Geophysical Research Abstracts
Vol. 19, EGU2017-4786, 2017
EGU General Assembly 2017

Transtensional basins from fault growth to bulk constriction: insights from the 'Old Red' basins of western Norway

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In areas of large-magnitude regional transtension, strain partitioning may lead to formation of constrictional supradetachment basins. In such basins, stratigraphic architectures will reflect complex accommodation creation patterns. Based on observations from an 'Old Red' supradetachment basin in western Norway, we discuss the complex patterns of accommodation that may arise in constrictional basins and the structural and stratigraphic architectures that may result. The Devonian basins in western Norway developed in a continental environment above a crustal-scale detachment in a strain field dominated by sinistral transtension. Based on observations in the Kvamshesten Basin, we document a basin evolution where large-magnitude fault growth and early inversion was followed by orthogonal shortening under bulk constriction. The fault growth stage was characterized by differential footwall unroofing, moderate basin inversion and separation of the initial depocentre. Subsequent constriction was characterized by coeval extension and orthogonal shortening, and by a clockwise change in the maximum elongation trend. In the resultant basin, stratigraphic thickness variations, facies transitions and complex onlap relationships became associated with fault-propagation folds as well as with extensional faults and folds. Syn-sedimentary normal faults terminate downwards at the detachment fault and stratigraphically upwards into fault-growth monoclines. Syn-sedimentary normal faults became rotated by further orthogonal folding. Together with the overall retrogradational stacking of sedimentary units, syndepositional faults and folds gave rise to a complex basin architecture. We use our observations from the Kvamshesten basin to conceptualize scenarios for constrictional basin evolution and suggest that such basins may be common in a number of transtensional settings such as rifted margins, extending orogens, and strike-slip plate boundaries.