



Petroleum system in supra-salt strata of extensional forced-fold systems. Examples from the Basque-Cantabrian Basin (Spain).

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The Mesozoic Basque-Cantabrian Basin holds the only onshore productive oilfield of Spain. There, as well as in the other uncommercial oil fields of the area, structural traps were formed by the Cenozoic Pyrenean inversion of rifting-related Mesozoic extensional forced folds. The availability of a large data set of seismic profiles, well data, oil shows, and the world-class exposures of reservoir and seal levels, make the area an outstanding analogue for petroleum plays in extensional settings with supra-salt reservoirs. The aim of this contribution is to present and discuss the 3D geometry, kinematics, and deformation pattern associated with extensional forced folding, and their relationships with the petroleum system.

Our work indicates that during extensional deformation the severe mobilization of Triassic evaporites has imposed the structural decoupling between faulted basement rocks and the folded cover that includes the reservoir and seal units. Two sets of basement faults were active during this extensional stage: master faults striking WNW-ESE and transverse faults striking NE-SW. Extensional forced folding occurred along both fault sets, which has implied severe stretching of the supra-salt pre-rift carbonate sequence during hanging-wall downthrown. Such a stretching has poorly affected the central portions of master faults, where basement faults have rapidly penetrated into the cover sequence after a short period of forced folding. Conversely, along the tip regions of the master faults and along the main transverse faults, ongoing extensional forced folding has produced intense layer-parallel stretching of the carbonate cover sequence. Field work documents that this stretching has produced intense extensional faulting and jointing in the pre-rift carbonate sequence, which has enhanced its permeability. The same stretching has occurred in the overlying syn-rift siliciclastic sequence, but with an upward decreasing intensity. In this portion of the multilayer, soft-sediment extensional deformation has produced a bulk reduction of porosity. As a result, the mechanism of forced folding has enhanced the quality of the pre-rift fractured carbonate reservoirs and has contextually improved the sealing capacity of the siliciclastic seals. Seismic profiles and oil shows and accumulations, indicate that anticlinal structural traps were developed in those sites where basement faults have not propagated into the cover sequence. Where cover breaching has occurred, the traps lost their integrity and oil reached the surface throughout carrier conduits provided by the damage zone of major faults. Those traps developed along transverse NE-SW striking faults have been further amplified upon Cenozoic Pyrenean reactivation when these faults were positively inverted.