Shortening in the southern Lhasa block during India-Asia collision

Y. Pan and W.S.F. Kidd
Dept of Earth and Atmospheric Sciences, University at Albany, Albany NY 12222, USA.

Recently, it has been suggested that shortening deformation in the Lhasa block during the India Asia collision, starting ~45Ma ago, has been minimal (Murphy et al, 1997). Our mapping in the area between Lhasa and Yangbajian in the southern Lhasa block shows that here, to the contrary, there is significant shortening of the Paleocene-Eocene Linzizong volcanics. Horizontal shortening due to folding and south-directed thrusts in these volcanics amounts to 20+/-5%, from a detailed 35km-long section along the Doilung Qu valley through the well-known locality at Maqu, where the unconformity that these volcanics cover is spectacularly exposed, above significantly more strongly folded strata of the late Cretaceous Takena Formation. It is important to emphasise that the Linzizong volcanics are well-folded and are locally vertical in the section; it is simply not true that they are all [nearly] flat-lying as seen at the Maqu unconformity locality. In some reports, it has been suggested that the underlying Takena Formation contains volcanics; we are of the opinion based on our detailed observations that this is also not the case, and that Linzizong volcanics have been included in the Takena solely because they are significantly dipping.

Age constraints on the time of shortening come from the youngest dated volcanics, about 50Ma [Pan, 1993, Coulon et al, 1986], and the time of opening of the Yangbajian graben and related normal faults that truncate the folds in the Linzizong volcanics, suggested to be about 11Ma [Harrison et al, 1995]. Medial Miocene volcanics near Majiang, dated as 14-15Ma [Pan, 1993, Coulon et al, 1986], are also tilted, but the amount and extent of significant shortening in these rocks is not yet clearly defined. It is perhaps possible that a significant part of the shortening in the southern Lhasa block occurred between 15-11Ma ago; other evidence, of significant and rapid Early Miocene unroofing of the southern Lhasa block associated with the Gangdese Thrust [Copeland et al, 1995; Yin et al, 1994; Pan et al, 1993; Copeland et al, 1987] suggests that the shortening may have been, at least in part, early Miocene [27-~15Ma], but not older than this.

As first suggested by England and Searle (1986), limited collisional shortening in the southern Lhasa block, within the area of the andean-type Gangdese batholith and related Linzizong volcanics, is consistent with the idea that this would have been the location of already thickened crust from subduction-related processes. However, the dating of exhumation of the southern Lhasa block (Copeland et al, 1987; 1995) shows that the simple model of thickening spreading north from the Indus-Zangbo suture cannot be correct since collision must have begun here by 40Ma, yet significant exhumation did not begin until about 25Ma ago.

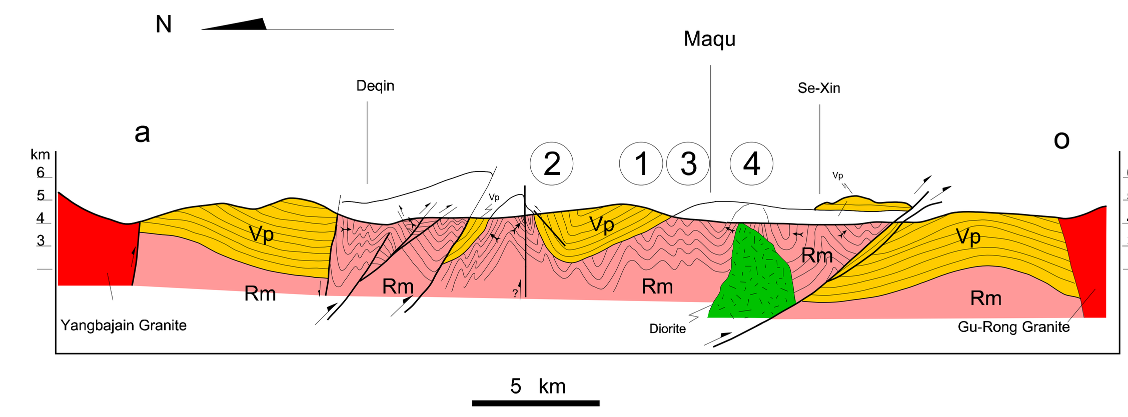
What is still unresolved in most places is how much shortening of India-Asia collisional age occurs in upper crustal strata north of this well-dated section near Lhasa. The occurrence of the 40-50% shortening in the 100km long section through the Eocene strata of the Fenghuoshan in northern Tibet [Chang et al, 1986; Coward et al, 1988], perhaps suggests that the minimal shortening reported by Murphy et al [1997] may be an anomaly, rather than representative of the Tibetan Plateau.

