Kinematics of a natural growth fold, Icy Bay, Alaska

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Unparalleled exposures of structures related to the collision of the Yakutat block with continental Alaska have been revealed by the rapid retreat of the Guyot and Yahtse glaciers over the past 100 years in Icy Bay, Alaska, located in the Gulf of Alaska between Yakutat and Cordova. The Yakataga anticline is such a structure and crops out as a beautifully exposed natural cross section of an asymmetric growth fold in the Karr and Guyot Hills at Icy Bay. This fold is found in the Yakataga Formation, a thick accumulation of marine and glacio-marine sediments which have been deposited from Late Miocene to the present. Collisional deformation has rapidly folded and uplifted these rocks from below sea level on the continental margin to elevations greater than 4000 feet. This particular outcrop is especially significant because unconformities resulting from syn-deformational channel deposits separate the back-limb of the fold into several dip panels with progressively gentler dips up section. This provides a progressive record of fold formation and offers an outstanding opportunity to reconstruct the growth of the fold and to compare its evolution with current models of fold growth. In addition, a thrust ramp is exposed where it cuts up section beneath the fold's forelimb, a feature often interpreted to be present beneath fault-related folds but rarely exposed.

The purpose of this study is to determine the geometry of the Yakataga anticline, develop possible models for its evolution based on the kinematic constraints provided by the back-limb unconformities, and compare the results to current models of fold development. Several models exist to describe the geometry and kinematics of fault-related folds, including fault propagation folds, detachment folds, and fault-bend folds. The Yakataga anticline has been cited as an example of a fault-propagation fold in the past, and there are many similarities between the geometry predicted for a fault-propagation fold and the geometry observed in the natural fold. Work to date has focused on describing the fold geometry and already some useful observations can be made. The gross fold geometry, with an overturned forelimb, is predicted by the fault-propagation model and obvious in the field. Of particular significance, we were able to locate a fault tip beneath the forelimb of the fold where displacement of a ramp decreases up section. This is an important part of the fault-propagation model, often interpreted to be present but rarely observed or able to be described. Of significance, however, is the indication that the back-limb of the fold has undergone rotation. The growth strata provide a clear record of changing limb dip over time, a characteristic not predicted by fault-propagation fold models. Fault-propagation folds, as predicted by the models, have their back limb dips fixed by the ramp angle and remain constant throughout fold development. Some other models for fault-related folds, namely variations on detachment folds, do predict changing limb dips. Future work will help constrain the kinematic evolution of the Yakataga anticline. Questions this will address include the possible role of strain in the rotating back limb and the possibility of an original detachment fold being overprinted by fault-propagation folding.

The results of such a study are applicable to fold-and-thrust belts worldwide and provide a natural test of models currently applied to fault-related folds in similar settings. Since it is unusual to find dramatic exposures such as those in Icy Bay, often times the interpretation of an area will be based largely on models. The model used has implications for the extrapolation of data into the subsurface and in areas where the data are incomplete, so it is important that the models be tested against natural folds. Such testing develops criteria that allow for the most appropriate model to be chosen where extrapolating folds.