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Why style matters – uncertainty and structural interpretation in thrust belts.

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Structural complexity together with challenging seismic imaging make for significant uncertainty in developing geometric interpretations of fold and thrust belts. Here we examine these issues and develop more realistic approaches to building interpretations. At all scales, the best tests of the internal consistency of individual interpretations come from structural restoration (section balancing), provided allowance is made for heterogeneity in stratigraphy and strain. However, many existing balancing approaches give misleading perceptions of interpretational risk – both on the scale of individual fold-thrust (trap) structures and in regional cross-sections.
At the trap-scale, idealised models are widely cited - fault-bend-fold, fault-propagation folding and trishear. These make entirely arbitrary choices for fault localisation and layer-by-layer deformation: precise relationships between faults and fold geometry are generally invalidated by real-world conditions of stratigraphic variation and distributed strain. Furthermore, subsurface predictions made using these idealisations for hydrocarbon exploration commonly fail the test of drilling. Rarely acknowledged, the geometric reliability of seismic images depends on the assigned seismic velocity model, which in turn relies on geological interpretation. Thus iterative approaches are required between geology and geophysics.
The portfolio of commonly cited outcrop analogues is strongly biased to examples that simply conform to idealised models – apparently abnormal structures are rarely described – or even photographed! Insight can come from gravity-driven deep-water fold-belts where part of the spectrum of fold-thrust complexity is resolved through seismic imaging. This imagery shows deformation complexity in fold forelimbs and backlimbs. However, the applicability of these, weakly lithified systems to well-lithified successions (e.g. carbonates) of many foreland thrust belts remains conjectural. Examples of lithified systems will be drawn from the foothills of the Colombian Andes and the Papuan fold-belt. These show major forelimb structures with segmented steep-limbs containing substantial oil-columns, suggesting forelimb complexity in lithified sections maybe more common than predicted by idealised models.
As with individual fold-thrust structures, regional cross-sections are commonly open to multiple interpretations. To date the over-reliance on comparative approaches with a narrow range of published studies (e.g. Canadian cordilleran foothills) has biased global interpretations of thrust systems. Perhaps the most significant issues relate to establishing a depth to detachment – specifically the involvement of basement at depth – especially the role of pre-existing (rift-originated) faults and their inversion. Not only do these choices impact on the local interpretation, the inferred shortening values, obtained by comparing restored section-lengths, can be radically different. Further issues arise for emergent, syn-depositional thrust systems where sedimentation prohibits flat-on-flat thrusting in favour of continuously ramping thrust trajectories. Inappropriate adoption of geometries gathered from buried (duplex) systems can create geometric interpretations that are tectono-stratigraphically invalid. This presentation illustrates these topics using a variety of thrust systems with the aim of promoting discussion on developing better interpretative strategies than those adopted hitherto.