Datapages/Search and Discovery Article #90211 CSPG© 2015 CSPG/CSEG/CWLS Convention 2006, What's New? Where is Our Industry Heading? Calgary, AB, Canada, May 15-18, 2006

Dynamical Numerical Models of Thin-Skinned Thrust-and-Fold Belts: Linkages Between Structural Style and Foreland Deposition

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Abstract

The sedimentary records of foreland basins reflect the structural and geodynamical evolution of the adjacent orogenic belts. For example, changes in mass distribution due to thrusting cause changes in lithospheric flexural response, which in turn cause changes in slope and accommodation space across the foreland basin. In addition, syndeformational sedimentation can profoundly influence structural style, as well as the timing and magnitude of motion on individual thrusts. These feedback relationships, i.e., structure influencing sedimentation and sedimentation influencing structure, are essential elements of the coupled thrust belt / foreland basin dynamical system.

We examine aspects of this coupled system using an arbitrary Lagrangian-Eulerian finite element approach to model the mechanics of thin-skinned thrust-and-fold belts (TFBs). Model faults are represented by narrow zones of high shear strain, yielding structural styles very similar to natural TFBs. Under appropriate mechanical conditions, syndeformational surface processes (erosion and sedimentation) may result in the proximal portion of the flexurally subsiding foreland basin achieving critical taper, without internal deformation. This causes the tip of the TFB to step out into the foreland, incorporating the proximal foreland basin as a piggyback basin, which may then be shortened by out-of-sequence thrusts. Continued convergence and repeated accretion of piggyback basins leads to a structural style characterized by broad, little-deformed synforms, separated by more strongly deformed antiforms, similar to features in the Alberta Foothills and elsewhere. Although syndeformational sediments have been erosionally removed across the Foothills, the structural characteristics of dynamical feedback between deformational style and surface processes remain.