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Lithosphere age controls structural styles or patterns of shortening in collision belts

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Continental deformation is known to preferentially focus in young tectonic provinces, where the lithosphere has been weakened during previous subduction, rifting and orogenic events1-3. This suggests that pre-existing thermo-mechanical properties and composition of the crust and mantle lithosphere may control the structural styles that develop in collisional orogens. Although long-term crustal shortening is now fairly well quantified in a number of external zones of orogens, the reasons for the differences in crustal-scale deformation in these settings has rarely been addressed4,5. Here, we examine the relationship between long-term crustal shortening in collisional orogens that have developed on lithospheres of different thermo-tectonic age and proxies of long-term lithosphere strength. By analyzing more than 50 data sets from 30 fold and thrust belts, we show that shortening and thermotectonic age at time of shortening are correlated. In particular, deformation of Phanerozoic lithosphere, characterized by low elastic thickness ($\sim$20 km), high lithospheric temperature and fertile, weak, instable mantle is prone to involve mid-crustal detachment, thus reducing bulk crustal strain (<35%). Older cratonic blocks, characterized by higher elastic thickness (>60 km) and high-viscosity mantle promote stable underthrusting characterized by higher, more localized, shortening (up to $\sim$70%) in weakly consolidated sediments. Our findings provide a key for linking distribution of continental deformation with secular cooling of the Earth and inherited properties of the lithosphere, including the nature of the sub-continental mantle and thermo-mechanical structure of the crust.