beds of the Zhaguo Member. Why? They suggested that the late Priabonian nannofossils found in the Zhaguo Member beds are all reworked from older strata and that the unit may be significantly younger than the Late Eocene–Early Oligocene age by their interpretation of the interval as nonmarine. First, it is necessary to note that we have differentiated the genera and species of the nannofossils and spores indicating the reworking of older Paleogene and Cretaceous strata from those in situ. Second, little evidence has been found for their nonmarine interpretation (see “Lithofacies”). Then, what is their evidence in the end? It seems that there is none. We are puzzled that despite the rejection of our age determination for the Zhaguo Member, it does not prevent Zhu et al. (2005) from applying this age to their Shenkeza Formation (see their fig. 10), even while indicating significant uncertainty for the age of this formation.

We concur with the authors that more detailed biostratigraphic studies are needed to more firmly establish the age of the youngest marine strata in southern Tibet. However, until such data become available, the stratigraphic framework as provided by Wang et al. (2002) has priority and should be retained.

Lithofacies

Similarly to Zhu et al. (2005), we have recognized from the sandstone petrographic study a change in the sediment source area, from a recycled orogenic province source for the sandstones of the Enba Member to a volcanic arc source for the Zhaguo Member (Wang et al. 2002), although much more detailed data are presented by Zhu et al. (2005). This change occurs at the erosional disconformity separating the greenish gray and overlying reddish-colored beds. On the basis of this change and their observation of the potential disconformity, Zhu et al. (2005) rejected a marine depositional setting; instead, they consider the reddish unit to represent a flood plain with fluvial channels.

Obviously, clastic composition changes cannot indicate that a nonmarine succession would follow when the sandstone texture and component maturities (clastic composition, sorting, roundness) are similar in both the gray and the reddish units. The disconformity between the Enba and Zhaguo members could be a sequence boundary in sequence stratigraphy. Above the boundary, a marine shelf margin systems tract, a terrestrial lowstand systems tract, or a marine transgressive systems tract can occur. On the other hand, a red color does not necessarily mean that sediments were deposited in a terrestrial environment. For example, modern prodeltaic deposits of the Colorado River are also reddish brown.

Therefore, it would be preferable to regard the reddish Zhaguo Member as having been deposited in a marine environment rather than a terrestrial environment until better nonmarine markers are discovered. What we would like to say is that the nonmarine deposition interpretation must be made cautiously when no evidence better than nannofossils is found.

Collision Implication

We also question the validity of the major conclusion by Zhu et al. (2005) concerning initiation of the India-Asia collision. The tectonic implication of our study is that the Nummulitic limestones comprising a carbonate ramp deposited on the shelf of the India continental margin during the Paleocene–Early Eocene (Willems et al. 1996) were buried by a terrigenous clastic wedge sourced from the volcanic arc situated on the Lhasa continental block to the north. Therefore, during the late Early and Middle Eocene, the foreland basin had to be nearly filled, as the sediments shed from the emerging volcanic arc to the north had to cross the "suture zone" to be deposited on the India margin continental shelf, located south of the suture. Such a setting requires an advanced stage of continental collision, with the foreland basin being very shallow and almost filled by the sediments and deposition occurring at the farther edge of the foreland basin (corresponding to the filled stage of a foreland basin, as classified by Sinclair 1997). Thus, a conclusion that the initiation of India-Asia continent collision occurred at 50.6 ± 0.2 Ma based on the change in sediment province in the Zhepure Shan region (Zhu et al. 2005) is questionable and may be wrong. On the other hand, the sedimentary strata in the Zhepure Shan region, Tingri, southern Tibet, provide conclusive evidence that the initiation of continental collision could have occurred much earlier than indicated by Zhu et al. (2005). These marine noncarbonate sediments are probably results of the closure of the remnant Tethys seaway (Wang et al. 2002).

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