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Strong plate coupling along the Nazca/South America convergent margin

G. Iaffaldano (1), H.-P. Bunge (2)

1. Dept. of Earth and Planetary Sciences, Harvard University, Cambridge - U.S.A.
2. Dept. of Earth and Environmental Sciences, LMU, Munich - Germany

Much information on the dynamics is embedded in the record of past and present plate velocities, featured with long- as well as short- term variations, but a precise budget, in particular of resistive coupling forces along convergent margins, is hard to come by. Building on substantial, yet separate progress in modeling lithosphere dynamics and mantle convection, we couple global lithosphere models with high resolution (more than 100 million grid points) 3-D circulation models of Earth's mantle and demonstrate that an accurate budget of plate boundary forces can be obtained. We prove the effectiveness of our approach by computing a detailed force budget along the Nazca/South America subduction zone, showing that a large portion of it comes from the recent uplift of the Andes. We find that forces computed with our global, coupled models provide simultaneous explanations for three seemingly unrelated key observations along the South American margin: (1) trench parallel gravity anomalies, (2) pronounced bathymetry variations, as well as (3) a substantial reduction in Nazca/South America plate convergence recorded over the past 10 million years. All these observations can be explained from along- trench, lateral and temporal variations in plate coupling forces that are predicted from our simulations. Interestingly enough, the distribution of great earthquakes such as the recent M 8.0 event of Peru coincides with moderate to low coupling between subducting and overriding plates. For the same convergent margin we also show that frictional forcing due to trench sediment infill is, by comparison, of minor importance. Finally, we provide an intriguing explanation for the peculiar convex shape of the South American margin. Paleomagnetic and geodetic data indicate substantial rotation over the past m.y. and continuing

at present day. We tie the bend of the margin to variations in plate coupling associated with Andean growth. Specifically, the symmetric distribution of plate coupling forces along the margin provides strong torques that could have caused the bend in a feedback mechanism between mountain belt growth and plate coupling.