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Cross-strike Discontinuities in the Moine Thrust Belt of NW Scotland; their identity, tectonic significance, and evolution

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ABSTRACT

Abrupt lateral changes in thrust geometry occur in many mountain-building fold-and-thrust belts. Whilst many works have dealt with palinspastic reconstructions and transport-direction-parallel balanced cross-sections, far fewer show a full three-dimensional architecture, or examine how these lateral variations in thrust architecture can be linked via so-called 'transverse zones' that demarcate different segments of the thrust belt. When identified, these transverse zones are commonly thought to be related to kinematic responses to irregularities generated across pre-existing, sometimes re-activated, sub-décollement basement faults, contrasts in pre-thrusting cover strata deformation across basement faults, development of duplex structures/antiformal stacks, and/or along-strike variations in mechanical stratigraphy. In many cases however the causative structure is concealed, either by distal parts of the thrust belt or by the foreland basin and so must be deduced from the overall structural architecture (Krabbendam & Leslie, 2010).

In NW Scotland, the classic WNW-vergent Caledonian Moine Thrust Belt (MTB) incorporates a variety of crustal-scale segments. North of the Loch Maree Fault, the MTB is characterised by imbricate thrust stacks as exemplified by the classic Assynt region whereas, to the south of Loch Maree and above the Kishorn-Kinlochewe thrusts, the southern MTB is more accurately referred to as a fold-and-thrust belt. Thrust-dominated sectors are typically foreland-propagating whereas fold-and-thrust-dominated sectors will often contain evidence for repeated switching between foreland-, and hinterland-propagating accommodation of contraction. There are excellent examples, at a variety of scales, of the structural architectures in the transverse zones that segment the MTB. This presentation will examine a number of these. The amplitude and complexity of the disturbance associated with the transverse zone is typically much greater than amplitude of any irregularity identified in the basement below the thrust belt.

In the Assynt Culmination of the Moine Thrust Belt, the Traligill Transverse Zone trends sub-parallel to the thrust transport direction, and is associated with an *en echelon* fault system cutting thrusts, with discontinuity of the thrust and thrust sheet architecture, and with oblique fold and thrust structures. This transverse zone is developed above a basement cross-fault which records repeated brittle reactivation of a Proterozoic shear zone. Thrusting thus deformed a sedimentary sequence that was already disrupted by faults aligned sub-parallel to the thrust transport direction.

In the southern MTB east of the Lochalsh Syncline on the Lochalsh peninsula, at least six separate thrust sheets can be identified. Brittle-ductile contraction in the middle to upper crust has considerably shortened successions already deformed by ductile folding and non-coaxial shear in the mid- to upper crust. These six thrust sheets alternate right-way-up and inverted successions and structurally higher thrusts truncate the underlying thrust sheet, demonstrating a hinterland propagating thrust sequence. Inverted successions show penetrative non-coaxial deformation whereas thrust sheets carrying a right-way-up succession show far less internal deformation and locally, perfectly preserve internal depositional contacts. The Moine Thrust (s.s) truncates the lower two of these thrust sheets and truncates the axial trace of the Lochalsh Syncline on Skye.

In the Kinlochewe district where the Loch Maree Fault Zone (LMF) transects the MTB, a fold-and thrust architecture including completely inverted slabs of Torridonian/Lewisian rocks can be clearly identified on the northern wall of the LMF. This architecture is in sharp contrast to classically imbricated repetitions of Torridonian-Cambrian rocks on the southern wall of the LMF. The compartmentalisation is suggested to be a response to a significant offset of the pre-thrust template that generated a transport-parallel lateral ramp or sidewall during transport.

The Loch Maree transverse zone marks the southward change to the fold-and-thrust architecture in the southern MTB but the still younger Achnashellach Culmination bulges up this fold-and-thrust system, and so demonstrates a return to foreland-propagating thrusting in the later stages of development of the MTB south of the Loch Maree Transverse

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Zone. The (brittle) Moine Thrust then truncated all of the structural elements beneath, indicating a final hinterland-propagating episode of movement all along the MTB suggesting that influence of the transverse zones diminished in time as the thrust belt evolved.

Three-dimensional visualisations of these complexities are challenging to construct and deliver to the geological community – this presentation will includes examples of progress in rendering fold and thrust surfaces in 3D (Figs. 1 & 2).

