COMPARISON OF THICK CRUST IN THE ANDES AND TIBET STUDIED BY PASSIVE BROADBAND SEISMIC DEPLOYMENTS

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INTRODUCTION

The great thickness of the high plateau crust of the central Andes and Tibet has been established for more than two decades, but the bulk composition and thickening processes are still actively debated. Two recent deployments of PASSCAL broadband seismic stations in the central Andes of Bolivia (1994-1995) and along a north-south traverse across the central Tibetan plateau (1991-1992) provide excellent pure-path crustal sampling of these highlands.

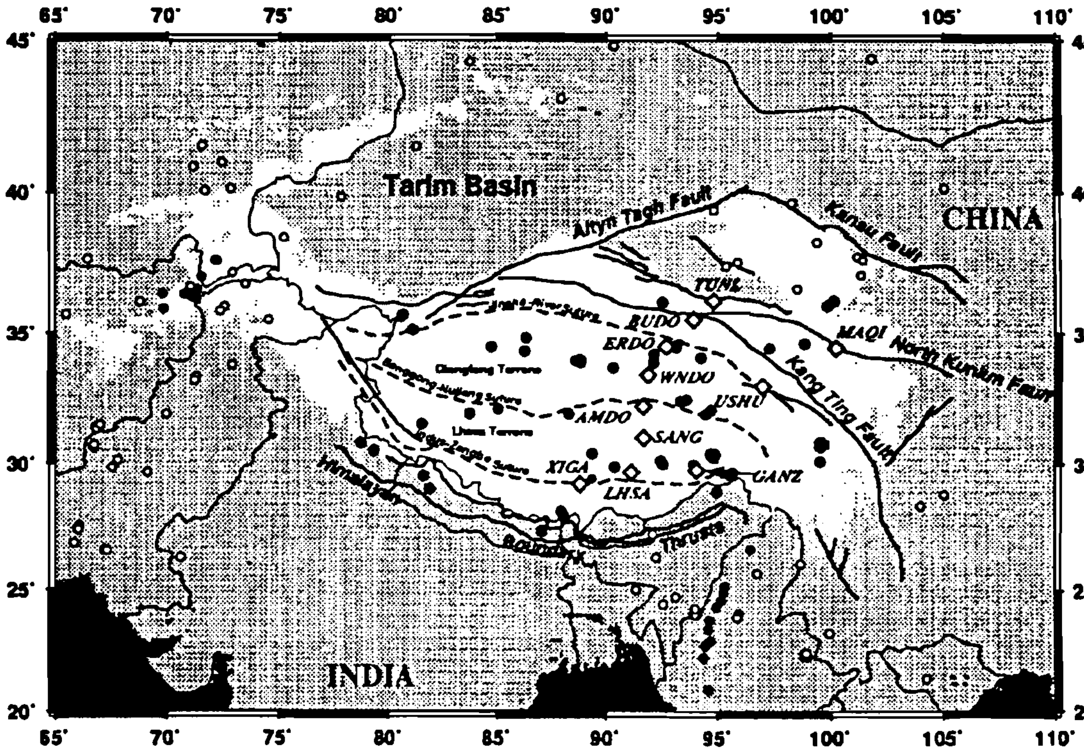
In the Andes, intermediate-depth earthquakes in the subducting Nazca Plate generate near-regional seismic waves that interact with the overlying Andean crust. Large amplitude, S-to-P converted, post-critical Moho reflections (SPmP) are modeled for average crustal properties of the Altiplano crust. Deep earthquakes and teleseisms are sources for a receiver function study of crustal variations across the entire Andean orogen.

For Tibet, our study was motivated, in part, by the observation of an impulsive, high signal-to-noise ratio S-wave of a 450-km-deep teleseismic earthquake recorded by the 1991-92 Tibet PASSCAL experiment (Owens et al., 1993). Especially energetic S-to-P converted phases and associated multiples (Zandt and Randall, 1985) from the Tibetan crust-mantle boundary are clearly visible prior to and following the S-wave arrival. These shear-coupled P-waves can be analysed to estimate bulk crustal properties beneath each seismic station.

OBSERVATIONS

The Andean Altiplano crust is characterized by relatively uniform bulk properties: an anomalously low mean velocity of 6.0 km/s, a Poisson's ratio (PR) of 0.25, and a thickness of 65 km. The crust thickens under both the western and eastern Cordillera and thins abruptly beneath the sub-Andean zone and Chaco Plain. The combination of the low mean P–velocity and relatively low PR of the Altiplano crust can be best explained by a predominantly silicic bulk composition. The velocity structure is consistent with tectonic models of thickening due to compressional shortening concentrated within a weak felsic layer. Some of the details of this work are described in a companion abstract by Beck et al. (1996).

In Tibet, we observed a P-wave arrival ~10 s before the S-wave that is the conversion from the Moho, Sp. A large up-swing ~12 s after the S-wave is a P-wave reflection after conversion at the free-surface, SsPmp. Comparing the displacement S-waveforms across the N-S network of PASSCAL stations (FIG. 1) reveals some striking similarities and consistent variations. All sites have an Sp arrival ~10s prior to S, although the Sp pulse is double-peaked at the southern stations (LHSA, XIGA, GANZ, SANG) and a simple pulse at the northern stations (AMDO, WNDO, USHU, BUDO, ERDO). From N to S there is a systematic moveout of the SsPmp phase from ~10 s at the northernmost stations (BUDO, ERDO) to ~15 s at the southernmost stations (LHSA, XIGA).

