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Thick-skinned tectonics and basement control on geometry, kinematics and mechanics of fold-and-thrust belts. Insights from some cenozoic belts worldwide

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Fold-and-thrust belts (FTBs) form either in lower and upper plates at the expense of proximal parts of former passive margins during collision or within the upper plate of subduction orogens. In contrast, inner parts of mountain belts are likely made of stacked units from the distal passive margin domains that have undergone continental subduction and HP-LT metamorphism.

There are increasing lines of evidence that the basement is involved in shortening in many FTBs worldwide, either pervasively (across the entire belt; tectonic inversion may even occur more forelandward than the mountain front) or mainly in their innermore domains where this basement is commonly exhumed. For thick-skinned FTBs that developed from former passive margins, the occurrence of weak mechanical layers within the proximal margin lithosphere (the middle and most of the lower crust are expectedly ductile) may explain that contractional deformation be distributed within most of the crust giving rise to basement-involved tectonic style. In contrast, because these weak crustal levels are usually lacking in distal parts of the margins as a result of thinning, these stronger lithospheric domains are more prone to localized deformation/subduction. Less understandable this way is the occurrence of thick-skinned wide domains within cold and strong interiors of upper plates of subduction zones, such as the Paleocene Laramide orogenic belt or the active Sierras Pampeanas belt.

Structural, geophysical and thermochronological investigations within Cenozoic thick-skinned (or basement-involved thin-skinned) FTBs provide evidence for how the pre-orogenic and syn-orogenic deformation of the basement may control the geometry, kinematics and mechanics of FTBs. In this contribution, we examine some examples of FTBs where the basement is known to be involved in shortening and we review some aspects of the control exerted by the basement on the deformation. This control is demonstrated (1) at the scale of the whole belt : belt curvature (Jura, Taiwan), segmentation and along-strike variations of structural styles (Taiwan), sequence of deformation (basement vs shallow thrusting : Jura, western Alps, Zagros), localization of contractional deformation and % of shortening (western Alps), magnitudes of compressional stresses (Taiwan, Zagros, Laramide uplifts), and (2) at the scale of tectonic units : reactivation or non reactivation of inherited basement faults (Laramide, Taiwan, western Alps), basement “folding” (Laramide, western Alps).

In (classical, if any) FTBs resulting from inversion of former proximal passive margins, basement thrusting that occurs in a rather localized way in their inner parts requires structural inheritance and/or a hot crustal temperature either inherited from a recent (pre-orogenic) rifting event (Pyrenees, Taiwan) or resulting from syn-orogenic underthrusting and heating (western Alps). Tectonic inversion occurring in the far-foreland, or development of thick-skinned belts within cratons likely require specific boundary conditions (strong interplate coupling (e.g., flat-slab subduction) ensuring efficient transmission of stresses (crustal/lithospheric stress guide) and propagation of deformation in the pro- or retro- foreland by crustal/lithospheric buckling or deep crustal decollement, in addition to local structural and/or possible compositional weakening.

Whatever its control(s) (structural inheritance, thermal state, composition), the rheology of the continental lithosphere appears to be central to understand mountain building processes.