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Pockmark-like depressions near the Goliat hydrocarbon field, Barents Sea: Morphology and genesis

S. Chand*, L. Rise, D. Ottesen, M.F.J. Dolan, V. Bellec, R. Bøe

Geological Survey of Norway, Leiv Eirikssons Vei 39, 7040 Trondheim, Norway

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ABSTRACT

Pockmarks are observed worldwide along the continental margins and are inferred to be indicators of fluid expulsion. In the present study, we have analysed multibeam bathymetry and 2D/3D seismic data from the south-western Barents Sea, in relation to gas hydrate stability field and sediment type, to examine pockmark genesis. Seismic attributes of the sediments at and beneath the seafloor have been analysed to study the factors related to pockmark formation. The seabed depths in the study area are just outside the methane hydrate stability field, but the presence of higher order hydrocarbon gases such as ethane and/or propane in the expelled fluids may cause localised gas hydrate formation. The selective occurrence of pockmarks in regions of specific seabed sediment types indicates that their formation is more closely related to the type of seabed sediment than the source path of fluid venting such as faults. The presence of high acoustic backscatter amplitudes at the centre of the pockmarks indicates harder/coarser sediments, likely linked to removal of soft material. The pockmarks show high seismic reflection amplitudes along their fringes indicating deposition of carbonates precipitated from upwelling fluids. High seismic amplitude gas anomalies underlying the region away from the pockmarks indicate active fluid flow from hydrocarbon source rocks beneath, which is blocked by overlying less permeable formations. In areas of consolidated sediments, the upward flow is limited to open fault locations, while soft sediment areas allow diffused flow of fluids and hence formation of pockmarks over a wider region, through removal of fine-grained material.

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1. Introduction

Surface, and near-surface, indications of migrating hydrocarbons provide the petroleum systems analyst critical information about source, maturation and migration (Abrams, 2005). The rate, and volume, of hydrocarbon seepage to the surface greatly controls near-surface geological and biological responses. Analysis of these parameters is therefore the most effective method for detection of hydrocarbon leakage. Often, the escape of such fluids to the water column is coincident with the presence of pockmarks. In this study we attempt to establish the morphology, genesis and various other factors associated with the formation of pockmarks.

Pockmarks are described as circular to oval depressions found on the seafloor (King and MacLean, 1970) and may appear as single features, as groups, or as longer chains (Hovland, 1981). Individual pockmark sizes vary from a few metres (limited by data resolution) to more than 400 m in diameter and 2 to more than 15 m in depth. Elongated pockmarks are observed to have their long axis orientation along the prevailing bottom current direction (Farin, 1980; Bøe et al., 1998). Their genesis can be due to many factors, including expulsion of water by the melting of deeper lying permafrost (Farin, 1980; King, 1980), dissociation of gas hydrates (Mienert et al., 1998), freshwater seepage through artesian aquifers (Whiticar and Werner, 1981) or escape of hydrocarbon fluids from underlying petrogenic source rocks (King and MacLean, 1970; McQuillin et al., 1979; Rise et al., 1999). Some studies suggest that the formation and preservation of pockmarks are closely related to sediment type (e.g., Hovland, 1981). However, it is still not clear whether one can relate pockmark formation to one of these mechanisms alone. Since pockmarks are essentially escape phenomena of gas or fluid from the sediment/bedrock, most often fine-grained sediment will be brought into suspension and transported away by currents. Hence, soft fine-grained sediment is often suggested as a necessary recording medium for the formation of pockmarks.

2. Regional setting

Pockmarks are observed along most of the Norwegian offshore region including the Barents Sea (Solheim and Elverhøi, 1985; Hovland, 1981; Ginsburg et al., 1999), North Sea (Van Weering,

* Corresponding author. Tel.: +47 73904283; fax: +47 73921620.
E-mail address: shyam.chand@ngu.no (S. Chand).

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