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Age of Initiation of the India-Asia Collision in the eastern Himalaya

Bin Zhu, William S.F. Kidd, Earth & Atmospheric Sciences, University at Albany, Albany, NY 12222
David B. Rowley, Geophysical Sciences, Univ. of Chicago, Chicago, IL 60637
Brian S. Currie, Department of Geology, Miami University, Oxford, OH 45056

Introduction

Precise dating of the age of initiation of collision between India and Asia is an important factor in constraining the models of mass balance within the Himalayan system (Rowley, 1996, 1998). However, the start of collision is still quite poorly constrained, and has been placed in a range somewhere from >65 to ~37 Ma due to the different and generally indirect approaches that have been used to date it (Rowley, 1996, 1998, and references therein; Najman et al., 1997, 2001, 2002; de Sigoyer et al., 2000, 2001; Searle, 2001, Wan et al., 2002; Wang et al., 2002; Clift et al., 2002).

The sediment composition of a foreland basin can provide significant information on the tectonic evolution of the associated collision zone (Dickinson and Suczek, 1979; Ingersoll et al., 1984; Garzanti et al., 1996; Dickinson, 1985; Zuffa, 1980; Cingolani et al., 2003). Additionally, changes in sediment provenance and composition provide one of the least ambigous constraints on the age of the initiation of collision, especially at the high plate convergence rates of the India-Asia system in the early Tertiary.
We report here stratigraphic and provenance data which improve our understanding of the onset of Himalayan collision, from the Tertiary section near Tingri, southern Tibet.

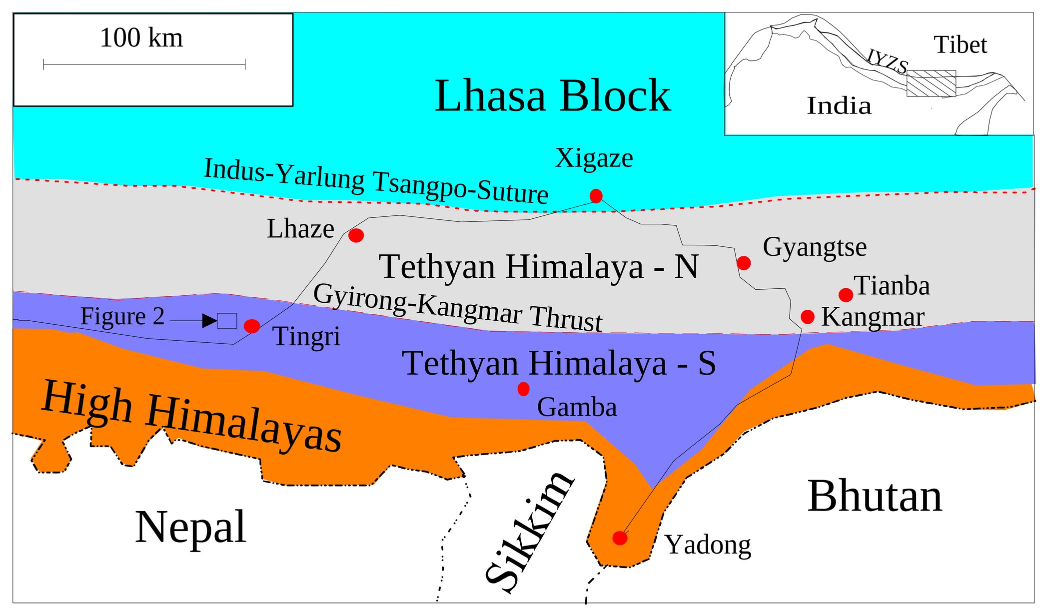

Figure 1. Sketch map of Tingri region, southern Tibet. The inset map shows this region located in the Himalayan system. Modified after Willems et al.(1996).