1 .View of Linzizong volcanics over unconformity on redbeds of Takena Fm; west bank of Doilung Chu, north of Maqu village.

2 Steeply dipping basal Linzizong volcanics east of Dou-bu village

3 View looking NE across the Doilung Chu valley of north-dipping volcanics over folded Takena Fm.

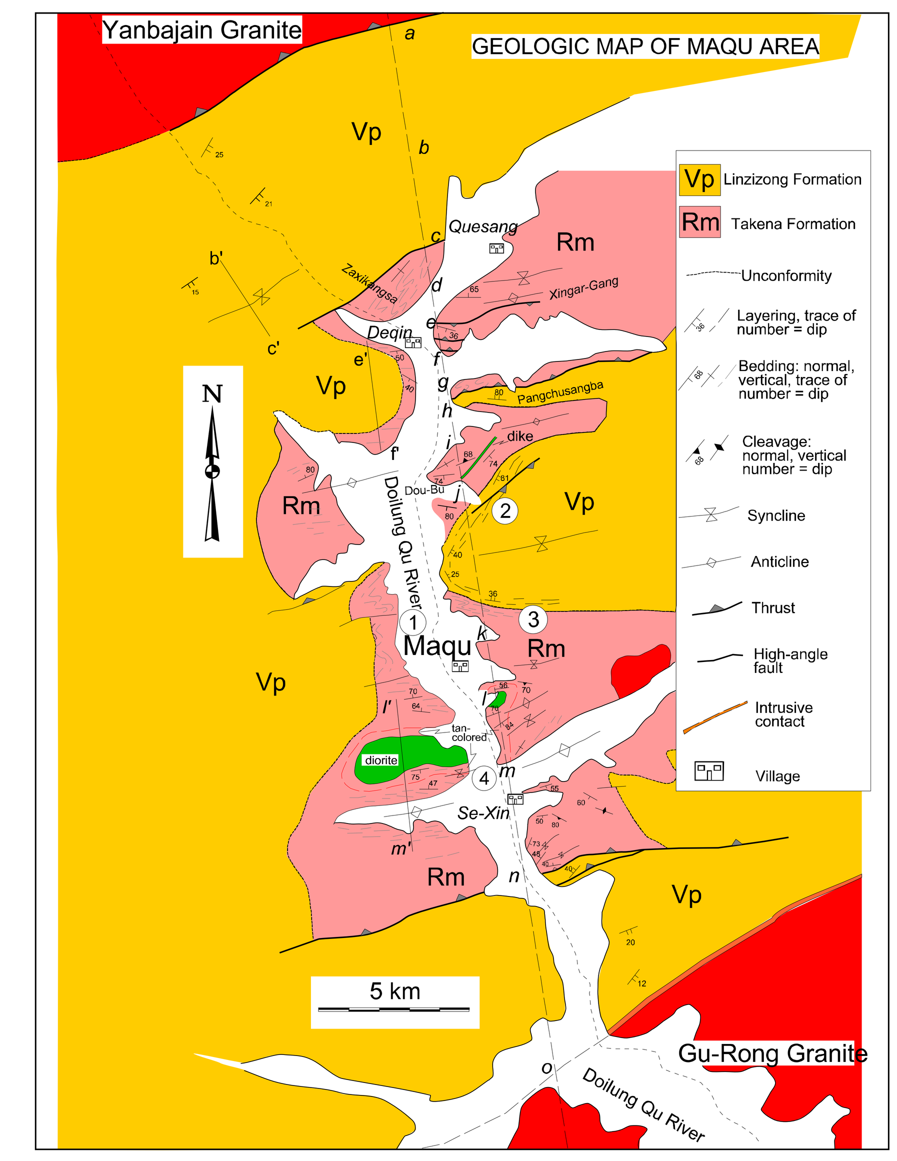
4 Diorite stock (right) intruding hornfelsed strata of the Takena Fm SW of Maqu village. Biotite Ar/Ar age from diorite is 65 +/- 2.8 Ma; because it cuts the Takena folds, this provides a lower age limit for that event.

