Anomalous body wave traveltimes from the 2003 January 22 Mexico earthquake

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In 2003 January 22, an earthquake with Mw 7.8 between the subducting Cocos plate and the Norht America Plate occurred near Colima, Mexico. The source mechanism is shallow thrust type, at the depth of 24 km. The earthquake is located about
100 degrees away from Tokyo. Body waves are recorded by more than 500 short pe
riod seismic stations of hinet, and about 50 broadband stations of fnet in Japan
. With these high density seismic networks, we identified two different
anomalous body wave phases from the Colima earthquake.

First arrivals are the direct P and diffracted P phases at the core-mantle bound
ary, and have a constant apparent velocity of about 4.6 sec/degree up to a dista
nce of 106 degree, where abrupt reduction of the apparent velocity by about 0.4
sec/degree occurs and continues to further distances up to 109 degree. Sparse Fn
et stations at the Ryukyu islands in southwest Japan indicate that the anomalous
traveltime in the short period frequency continues at least to 115 degree. The
broadband waveforms show that a simple long-period main pulse indicating source
duration of about 20 sec has the constant apparent velocity from the shortest di
stance, 93 degree, to the furthest distance, 115 degree. The apparent change of
the Pdiff phase traveltime near 106 degree observed by hinet is due to the chan
ge of the shape of the initial part of the main pulse. Up to about 106 degree,
the main pulse has a sharp rise time. At longer distances the main pulse increa
ses gradually in amplitude. Because the main pulse peak keeps a constant apparent velocity, the start time of the main pulse is shifted gradually backward in time as the main pulse has a slower rise time. The change of the Pdiff traveltime in the shorte period network, or equivalently the change of the Pdiff phase indicates that a thin layer with a higher seismic P velocity than the above existsat CMB beneath the northeastern Pacific. Transition from normal to anomalous CMB with a high seismic velocity layer occurs within a distance of a few degrees.The change of the main pulse shape gives constraints on the seismic high velocity model at CMB.

A peculiar seismic phase X with slowness of about 10 sec/deg but arriving earlier than the PP phase is recorded at the distance from 95 through 98 degrees, from the Tohoku through Kanto-chubu regions, by hinet. Because the slowness of the P
P phase at these distances is about 7.8 sec/deg, the X phase is not the PP phase precursors or its reverberation phases. Slowness of the X phase is about equal to that of SP or PS, but the arrival of SP and PS is more than 500 sec behind of PP, the phase is not the precursor of the SP nor PS phase. The particle motion indicates X is a P body wave phase slightly polarized toward the north-south direction relative to the PP phase. It seems impossible for a phase of 1D spherica
lly symmetric Earth to have such a early arrival and a larger slowness. We need a change of the slowness somewhere from the source to the stations. Current interpretation is that the phase is a reflected or refracted phase of the main P phase by a scatterer in the mantle. Although the traveltime difference between the direct P and X phases are about 200 second, the distance between the source and the station is more than 10000 km and the 200 sec delay can be achieved if the scatterer is located at about 10 degrees off the great circle path of the direct P phase. Possible candidates are the slabs subducting from the Aleutian, Kuril, and Japan trenches. The slowness and the particle motion measurement by the dense seismic networks will be used to locate the scatterer.