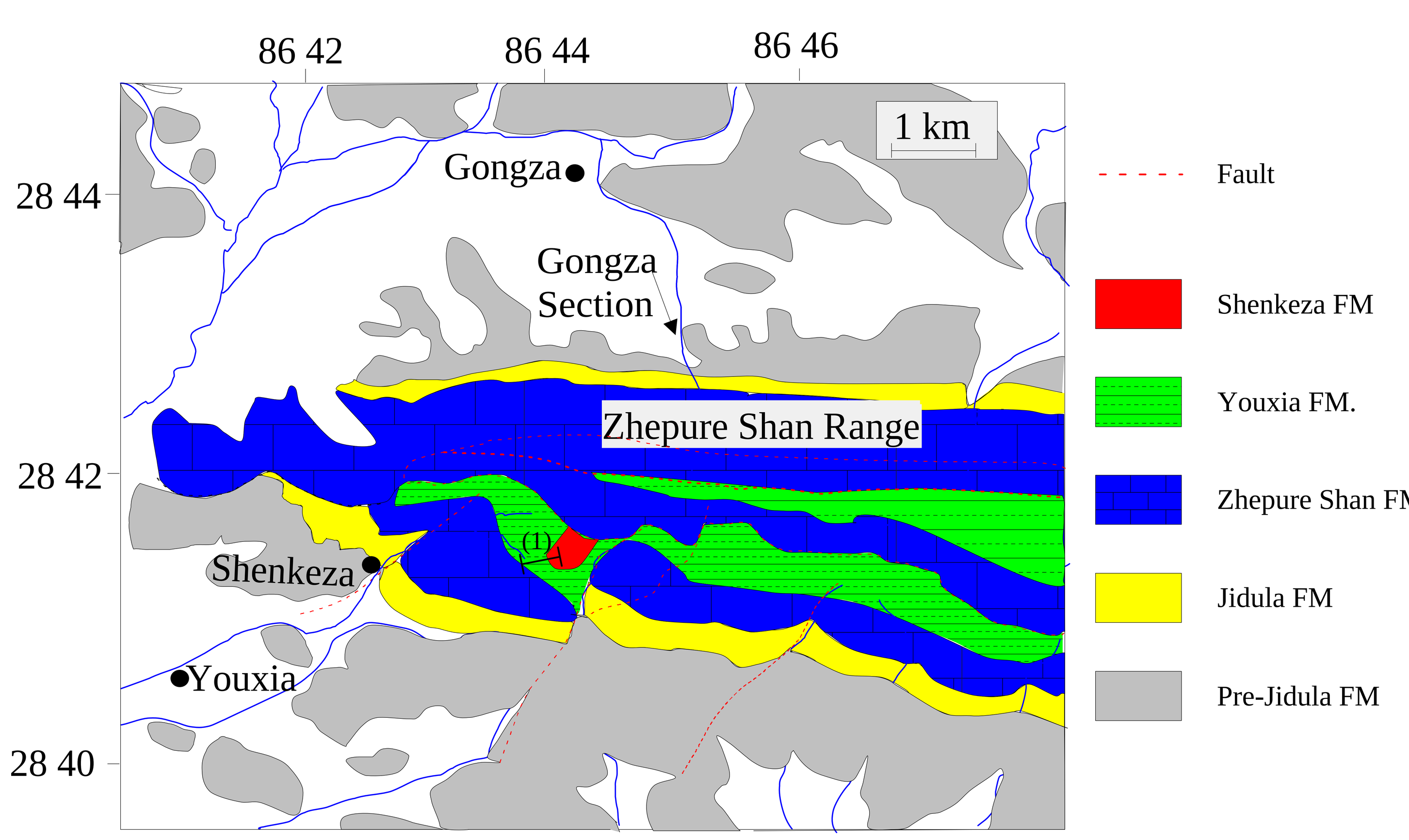

Figure 2. Simplified geologic map showing the location of the studied sections in the Tingri region on the western flank of Zhepure Shan Mountain. Note: (1) is measured section at Shekeza.

