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Why does the northeastern Pacific coast of Japan subside?

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There is a long standing problem as to the crustal deformation along the northeastern Pacific coast of Japan. While the geodetic data shows stationary subsidence along the pacific coast with several to 10mm/yr, late quaternary deformation suggests that the coast line shows a slight upheaval of 0.3-0.5mm/yr. Therefore, there should be some rebounding mechanism of the subsidence along the coast. A simple thought may be that a repeating large interplate earthquakes rebound the subsidence. However, this is not the case because the seismogenic zone is too far from the coast and all of upheaval area is in the ocean and the coast is rather residing in the subsidence area. Some researchers postulated that there would occur a super large earthquake of M9 among some repeated interplate large earthquakes of M8 and rebounds the subsidence. However, the 2011 Tohoku earthquake denied this possibility. Sawai et al. (2004) hypothesized, on the other hand, that a large transient uplift would occur after a large interplate earthquake. We will see if such a large post-seismic slip that extend downward of the seismogenic zone would occur in the coming days and uplift the Pacific coast of Tohoku significantly.

There are some other factors that may be responsible for such recovery uplift; high-angle reverse faulting that branches from the main plate interface, and visco-elastic stress re-adjustments in the upper mantle. First, such branching faults would play some role for the uplift. A part of the Solomon earthquake that occurred on April 1st 2007 (Mw8.1) would be one of such branching earthquake. The Inomisaki fault at the time of 1946 Nankai earthquake or the Patton Bay fault at the time of 1964 Alasuka earthquake would be other examples of such branching faulting. However, the region of crustal deformation would be much localized than the area that subsided due to the M9.0 earthquake.

Visco-elastic deformation due to stress re-adjustment around the source area was first modeled for the 1946 Nankai earthquake. The crust and the upper mantle was assumed to be a Maxwell body for which an elastic spring (crust) and a dash-pot (upper mantle) are connected in a series manner. This model has been successfully applied to some other earthquakes to interpret a part of post-seismic crustal deformations. However, neither high-angle reverse faulting nor the visco-elastic readjustment can solely resolve the inconsistency between geodetic and geological deformations. Synthetic role of these possible causes ? namely, post-seismic deeper slip, high-angle reverse faulting and visco-elastic stress re-adjustment - may fulfill the inconsistency between geodetic and geological strain rates. Quantitative evaluation of contribution of each these factors is required for solving this long standing problem.

Keywords: Tohoku earthquake, Crustal movement, Pacific coast