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How stable are the ’stable ancient shields’?

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"Archean cratons are relatively flat, stable regions of the crust that have remained undeformed since the Precambrian, forming the ancient cores of the continents" (King, EPSL, 2005). While this type of statement is supported by a wealth of constraints in the case of episodes of thoroughgoing ductile deformation affecting shield regions of Archean and also Peleoproterozoic age, a growing amount of research indicates that shields are not nearly as structurally stable within the broad field of environmental conditions leading to brittle deformation.

In fact, old crystalline basements usually present compelling evidence of long brittle deformation histories, often very complex and challenging to unfold. Recent structural and geochronological studies point to a significant mechanical instability of the shield areas, wherein large volumes of ’stable’ rocks actually can become saturated with fractures and brittle faults soon after regional cooling exhumes them to below c. 300-350° C.

How cold, rigid and therefore strong shields respond to applied stresses remains, however, still poorly investigated and understood. This in turn precludes a better definition of the shallow rheological properties of large, old crystalline blocks. In particular, we do not yet have good constraints on the mechanisms of mechanical reactivation that control the partial (if not total) accommodation of new deformational episodes by preexisting structures, which remains a key to untangle brittle histories lasting several hundred Myr.

In our analysis, we use the Svecofennian Shield (SS) as an example of a supposedly ’stable’ region with Archean nucleii and Paleoproterozoic cratonic areas to show how it is possible to unravel the details of brittle histories spanning more than 1.5 Gyr. New structural and geochronological results from Finland are integrated with a review of existing data from Sweden to explore how the effects of far-field stresses are partitioned within a shield, which was growing progressively saturated with fractures as time passed from its initial consolidation. The comparison of time-constrained paleostress data derived from three different locations of the shield shows a remarkably similar stress evolution through time, despite the different geological frameworks of the investigated areas. This suggests that the southern SS has behaved as a coherent rigid crustal block since the Late Mesoproterozoic. By that time, the SS had already reached structural maturity with respect to the saturation of brittle structural features. Therefore, structural reactivation rather than generation of new faults and fractures is the key mechanism that has controlled the mechanical evolution of the shield and that will steer its future evolution within the brittle regime. Comparable brittle structural histories within parts of the shield that are far apart also imply that far-field stresses can propagate over large distances and can lead to similar deformational histories, with the local geological conditions only playing a second-order role on the final brittle strain pattern recorded by the rock.