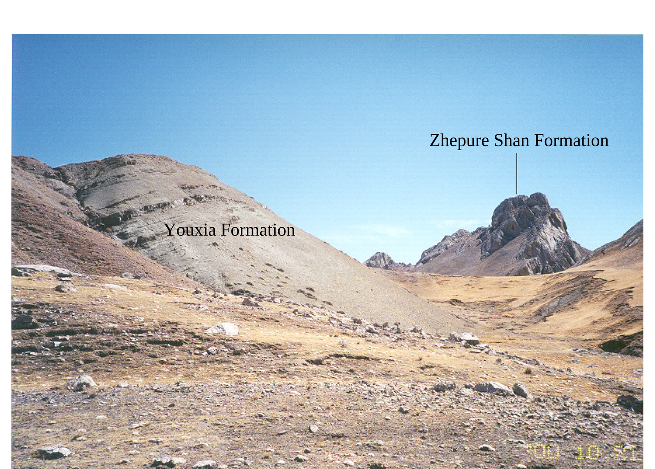

Figure 3. View to E of the upper part of the Youxia Formation in the head of the Shenkeza valley, made up of green shales and sandstones. The shales conformably overlie the Zhepure Shan limestones. The section of the upper Youxia Formation was measured up the gully on the left side of the photo.