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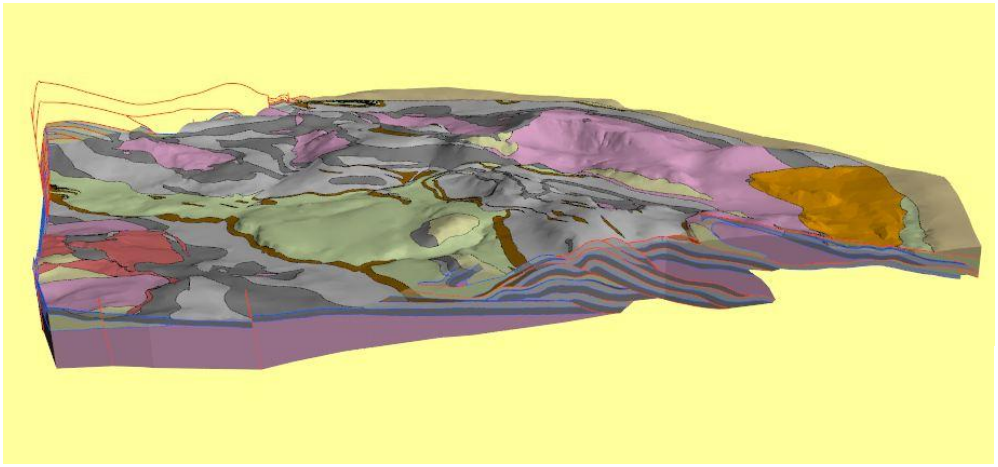

Fig. 1 – The geology of the Assynt Culmination in the Moine thrust Belt, viewed from the south. The simplified geological map is draped on the DTM.

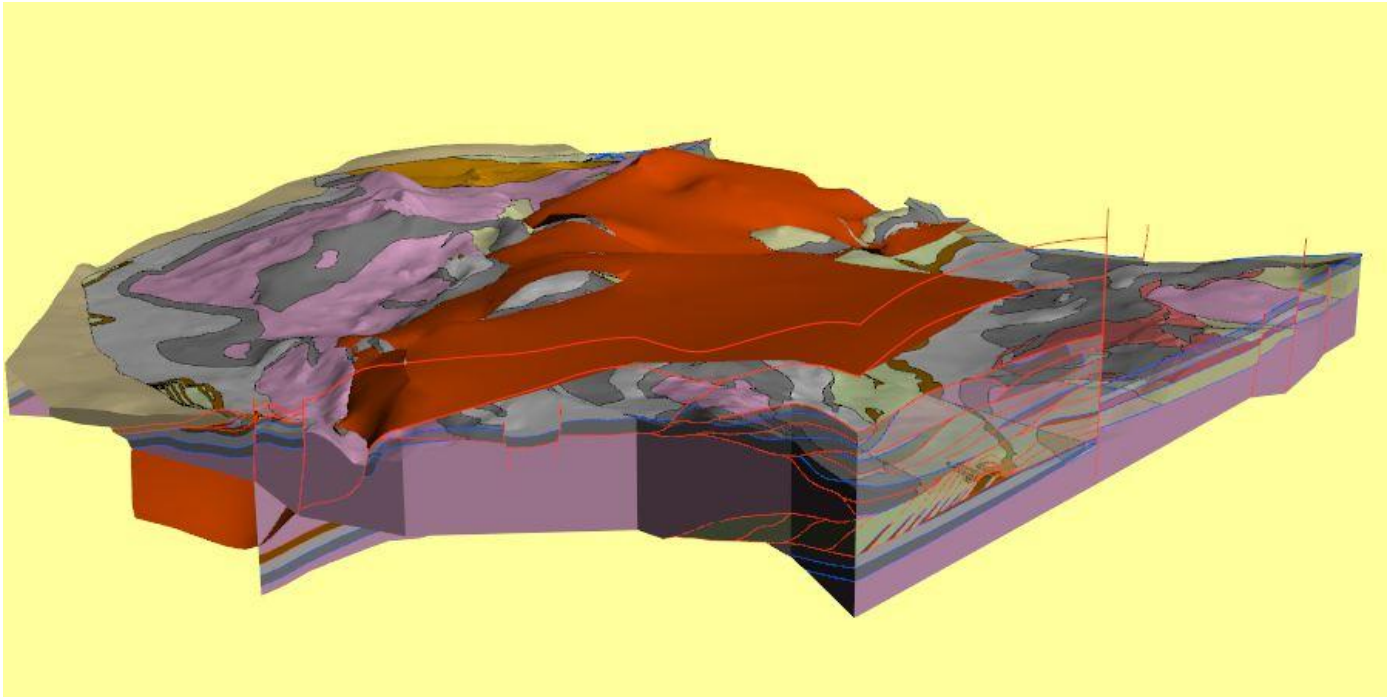

Fig. 2 – The geology of the Assynt Culmination in the Moine thrust Belt, viewed from the north-east. The Ben More Thrust (red) has been modelled in 3D using GOCAD® and embedded in the model.