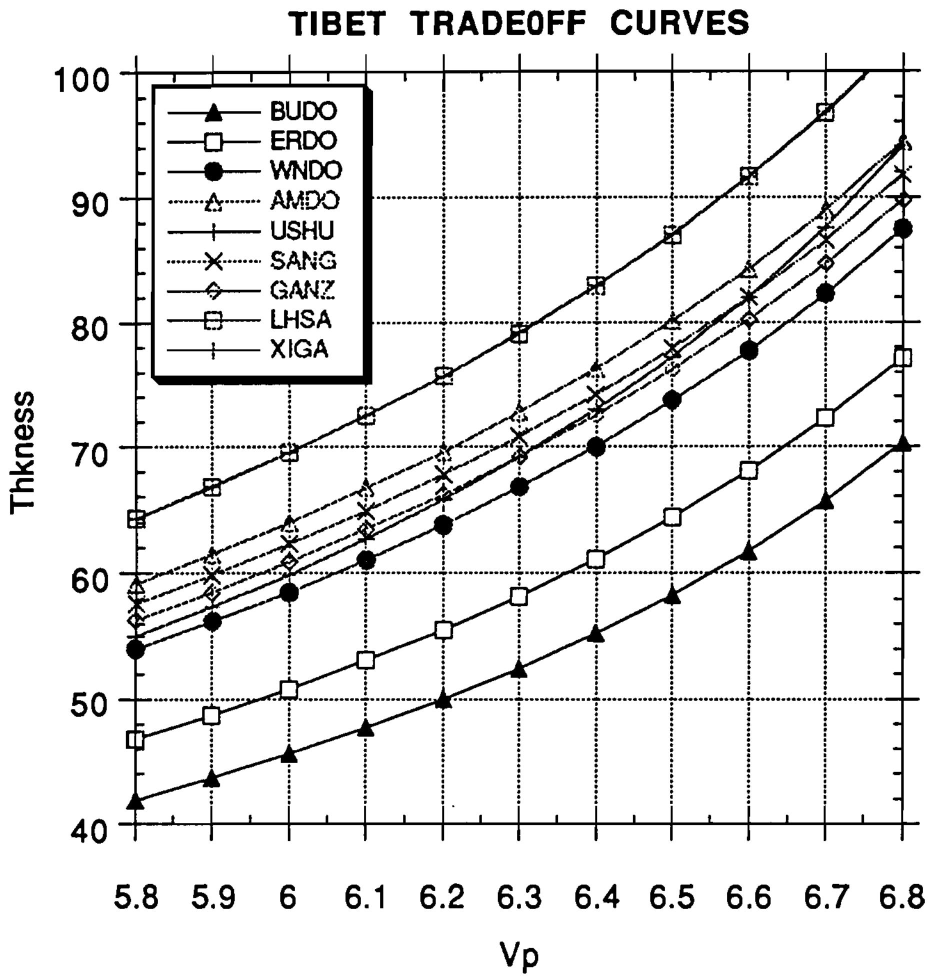


The relative timing of these phases with respect to the S-wave are dependent on three crustal properties: mean crustal P-velocity, Vp; mean crustal S-velocity, Vs; and crustal thickness, H. The consistent changes observed are direct evidence of a systematic N-S variation in crustal properties across Tibet. By measuring the differential traveltimes (SsPmp - S) and (S - Sp), we constructed a suite of H–Vp and PR–Vp tradeoff curves at all the stations (FIG. 2). We calculated both the H–Vp and PR–Vp tradeoff curves for all the PASSCAL stations. These curves represent the range of crustal thickness consistent with the (SsPmp - S) times and the range of crustal PR consistent with the (S - Sp) times. Two end-member models are possible. In one, the crustal thickness is constant, say at 70 km with a constant PR of 0.27, and the mean crustal Vp ranges from 6.0 km/s in the south (LHSA) to 6.8 km/s in the north (BUDO). In the other end-member, the crustal Vp is constant, say at 6.3 km/s, then the crustal thickness must vary from 78 km in the south to 52 km in the north, and PR varies from 0.22 in the south to 0.35 in the north. To choose between the end-member models, or any in between, other data or constraints are required.

In our final model, crustal thickness decreases and PR increases from south to north across the Tibetan plateau. In southern Tibet, the crust is 70-75 km thick, with low-to-normal PR, and a high-velocity lower crustal layer. In the middle latitudes, the crust is ~70 km thick with a higher PR of ~0.27-0.28, and the lower crustal layer terminates near the latitude of the Bangong suture. Further north, the crust thins to < 55 km and is characterised by unusually high PR > 0.3. More detailed studies in this region by the French Lithoprobe team indicates the thinning occurs abruptly near the Jinsha suture (Herquel et al., 1995). The relatively thin, high PR crust overlaps the northern half of the zone of Sn blockage and low Pn velocity in northern Tibet indicative of high mantle temperatures (McNamara et al., 1995).

CONCLUSIONS

Comparison of the crustal structures estimated from PASSCAL experiments across the Andean and Tibetan orogens reveals some similarities but also some significant differences. The narrower Andean orogen is characterized by relatively uniform bulk properties that are consistent with formation by compressional shortening of a weak lithosphere between two stronger lithospheres. The highlands appear to be in isostatic balance at the Moho. The Tibetan crust exhibits a systematic N-S variation in crustal thickness and PR not reflected in its relatively uniform elevation. The high PR of northern Tibet is probably due to pervasive partial melting of the crust that reduces the S–wave velocity more than the P–wave velocity. Isostatic forces in the upper mantle or nonisostatic forces must be acting to maintain the uniform elevation of the plateau.



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