1. Lithostratigraphy in the Tingri region

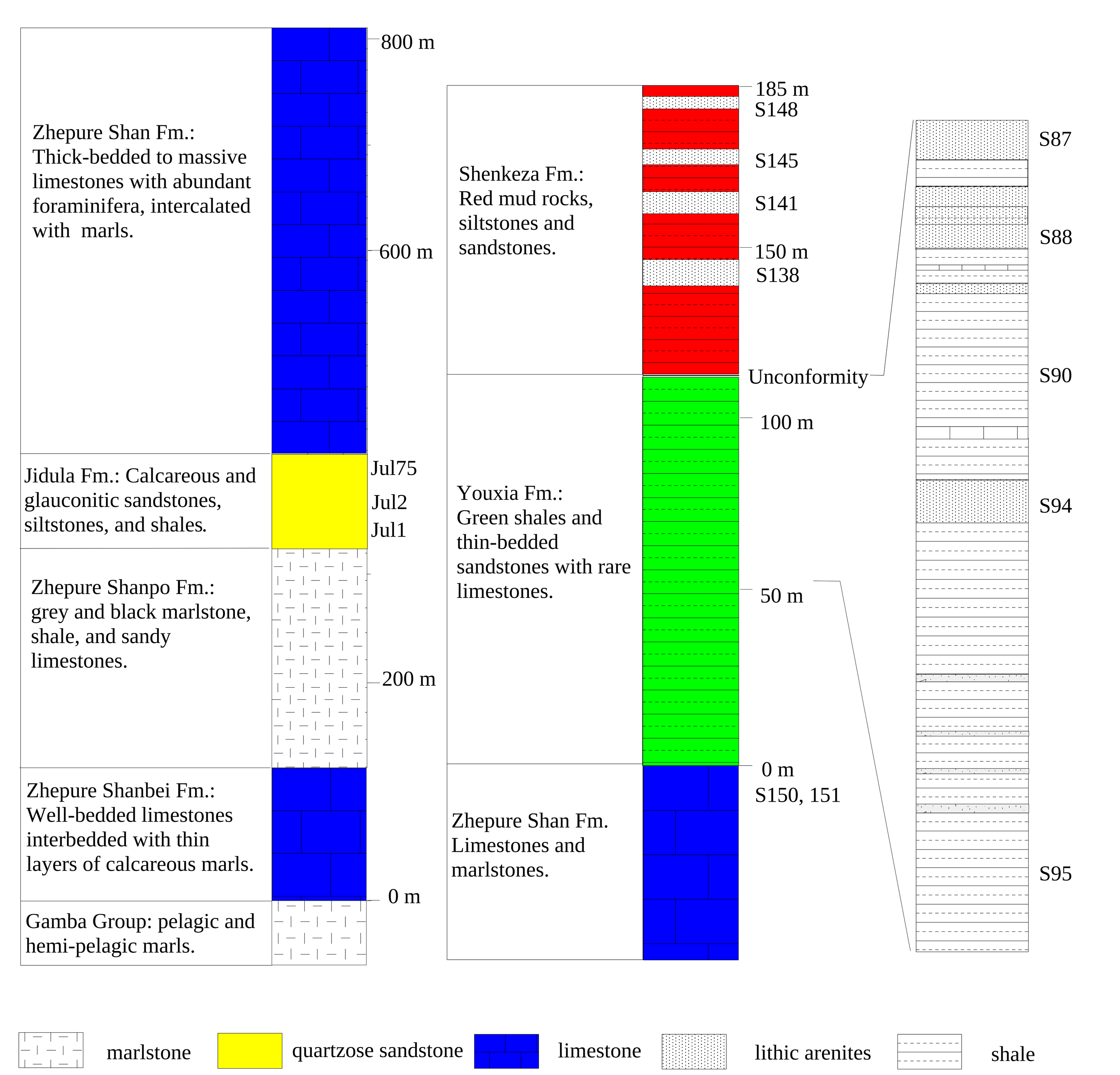

Figure 4. Stratigraphic columns of lower Tertiary sequence in the Tingri region. The Youxia and Shenkeza Fms. were measured by us in 2000 at Shenkeza; the Gongza section is from Willems et al. (1996). Section locations are shown in Figure 2. Sample locations are indicated by "Sxxx" at Shenkeza section and "Julxxx" at Gongza section.

