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# The Seismic Signature of "Hidden" Faults at Magma-Poor Rifted Margins

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Observations from Magma-Poor Rifted Margins commonly reveal an “extension discrepancy” where the amount of stretching accommodated in the upper crust (as calculated from seismically observable fault heaves) is far less than required to thin the entire crust to the extent that is observed on wide-angle seismic and gravity models. Possible solutions to this “extension discrepancy” include depth-dependent stretching/thinning, or multiple phases of unrecognised faulting. Here we focus on why multiple phases of faults may go unrecognised.

In order to facilitate high degrees of stretching (Beta > 1.7 – 2.0) multiple fault generations are required. If upper crustal stretching is accommodated through brittle faulting mechanisms it is probable that unrecognised polyphase faulting (PPF) combined with sub-seismic scale deformation accommodates the “missing” extensional strain. It is therefore likely that the complexity of the structural geometries, and velocity gradients produced by the PPF mechanism serve to render the earliest fault generations effectively invisible on reflection seismic data.

We present synthetic seismic models demonstrating how the PPF mechanism is expressed on reflection seismic data. From these synthetic data we highlight the characteristic PPF identifiers that may be observed; crestal wedges, fault bifurcations (up-dip, and down-dip), and oversteepened stratigraphy. It can be seen that due to complex velocity gradients produced by the PPF mechanism, strong velocity distortions are be observed in the data. These velocity distortions can greatly inhibit correct interpretation of the data. It is clear from the modelled data that reflector complexity increases oceanward concomitantly with greater strain and that the chances of PPF being correctly identified diminish rapidly at very high strain (Beta > 3.0) The PPF mechanism effectively becomes seismically invisible, with only the most recent faults recognisable.

Through comparison between the synthetic seismic models and reflection seismic data from the Irish Atlantic Margin, and the W. Iberian Margin we present new interpretations that exemplify previously unrecognised PPF structures. We show that many PPF identifiers can be observed in the medium to high strain regions (Beta > 1.7-2.5) of the crust, and that the mechanism is more difficult to recognise in the regions of hyper-extension.

From the observations made using the synthetic models it can be seen that great care must be taken when interpreting seismic data from MPRMs as key structural information can very easily misinterpreted, or completely hidden due to the complex velocity gradients that may be involved. The data also show that even when all PPF structures generate reflections, they are highly unlikely to be interpreted correctly, and importantly, failure to recognise the PPF mechanism would cause any estimation of stretching accommodated by upper crustal faulting to be grossly underestimated. Thus PPF predicts an extension discrepancy in just the place, the deep margin, where it is observed.