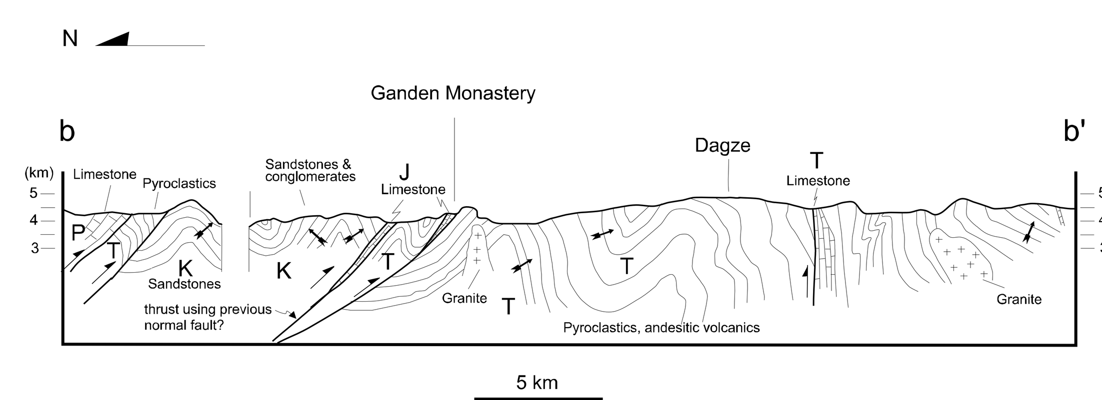


The Maqu Cross Section (a-o) showing fold and fault geometry in the Takena Formation (Rm) and the Linzizong Formation (Vp). The younging directions in Rm are indicated by small black arrows. The fold geometry and the cutoff positions of the unconformity are used to estimate the shortening that postdates Vp, and the fold geometry in the Rm alone is used to estimate the shortening of the Rm

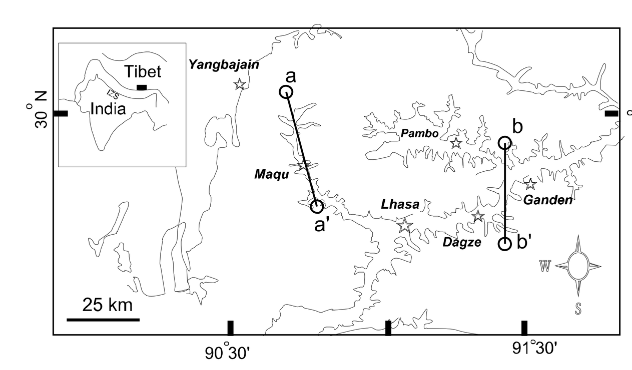
The results give a relative shortening in the Linzizong Formation of ~19 %. Because the estimated cutoff points of the unconformity along thrusts are used, the shortening estimate for the Linzizong Formation includes faulting deformation, and only bulk volume change is ignored. The bulk volume change by straining is probably very small, because no strong cleavage or other type of foliation is developed here, and the metamorphic grade is very low. Considering the uncertainty in the geometry, the total post-Linzizong shortening is estimated to be in the range 15-25 %. The folds alone require shortening of about 8-11 %.

The estimated amount of shortening in the Takena Formation has a range of ~36-44 %, depending on the particular bed picked for calculation. This estimate is based on fold geometry only, and therefore it does not include the thrust faulting deformation. However, it is likely that only a small amount shortening was introduced by thrusts in this section because no strata lower than the Cretaceous are seen along it.





Ganden-Dagze Cross Section (b-b') showing the deformation in the pre-Linzizong sedimentary sequence. P - Permian, T - Triassic, J - Jurassic, K - Cretaceous. Younging direction (small black arrows) and major lithologies are indicated. The geometry of folds alone is used to estimate the crustal shortening along this section, ~37 %. This is only a minimum estimate, because the shortening along faults, as well as bulk-volume shortening, are ignored. The displacement and the bulk-volume strain may be both more significant than at the Maqu area, because ductile stretched volcanoclastics occur, and because cleavage is better developed than in the Maqu area



Locations of the Maqu cross section and the Dagze-Ganden cross section in the Lhasa area, southern Tibet.

40Ar/39Ar isotopic ages of volcanics (from Pan, 1993)

Amphibole from a microdiorite or massive andesite near the unconformity at Maqu gave an isochron age of 64.1+/-4.3Ma.

The diorite stock intruding and cutting the Takena folds at Maqu yields a plateau age of 65.0 +/- 2.8Ma [isochron age 65.6+/-1.9Ma].

K-feldspar from an ignimbrite at Maqiang gives a plateau age of 49.5+/- 0.4Ma.

Coulon et al(1986) report 59Ma (biotite) from Linzhu, and 50Ma age from latite north of Yangbajian. The volcanics likely range from 65Ma at the base to about 50Ma for the youngest preserved.

Several K-feldspar samples from ignimbrites in the Maqu section have minimum ages in the range 41-53Ma which are suggested to indicate Ar loss consistent with heating resulting from significant burial; an apatite FT age of about 39Ma from one sample, and 45Ma from the diorite stock at Maqu, suggest cooling and exhumation in the 50-40Ma interval.

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