2. Sedimentary Geochemistry

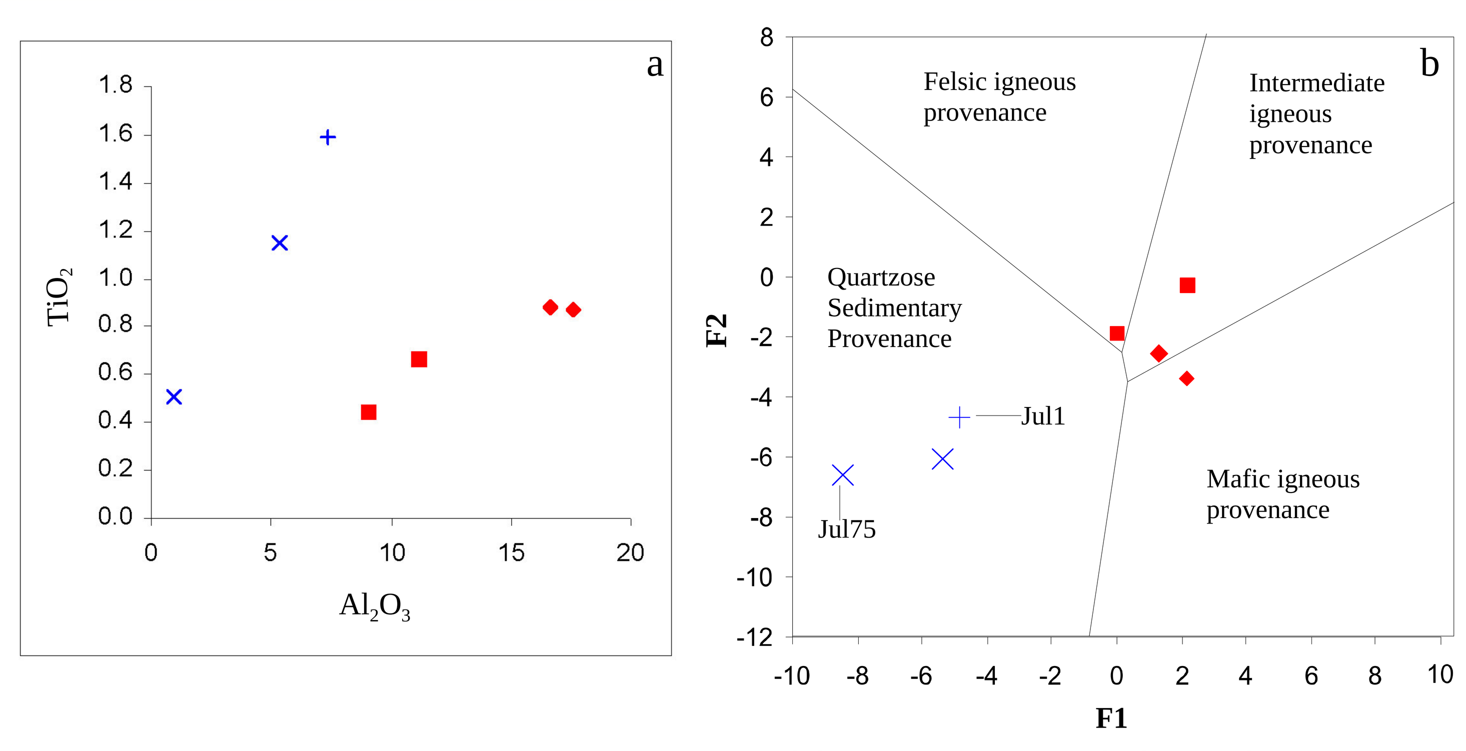

Figure 5. Geochemical plot of the lower Tertiary clastics in the Tingri region. a. Al_2O_3 vs. TiO_2 plot; b. Provenance discrimination diagram. Tectonic setting fields are from Roser and Korsch (1988) for Figure b. In Figure 5b, Jul1 and Jul75 are recalculated to 100% CaO and volatile-free basis because of significantly high CaO contents

3. Sedimentary petrology

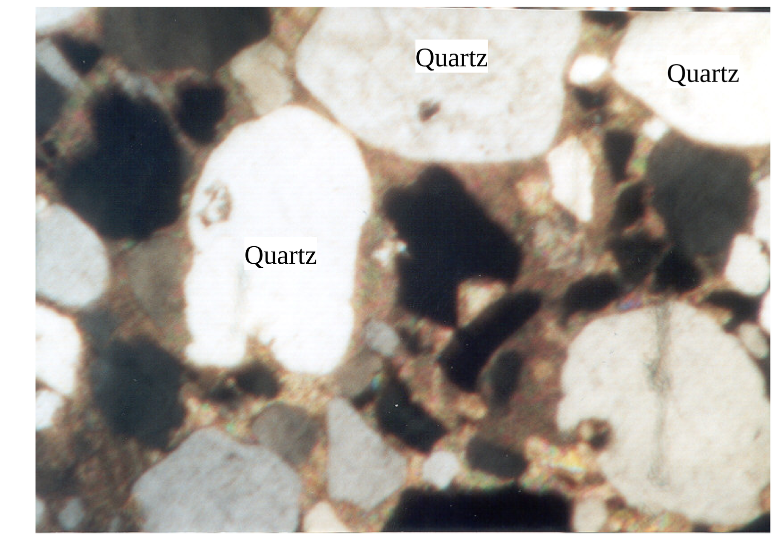

Figure 6. Photomicrograph (crossed polars) of well-rounded monocrystalline quartz gains with calcite cement in the Jul 75 sandstone of Jidula Formation, Gongza Formation. Opaque minerals are magnetite or ilmenite.

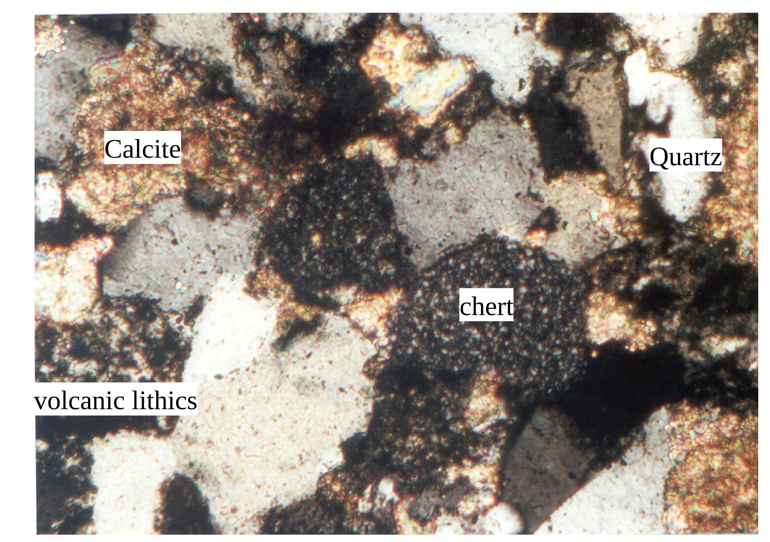

Figure 7. Photomicrograph (crossed polars) of volcanic and sedimentary rock fragments in the Shen87 sandstone of the Youxia Formation, Shenkeza section.

