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Abstract

Chimney detection and interpretation, revealing sealing quality of faults, geohazards, charge of and leakage from reservoirs

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Abstract

Understanding the migration of hydrocarbons in the subsurface is of primary importance for oil and gas exploration. Fluid migration structures on reflection seismic data are difficult to map manually and subtle features that are related to hydrocarbon migration are often overlooked. ChimneyCube processing is a new technique in which fluid migration paths are detected in a semi-automated way, using an assemblage of directive, multi-trace seismic attributes, supervised neural networks and the interpreter's insight.

Chimney detection results indicate where hydrocarbons originated, how they migrated into a prospect, and how they spilled or leaked from this prospect and created shallow gas pockets, mud volcanoes and pockmarks near and on the seabed. Integration with other geological information is a prerequisite for correct interpretation of the results. Examples show that it provides important information for prospect evaluation, distinguishes between charged and non-charged prospects, detects shallow gas hazards, distinguishes between sealing and non-sealing faults, determines seal quality and helps in the prediction of reservoir hydrocarbon phase in multi-phase basins.

Keywords: Hydrocarbon migration; Gas chimney; Seepage; Seal

1. Introduction

The described method for detecting fluid migration paths in seismic data facilitates the identification and mapping of gas chimneys and aids in a better understanding of the hydrocarbon migration system. The technique has been applied to large data sets from the Central North Sea, Danish Central Graben, offshore Nigeria and Gulf of Mexico, besides other areas. Analysis of ChimneyCube results in combination with other geological data of the studied basins reveals indispensable information for oil and gas exploration and will be discussed.

2. Method

The detection method is using a set of directive, multi-trace seismic attributes and a supervised neural network (Meldahl et al., 1998). Representative example locations of chimneys are selected by the interpreter

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and contain characteristics of chimneys: low energy, (near-) vertical structure and disturbed character, which is enhanced by different seismic attributes such as coherency and variance in local dip/azimuth. Additionally, example locations are selected that do not represent chimneys. Seismic attribute values are extracted at all example locations and subsequently, a neural network is trained on the extracted attribute data to be able to distinguish between chimneys and non-chimneys. Finally, the trained neural network is applied to the 3D seismic volume and creates a so-called chimney probability cube. The same method can be applied for other objects, such as faults and salt bodies (Meldahl et al., 2001).

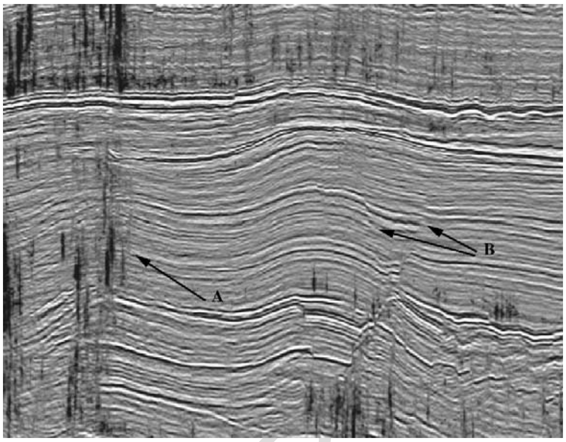

Fig. 2. Overlay of chimney detection results (black) on seismic, indicating leaking (A) and sealing faults (B).

3. Results and analysis

Prominent achievements from the analysis of chimney detection on seismic surveys are the determination of sealing quality of faults, indication of possible charging of reservoirs, indication of possible spillage or leakage from these reservoirs and detection of geohazards.

Combining chimney detection results with fault structures reveal characteristic features around leaking faults, such as circular carbonate build-ups in and above faults (Connolly et al., 2002) and high probability of chimneys in these faults (Figs. 1 and 2). The results show if faults are part of the fluid migration path or if they form a barrier and have good sealing quality.

The charging of and spillage or leakage from shallow reservoirs is highlighted by the chimney detection method, providing a better understanding of the hydrocarbon migration system and knowledge on the presence of hydrocarbons in these reservoirs. Regional tectonics often plays an important role in the leakage of reservoirs. For example, chimneys often occur in areas of high strain such as above mud diapirs and salt domes (Connolly et al., 2002), and the reactivation of faults causing fault seal failure and seal breaching (O'Brien et al., 1998).

Gas hazards are often manifested as pockmarks and mud volcanoes near or on the seabed. However, it

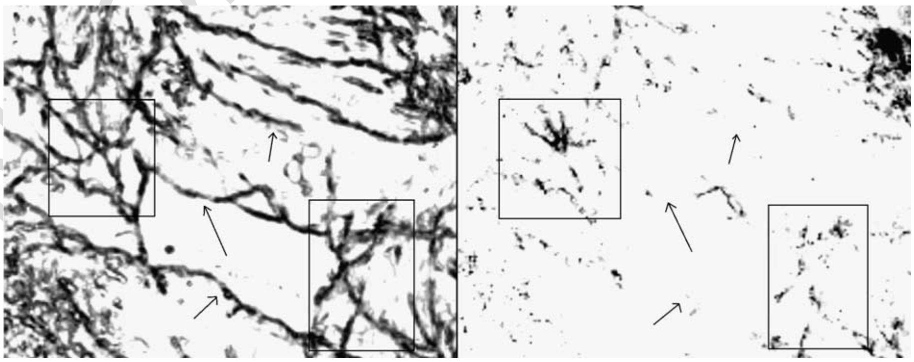

Fig. 1. Comparison of fault detection results (left) and chimney detection results (right) provides information on the sealing quality of faults. No chimneys are detected in the sealing fault (arrows), in contrast to leaking faults (boxes).

may occur that migrating gas does not reach the surface and thus does not form any surface expressions, but creating hazardous shallow gas pockets. These shallow gas zones may be difficult to distinguish on seismic data, but can be recognized by the described method of chimney detection. Besides, the prediction of shallow overpressured zones can be improved by using the described technique (Aminzadeh et al., 2002).

4. Conclusions

The method of detecting chimneys by using an assemblage of seismic attributes and supervised neural networks has been proven to be of indispensable use for oil and gas exploration. Processed chimney detection data reveal the hydrocarbon migration paths in the studied basins. Integrated with other geological knowledge of the basins, they provide relevant information regarding the charge of reservoirs and leakage or spillage from reservoirs, indicate possible geohazards and can determine the sealing quality of faults.

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