



A 3D seismic analysis of the geometries and distribution of upper Miocene pockmarks in the central North Sea

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Over the last three decades, circular and semicircular fluid escape structures, termed pockmarks, have been described from continental shelves and slopes around the world. The availability of a large number of 3D seismic datasets, originally acquired for hydrocarbon exploration in the Danish Central Graben, has enabled the identification and mapping of a large number of pockmarks of variable character within the post-middle Miocene succession. Pockmarks of a largely circular geometry are thought to represent pure fluid and sediment expulsion, whilst elongated pockmarks may represent pockmarks modified by current scour, or they may be coalesced, circular pockmarks, e.g. aligned along faults in the substrate. The objective of this study is to subdivide the pockmarks into a number of different classes based on geometry, seismic and stratigraphic context, and to use this classification to infer the history of fluid venting and bottom current scour in the central North Sea during the late Miocene.

The Cenozoic succession of the North Sea Basin is located in a bowl shaped basin centred above the Mesozoic Central and Viking Grabens. The post-middle Miocene succession in the Danish North Sea is up to 1500 meters thick in the Central Graben area and is characterized by overall westward progradational units.

The pockmarks were mapped using 3D seismic time-slices, seismic cross sections, amplitude and dip maps of selected horizons. They were identified by their change in reflection amplitude and continuity on time-slices and amplitude maps, and the shape is defined both by erosional truncations on cross-sections and by following continuous amplitudes through the structures.

In plan view the mapped pockmarks appear circular to elliptical with a large proportion

trending towards the elliptical. The axial ratio (length/width) varies from 1 to 11, and the absolute size from 620 m to 6210 m for the long axis and 190 m to 1150 m for the short axis. In cross-section the pockmarks vary from V-shaped over U-shaped to having steep sides and a flat bottom. In a few cases it is observed that the bottom is rough with minor highs. Seen in 3D view it is clear that most of the pockmarks are asymmetrical with one deeper end. This wedge shaped form is for the most consistent within groups of pockmarks. The maximum depth observed is approximately 70 m.

The long axis of the elliptical pockmarks tends to be parallel to the slope of the progradational units which may lead us to suggest that the generation of the pockmarks was controlled by the deposition i.e. lithology of the unit in which the pockmarks occur and partly by pressure development in response to the loading pattern of the overlying units. The shape of the pockmarks was modified secondarily by contour parallel bottom currents. However, the pockmarks seem to be restricted to the central and eastern part of the Danish Central Graben since no pockmarks are observed in the western most dataset (PAG 95) or east of the Central Graben. This clearly indicates that the initial generation of the pockmarks is related to fluids originating from the underlying succession and that the sediment characteristics only played a role for the spatial position of the pockmarks with respect to the clinoform breakpoint of the progradational units.