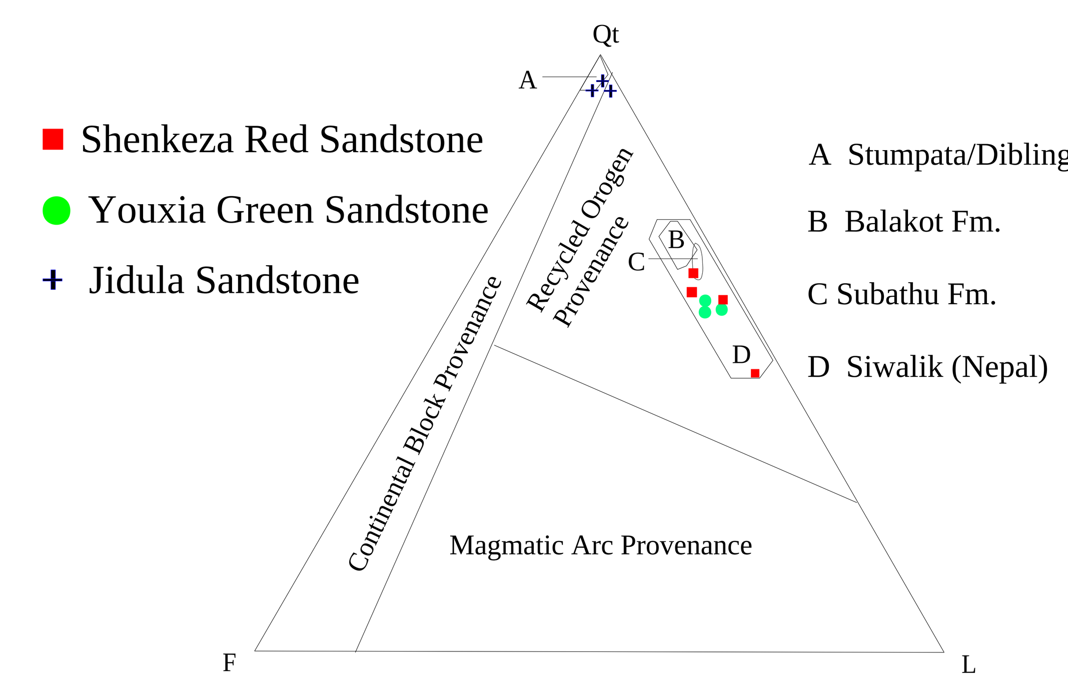

Figure 8. Detrital mode plot of lower Tertiary sandstones in the Tingri region Tectonic fields from Dickinson, 1985. Fields of other related Himalayan sandstones shown are from Garzanti et al. (1996)

