New insights into the kinematics and timing of superimposed rifting events through integration of offshore data, onshore fieldwork and U-Pb geochronology: Inner Moray Firth Basin, Scotland

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The E-W striking Inner Moray Firth Basin (IMFB) lies in the western part of the North Sea trilette rift system formed mainly in the Upper Jurassic. The IMFB has experienced a long history of superimposed rifting with plenty of uplift and fault reactivation during Cenozoic. The basin is overlying the Caledonian basement, the pre-existing Devonian-Carboniferous (Orcadian Basin) and a regionally developed Permo-Triassic basin. The potential influence of older structures related to the Orcadian Basin on the kinematics of later basin opening has received little attention, partly due to the poor resolution of seismic reflection data at depth or sparse well data.

By integrating onshore fieldwork with the interpretation of 2D and 3D seismic data and U-Pb geochronology of syndeformationally grown calcite we provide new insights into the kinematic opening of the basin as well as the role of pre-existing Devonian-Carboniferous (Orcadian) basin structures.

The Jurassic opening of the rift basin is known to be associated with major NE-SW trending faults. New detailed mapping of offshore 3D seismic data revealed that at a smaller scale en-echelon E-W to NE-SW trending faults, en-echelon N-S to NNE-SSW faults arrays coexist. This suggests an oblique-sinistral component associated with the major NE-SW rift basin trends. This correlates with onshore findings, which suggest that the inherited Orcadian fault systems (mainly N-S to NE-SW) have been dextrally reactivated. Sinistral WNW-SSE to NW-SE striking faults and associated transtensional folds are also present in the Devonian rocks. This later deformation is consistently associated with calcite mineralization (e.g. slickenfibers, calcite tensile veins or Riedel shear fractures). New U-Pb dating of the calcite mineralization, related to the reactivated faults, shows that the age of fault reactivation is 153 ± 0.68 Ma (Upper Jurassic).
The integration of fieldwork with subsurface interpretations and absolute dating techniques has provided better constraints on superimposed basin development, as well as explaining complexities that have hitherto been ignored. This can reduce subsurface uncertainties regarding the structural evolution of the basin and unlock the full potential of the area and significantly enhance future exploration programs.