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Detachments in Shale: Controlling Characteristics on Fold-Thrust Belt Style

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Fold-thrust belts occur across multiple tectonic settings where thin-skinned deformation is accommodated by one or more detachment zones, both basal and within the fold-thrust belt. These fold-thrust belts exhibit considerable variation in structural style and vergence depending on the characteristics (e.g. strength, thickness, and lithology) and number of detachment zones. Shale as a detachment lithology is intrinsically weaker than more competent silts and sands; however, it can be further weakened by high pore pressures, reducing resistance to sliding and; high temperatures, altering the rheology of the detachment. Despite the implications for petroleum exploration and natural hazard assessment the precise nature by which detachments in shale control and are involved in deformation in fold-thrust belts is poorly understood. Present-day active basal detachment zones are usually located in inaccessible submarine regions. Therefore, this project employs field observations and sample analysis of ancient, exhumed analogues to document the nature of shale detachments (e.g. thickness, lithology, dip and dip direction, deformational temperature and thrust propagation rates) at field sites in Thailand, Norway and New Zealand. X-ray diffraction analysis of illite crystallinity and oxygen stable isotopes analysis are used as a proxy for deformational temperature whilst electron-backscatter diffraction analysis is used to constrain microstructural deformational patterns. K-Ar dating of synkinematic clay fault gouges is being applied to date the final stages of activity on individual faults with a view to constraining thrust activation sequences. It is not possible to directly measure palaeo-data for some key detachment parameters, such as pore pressure and coefficients of friction. However, the use of critical taper wedge theory has been used to successfully infer internal and basal coefficients of friction and depth-normalized pore pressure within a wedge and at its base (e.g. Platt, 1986; Bilotti and Shaw, 2005; Morley, 2007). Therefore, through a mixture of field observations, sample analysis and theoretical analysis it will be possible to determine a full range of shale detachment parameters and their impact on the structural style of fold-thrust belts across a variety of settings. Recent work in Muak Lek, central Thailand has focused on a structural investigation of fold-thrust belt deformation of a passive margin sequence as a result of continent-continent collision during the Triassic Indosinian Orogeny. Exceptional outcropping of the detachment lithology is accessible in the Siam City Cement quarry allowing construction of sections detailing the deformational style across the detachment itself. The detachment forms complex, 3-dimensional duplex-like structures creating egg-carton geometries enveloping foliation surfaces in the zones of most intense strain. Up section strain decreases to discrete thrust imbricates of decametre scale. Samples of limestone and secondary calcite were collected through the sections for oxygen stable isotopes analysis which show a distinct pattern of isotopic fractionation across the main thrust and into the detachment. Results from this study give insights into the nature of shale detachments and the control on fold-thrust belt development.