4. Spinel characteristics of Youxia & Shenkeza Fm.

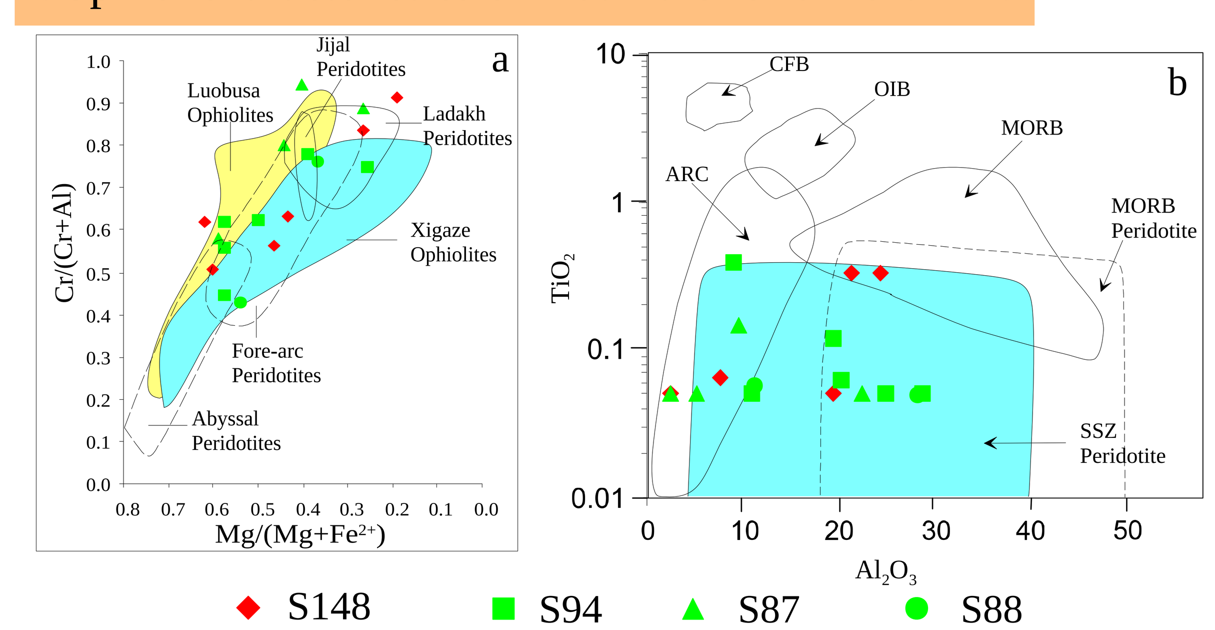

Figure 9. Geochemical plot of Cr-rich spinels from the Youxia and Shenkeza sandstones. a. Cr/(Cr+Al) vs. $Mg/(Mg+Fe^{2+})$ plot, b. TiO_2 vs. Al_2O_3 plot, fields displayed are from Kamenetsky et al. (2001): CFB-continental flood basalt, OIB-oceanic island basalt, MORB-mid-ocean ridge basalt, ARC-volcanic island arc, SSZ-suprasubduction zone. No spinel has been observed in the Jidula sandstones.

5. Regional correlatives of lower Tertiary deposits

Comparisons with sedimentary sequences from the Himalayan foreland basin show that sandstones from the middle Eocene Upper Subathu Formation (Najman and Garzanti, 2000) and the middle Eocene-Miocene Murree Formation in northern Pakistan (Bossart and Ottiger, 1989; Critelli and Garzanti, 1994; Garzanti et al., 1996) are similar to the Youxia and Shenkeza sandstones (Figure 10.). Detrital modes show that those sandstones were derived from the recycled orogen setting (Figure 8.), characterized by significant amounts of immature framework grains (plagioclase, felsitic to microlitic volcanic rock fragments, serpentine schist lithics), and common spinels. The close similarity in the compositions of Cr-rich spinels (Figure 9.) also suggests that there was a common source for the lithic-rich sandstones. This is different from the underlying Paleocene quartzose arenites intercalated within mainly shelf carbonates deposited on the passive margin of the Indian continent, including the Stumpata and Dibling Fms. (Garzanti et al., 1987) in Zanskar, the Patala Fm. in Hazara-Kashmir (Bossart and Ottiger, 1989), and the Jidula Fm. in southern Tibet.

