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Inversion tectonics during post-orogenic extensional collapse: a comparison between ancient (North Sea, UK) and recent (Fucino Basin, central Apennines Apennines) intermontane systems

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Post-orogenetic extensional/gravitational collapse events constitute a relatively poorly understood tectonic process, which is responsible for the quick and effective dismantling of the thickened crust and topographic bulge of fold-and-thrust belt edifices. These events are also responsible for the accumulation of very thick post-orogenetic successions and, in case of active extension, may trigger moderate to strong earthquakes resulting in obvious seismic hazards (e.g., the 1915 Mg 7.0 Fucino earthquake in Central Italy, which caused 30,000 victims)

Here, we combine seismic interpretation coupled with well analyses, basin modelling and a thorough literature review, in order to compare an ancient and a modern example of study areas subject to post-orogenetic collapse. The Devonian-age Old Red Sandstones of north-western Europe and ?Plio-Quaternary fill of the Fucino intramontane extensional basin in the central Apennines (Italy) share several stratigraphic, depositional and tectonic characteristics. Both are characterized by remarkably similar seismic-stratigraphic architecture (with syn-depositional half-grabens) and maximum thickness of >1,500 metres. In the Fucino, the border faults associated to the main tectonic depocentres achieved maximum throw rates of 1,000-1,400 mm/kyr.

Both units comprise thick continental siliciclastic successions, dominated by lacustrine and alluvial to fluvio-deltaic facies. The facies architecture reveals a progressive transition from localized, fault-bounded depocentres to transgressive lacustrine successions in wider basins that are less reliant on the sole fault-driven subsidence. The studied units were deposited due to high and quick tectonic subsidence which took place very shortly after the end (or during?) of crustal shortening processes (respectively Caledonian and Apenninic orogenesis) and in a post-orogenic collapse context.

In both study areas, the sedimentation of the thick continental units are intimately associated to a polyphase inversion tectonics, with pre-existing inherited deep-seated discontinuities affected, in places, first by a positive and subsequently by a negative reactivation during the extensional collapse. A further element common in the two study areas, is a strike-slip or oblique tectonics occurring during or immediately prior to the extensional collapse achieved by the normal faulting. This has been interpreted as a consequence of the gradual rotation of the stress vectors around their axes, culminating in the relaxation of the horizontal compressive stress and the onset of the

post-orogenetic extensional/gravitational collapse process itself. For example, in the Fucino Basin, maximum Plio-Quaternary sediment thicknesses of >1700 m occur in two tectonic depocentres, situated respectively to the north and east of the basin. In contrast, the south-eastern striking dip-slip border faults bounding the eastern edge of the Fucino show maximum slip rates in the Lower-Middle Pleistocene, with evidence (e.g., Gioia dei Marsi) for a very recent activity, possibly linked with the 1915 seismic event.

The study of post-orogenic extensional collapse by comparison of ancient and recent basins suggest that in these settings poly-phase tectonic inversion commonly occurs and promote multiple reactivation of inherited zones of weakness. The comprehension of the common and dissimilar features, may be fundamental to better understand the mechanism and evolution of post-orogenic chain reworking and for natural resources and geological hazards assessment, including earthquakes. The coupled analysis of an ancient and recent example enables just that.