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Antiformal closure in ductile and brittle-ductile in fold-and-thrust belt tranverse zones, Moine Thrust Belt, NW Scotland

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Abrupt lateral changes in thrust geometry occur in many mountain-building fold-and-thrust belts. Such changes in architecture are referred to as so-called transverse zones, and are commonly thought to be related to kinematic responses to irregularities generated across pre-existing, sometimes re-activated, basement faults. In many cases however the causative structure is concealed, either by distal parts of the thrust belt or the foreland basin. Sharp lateral changes in the structural geometry of ductile thrust stacks are less widely studied and reported. In NW Scotland, the classic Caledonian WNW-vergent Moine Thrust Belt exposes excellent examples of the structural architecture in such transverse zones, both in kilometre-scale thick monolithic (meta-)sandstone packages subject to ductile deformation, and in much thinner heterolithic packages subject to brittle-ductile deformation. In both cases the amplitude of the antiformal disturbance associated with the transverse zone is much greater than amplitude of any irregularity identified in the basement below.

In Neoproterozoic Moine rocks in the hanging wall of the Moine Thrust, a large-scale lateral culmination wall forms a component part of the Oykel Transverse Zone (OTZ), a kilometre-scale thick constrictional ductile shear zone striking sub-parallel to the WNW-directed thrust transport direction. The OTZ forms the SW limit of the Cassley Culmination. ESE-plunging mullions are an integral part of the fabric of the transverse zone and were generated by constriction sub-parallel to the WNW-directed thrust transport direction. Main folds and fabrics in the transverse zone hanging-wall are folded by main folds and fabrics in the footwall, demonstrating the overall foreland-propagating record of ductile deformation as the Cassley Culmination grew. Constriction and mullion development are attributed to differential, transtensional movement across the transverse zone during the later stages of culmination development. Subsequent formation of the classic Assynt Culmination below the Moine Thrust accentuated upwards-bulging of the Cassley Culmination above, amplifying the lateral change across the Oykel Tranverse Zone. The OTZ aligns with a pronounced gravity gradient; interpretive geophysical modelling relates this gradient to a buried basement ramp that possibly controlled the location of the transverse zone.

Farther towards the foreland in the Assynt Culmination of the Moine Thrust Belt, the Traligill Transverse Zone also trends sub-parallel to the 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. The amplitude of the anticlinal disturbance in the fold-and-thrust architecture along the Traligill Transverse Zone is much greater (c. 1000 m) than the vertical displacement (c. 100 m) determined along the fault; this is attributed to oblique transpressional thrust-stacking within the transverse zone, generated by the small angle between the thrust transport direction and the strike of the pre-existing fault.