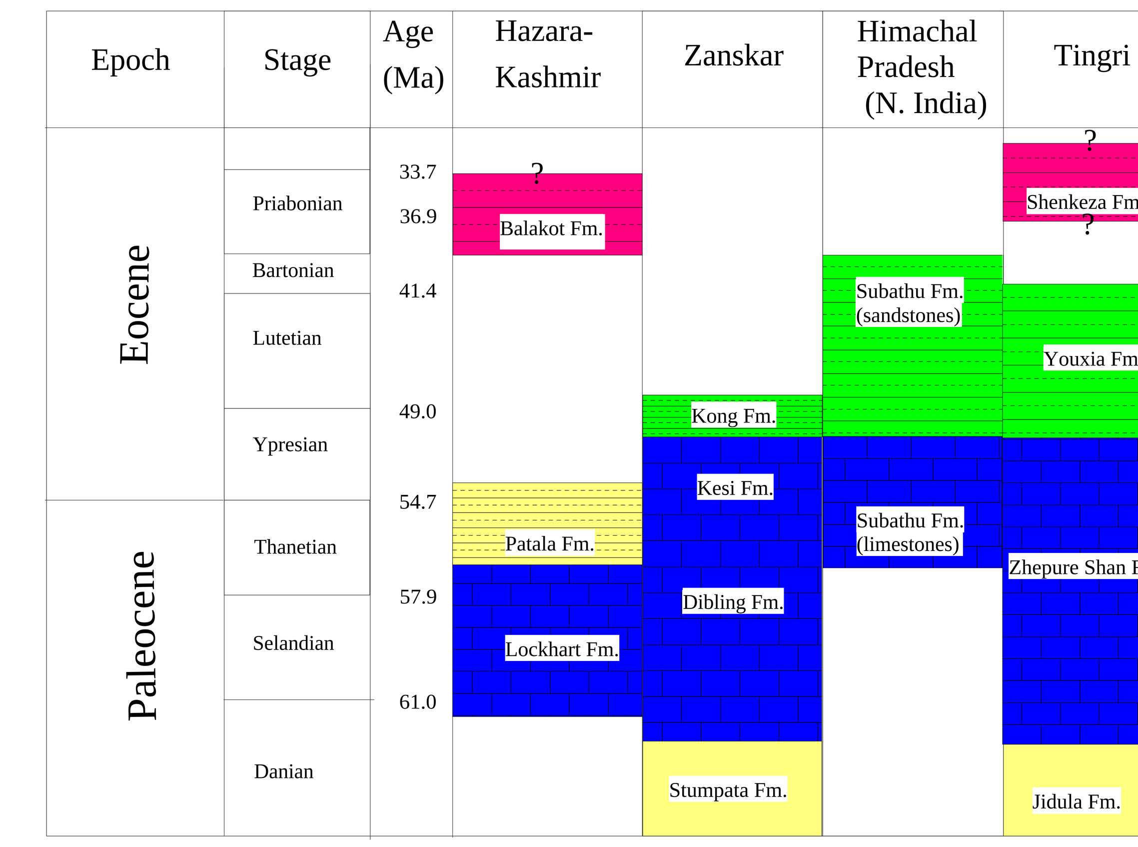

Figure 10. Comparison of stratigraphic columns of the Himalayan foreland basin, from Hazara-Kashmir (Bossart and Ottiger, 1989, which is modified by Najman et al. (2002)), through Zanskar (Garzanti et al., 1987, 1996), Himachal Pradesh (Najman and Garzanti, 2000), to Tingri, southern Tibet (this study). Timescale after Berggren et al. (1995).
Yellow-mature clastics of Indian passive margin; blue-carbonates of the Indian passive margin; green-marine orogenic clastics; red-non-marine redbeds.

6. Age of the start of the Indian-Asian continental collision

Collisions between an arc and a passive margin are associated with marked changes in patterns of subsidence and sedimentation. Therefore the sharp change of the sedimentary compositions between the times of deposition of the Jidula and Youxia Formations in the Tingri section provides a time constraint on the start of the India-Asia collision in the eastern Himalaya. The 1500-m-thick, well-exposed marine stratigraphy of the Zhepure Shan shows evidence for continuous passive margin sedimentation along the north flank of the Indian continent from late Albian to early Lutetian time (Willems et al., 1996). This suggests that collision did not occur until the early Lutetian in southern Tibet, consistent with the slow subsidence inferred from the Zhepure Shan Formation deposition (Rowley, 1998). The conformable contact between the Youxia and Zhepure Shan Formations marks the transition from a passive margin carbonate platform to a collisional foredeep, exhibiting a compositional change similar to that observed in Zanskar (Garzanti et al., 1987). The abundant planktonic foraminifera we find in the shales of the Youxia Formation point to a late Ypresian age (P8) of deposition which suggests that the final closure of the Neo-Tethys and the onset of continental collision occurred at ~50.6 Ma in the Tingri region of southern Tibet. This is exactly the same age reported by Garzanti et al (1996) from Zanskar, and implies the collision began synchronously along much of the Himalaya.

Acknowledgements

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