TITLE: **Mapping of fluid flow by the use of 3D seismic data and special processing.**

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Since the late 1980's, exploration 3D seismic data have proved to be very useful for shallow gas and geohazards evaluations for E&P drilling sites (Gallagher and Heggland, 1994, Heggland et al., 1996). As part of this work, indicators of fluid flow, like gas chimneys, pockmarks, possible carbonate build-ups, as well as mud volcanoes and diapirs, were mapped. For mapping of gas seepages based on seabed and high resolution surveys from different parts of the world, see Hovland and Judd, 1988.

The mechanisms responsible for the generation of gas chimneys, visible in the seismic data as vertical disturbances, can be described as follows. Free gas in shale is believed to cause a columnar disturbance in the seismic data, due to attenuation of the seismic signal. Hydrocarbons can not move upwards in a shale because of capillary resistance. There has to be an open fault, or a fracture, through which the hydrocarbons can move. This can occur only as a result of overpressure in a reservoir, and the fault, or fracture, will be open for a time until the pressure has dropped (Bjørkum et al., 1998). The gas is expected to move horizontally into the shale for a limited distance, i.e. in the order of 100 m, generating a "narrow" chimney. This can happen as a result of free gas migrating through a fault, or it can be caused by oil migrating through the fault, releasing gas as the pressure drops, or in the same manner, by gas saturated water moving up the fault. A number of 3D seismic examples show that chimneys are located at faults. Many examples also show chimneys that are not related to faults. This may be explained by gas saturated water moving upwards through the shale, releasing gas as the pressure decreases. In this case the chimneys can get several hundred meters wide. Chimneys of this kind have also been observed in seismic data.

From interpretations of 3D seismic data, chimneys were seen to tie in to features associated with gas seepage, and to shallow gas accumulations and faults. Observations of these features at different, but not all, subsurface horizons, indicated that gas seepage is not a continuous process, but takes place during limited periods in geological time (Heggland, 1998). This may be related to pressure increase in deeper reservoirs.

It is very time consuming and difficult to map chimneys from seismic data because of their diffuse character and often weak appearance, and in most cases they are visible in vertical seismic sections only, not on 3D seismic time slices and various attribute maps. To improve the identification of chimneys in seismic data and to make mapping more consistent and efficient, a method for detection of chimneys was proposed and developed in co-operation between Statoil and de Groot – Bril Earth Sciences B.V. (dGB) (Meldahl et al., 1998, 1999 and Heggland et al., 1999). The method makes use of multi attribute calculations and a neural network, and the output is a 3D probability cube, giving high values for chimneys and low values in the surrounding volume. Results from application of the chimney detection have showed more clearly that chimneys tie in, not only to faults and seepage related features, but also to oil and gas reservoirs. Because of this, the method has been used in several prospect evaluation projects (Heggland et al., 2000).

By looking at wells penetrating chimneys, the mud logs show increase of gas in the drilling fluid when penetrating a chimney. Assuming that increasing amounts of gas will have increasing impact on the seismic data, the chimney probability cube may give a quantitative image of free gas present in the sediments. By calibrating values from the 3D chimney probability cube with gas seepage rates in areas where 3D seismic data show chimneys reaching the seabed, the chimney cube may perhaps be used on a larger scale to give an idea of seepage rates.

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