Geophysical Research Abstracts,
Vol. 10, EGU2008-A-03199, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-03199
EGU General Assembly 2008

Dynamics of the subduction wedge system: insights from numerical modeling

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A distinct empirical correlation between the location of forearc basins and both the asperity area and amount of seismic moment released by mega-thrust earthquakes is observed by Wells et al. (2003) and Song and Simons (2003). Information on the location and cause of these regions of high coseismic slip is of vital importance for the prediction and hazard assessment of earthquake distributions. The physical mechanism underlying this correlation is ambiguous, but an intriguing point is that large-scale architecture and evolution of the forearc can contain some information on the location of asperities. However little is known on the formation of forearc basins in this dynamic subduction environment. In order to gain knowledge on the evolution of the geometry and structure of the subduction wedge as a self-consistent response to subduction dynamics, and thereby collect information on possible causes of asperities and mechanisms of forearc basin formation, two-dimensional implicit mechanical lagrangian finite element models is used. The model is setup in three different entities reproducing the incoming subducting plate, with a layered linear viscoelastic lithosphere, the overriding plate and a subduction wedge. A contact algorithm is used to take care of the interaction between them. In order to model the large deformations correctly a regular separate remeshing algorithm is employed. The important role of erosion and sedimentation is also implemented through the remeshing algorithm. The passive unbounded mantle is represented by drag forces. In this dynamic and self-consistent setup, the feedback between wedge, lithosphere and underlying mantle can be correctly modeled simulating also complex mechanisms like accretionary wedge accumulation and erosion. The mechanical and energy conservation equations

are solved using the finite element package ABAQUS. This setup is used for an “ad hoc” parameter searching analysis. The first parameter set investigated is the force distribution characterizing the subduction system. In particular, the role played by the variation of slab pull and the variation of friction along the plate contact is explored. Secondly, an important emphasize of this work is to search for the best formulation of the rheology of the subduction wedge. Several rheologies are investigated while trying to observe their feedback to the subduction system. Initially a Mises power law rheology is used from which additional complexities are added towards a Mohr-Coulomb rheology with strain weakening. Finally, the feedback of simplified basal erosion and accretion on the wedge evolution is explored.