Seismic geomorphology and origin of diagenetic geobodies in the Upper Cretaceous Chalk of the North Sea Basin (Danish Central Graben)

Kilometre-scale geobodies of diagenetic origin have been documented for the first time in a high-resolution 3D seismic survey of the Upper Cretaceous chalks of the Danish Central Graben, North Sea Basin. Based on detailed geochemical, petrographic and petrophysical analyses it is demonstrated that the geobodies are of an open-system diagenetic origin caused by ascending basin fluids guided by faults and stratigraphic heterogeneities. Increased amounts of porosity-occluding cementation, contact cement and/or high-density/velocity minerals caused an impedance contrast that can be mapped in seismic data, and represent a hitherto unrecognized, third type of heterogeneity in the chalk deposits in addition to the well-known sedimentological and structural features. The distribution of the diagenetic geobodies is controlled by porosity/permeability contrasts of stratigraphic origin, such as hardgrounds associated with formation tops, and the feeder fault systems. One of these, the Top Campanian Unconformity at the top of the Gorm Formation, is particularly effective, and created a basin-wide barrier separating low-porosity chalk below from high-porosity chalk above (a regional porosity marker, RPM). It is in particular in this upper high-porosity unit (Tor and Ekofisk formations) that the diagenetic geobodies occur, delineated by ‘Stratigraphy Cross-cutting Reflectors’ (SCRs) of which 8 different types have been distinguished. The geobodies have been interpreted as the result of: 1) escaping pore-fluids due to top seal failure, followed by local mechanical compaction of high-porous chalks, paired with 2) ascension of basinal diagenetic fluids along fault systems that locally triggered cementation of calcite and dolomite within the chalk, causing increased contact cements and/or reducing porosity. The migration pathway of the fluids is marked by the SCRs, which are the outlines of high-density bodies of chalk nested in highly porous chalks. This study thus provides new insights into the 3D relationship between fault systems, fluid migration and diagenesis in chalks, and has important applications for basin modeling and reservoir characterization.