Geophysical Research Abstracts,
Vol. 11, EGU2009-6394-1, 2009
EGU General Assembly 2009


# Theory of mechanically heterogeneous critical-taper wedges with application to Barbados

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Many well-imaged accretionary wedges are mechanically heterogeneous based on spatial variations in wedge taper. For example, the toes of active accretionary wedges such as the Nankai trough and Barbados display deceasing surface slope $\alpha$ away from the toe, with no associated variation in the detachment dip $\beta$. Likely sources of this heterogeneity in taper are spatial variations in fluid pressure, density, cohesion, and fault strength. We parameterize these in-situ observables from the active accretionary wedges and evaluate the influences of spatial variations of these observables on the development of heterogeneous wedges. We show that the spatial gradients in pore-fluid pressure can be approximated by a single easily observable parameter, the fluid-retention depth $z_{FRD}$ below which compaction is strongly diminished. The Hubbert-Rubey weakening $(1-\lambda)$ is a simple function of fluid-retention depth $(1-\lambda) = (1-\lambda_h)[z_{FRD}/z]$ . We find that the heterogeneous critical taper wedge theory of Dahlen (1990) can be recast in terms of the ratio of fluid-retention depth $z_{FRD}$ to the detachment depth $H$, which leads to more concise and easily applied critical-taper wedge equations.

The analysis results of the Barbados wedge show that the fluid-retention depth ratio$z_{FRD}/H$ dramatically decreases in the toe area and slightly declines into the back of wedge. This leads that both wedge and fault strengths follow the similar trend as fluid-retention depth ratio does. For example, wedge strength of 0.4 significantly lessens in the first 30km of toe area and reaches 0.1 into the wedge interior. Fault strength has the similar reduction from 0.03 to 0.01, indicating a noticeable weak fault in general. The lateral gradients of mean physical properties only contribute small influence to develop this heterogeneous wedge. Compared with the CORK measurement of fluid pressure within the detachment, the fault strength is contributed from either extremely weak basal friction coefficient of 0.15 with the static fluid pressure at the wedge base or the high transient fluid pressure pulse of 0.97 with the basal friction coefficient of 0.45. Our results strongly indicate that temporal-spatial variations of fluid pressure play an important role of developing heterogeneous wedges. The detailed analysis on both co-variations of surface slope-detachment dip and fault strength-wedge strength displays that the entire wedge and detachment are completely heterogeneous, even in the apparently homogeneous interior.