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Collision and Break-off : Numerical models and surface observables

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The process of continental collision and slab break-off has been explored by many authors using a number of different numerical models and approaches (Andrews and Billen, 2009; Gerya et al., 2004; van Hunen and Allen, 2011). One of the challenges of using numerical models to explore collision and break-off is relating model predictions to real observables from current collision zones. Part of the reason for this is that collision zones by their nature destroy a lot of potentially useful surface evidence of deep dynamics. One observable that offers the possibility for recording mantle dynamics at collision zones is topography.

Here we present topography predictions from numerical models and show how these can be related to actual topography changes recoded in the sedimentary record. Both 2D and 3D numerical simulation of the closure of a small oceanic basin are presented (Bottrill et al., 2012; van Hunen and Allen, 2011). Topography is calculated from the normal stress at the surface applied to an elastic beam, to give a more realist prediction of topography by accounting for the expected elasticity of the lithosphere. Predicted model topography showed a number of interesting features on the overriding plate. The first is the formation of a basin post collision at around 300km from the suture. Our models also showed uplift postdating collision between the suture and this basin, caused by subduction of buoyant material. Once break-off has occurred we found that this uplift moved further into the overriding plate due to redistribution of stresses from the subducted plate. With our 3D numerical models we simulate a collision that propagates laterally along a subduction system. These models show that a basin forms, similar to that found in our 2D models, which propagates along the system at the same rate as collision. The apparent link between collision and basin formation leads to the investigation into the stress state in the overriding lithosphere. Preliminary results in this area indicate the stress experienced by the overriding lithosphere changes through the collision and slab break-off process. This change is stress affects the topography, but also offers another observable for understanding collision zones.

We relate our numerical model to Arabia-Eurasia collision which is thought to have begun around 35 Ma (Allen and Armstrong, 2008; Vincent et al., 2007). The post collision basin predicted by our numerical model can be associated with the Miocene carbonate deposits of the Qom formation (Morley et al., 2009). These Miocene carbonate deposits are found at approximately 200-300km from the suture zone and are stratigraphically "sandwiched" between terrestrial clastic sedimentary formations. The position of these deposits shows that they are intimately related with the collision process, and that this area of the overriding plate has dipped below sea level for about 10 Myrs during the Early Miocene. Another geographic area that offers possibility for observation of topography change produced during continental collision is the Italian Apennines. Here, slab detachment is proposed to have started around 30 Ma and a tear propagated north to south along Italy (Wortel, 2000). Van der Meulen et al., (1998) observed a period of basin formation followed by uplift using the sedimentary record. Migrating depocentres were interpreted as evidence of a slab tear propagating north to south. These depocentres are located on the overriding plate with the maximum observed depression around 100 km from the suture (Ascione et al., 2012). These observed depocentres could be analogous to the depressions observed in our numerical models.

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