

# ge



# LOGIC

News

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## ABSTRACT

Gas chimneys are manifested by vertically noisy and chaotic response on conventional seismic sections. In many cases chimneys correspond to hydrocarbon migration paths from its source into the reservoir trap all the way up to the surface (shallow gas). A new (patent pending) method has been introduced to highlight gas chimneys and use them as a tool for exploration and better understanding of the hydrocarbon system. Given the ever increasing number of successful applications of this technology and SCA's recent technology alliance with dGB-USA (see insert), we have decided to highlight it in this issue of our technical newsletter- geoLOGIC.

## INTRODUCTION

Gas clouds, chimneys and mud volcanos can be seen in many parts of the world, including West Africa, North Sea, Gulf of Mexico, South Caspian, The Middle East, South America, and other hydro-carbon rich parts of the world. A novel approach to predict gas chimneys and produce "The Chimney Cube@" highlighting areas with high chimney probability has been developed by Statoil and de GrootBril Earth Sciences (d GB), leading to a patent application (Meldahl et al., 1998). d GB has the exclusive license to provide technical services using chimney technology. Many service projects have been carried out successfully by d GB and its Sister Company, dGB-USA, in many parts of the world.

## THE CHIMNEYCUBE®

The ChimneyCube® is a 3D volume of seismic data, which highlights vertical chaotic behavior of seismic characters. These disturbances are often associated with gas chimneys. The cube facilitates the difficult task of manual interpretation of gas chimneys. It reveals information on the

hydrocarbon history, migration paths and fluid flow models. Practically, chimney cubes can reveal where hydrocarbons originated, how they migrated into a prospect and how they spilled from this prospect and/or created shallow gas, mud volcanoes or pock marks at the sea bottom. As such a chimney cube can be seen as a new exploration tool.

## Procedure and Attribute Selection

A volume of 3-D seismic data is provided as an input to a specially designed neural network. This volume is transformed to a chimney probability cube volume using a set of attributes of the input data as shown in, Figure 1.

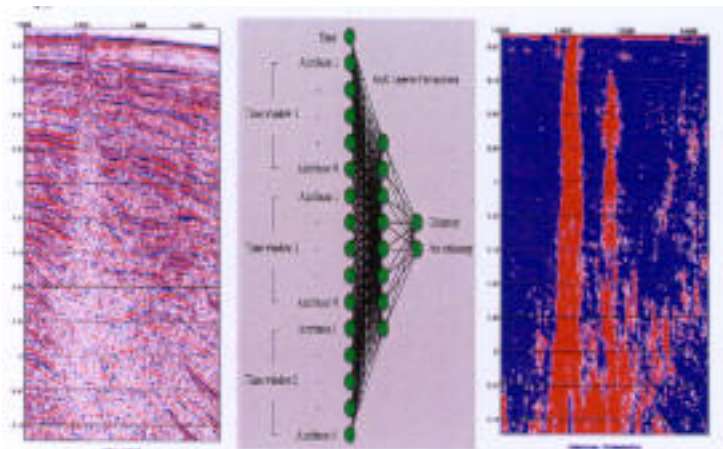


Figure 1- Slices of input 3-D volume of Seismic, a Neural Network and the output chimney cube.

This procedure involves:

1. Calculating and identifying a set of single- trace and multi-trace seismic attributes that distinguishes between chimneys and non-chimneys
2. Designing and training a neural network with known chimneys and non-chimneys
3. Creating a "chimney cube" volume from multi-attribute transformation of the 3D seismic volume highlighting vertical disturbances as the output of the trained neural network
4. Visualizing and interpreting the chimney volume. Using the chimney cube in conjunction with other structural, stratigraphic and geophysical interpretation tools.

## Chimney Interpretation

Gas clouds or chimneys appear as low quality seismic response with vertical bodies of varying dimensions. Also shape and distribution may vary, although cigar- shapes and a distribution along faulted zones are common. The internal texture shows a chaotic reflection pattern of low energy. The exact outline of a chimney is very difficult to determine on conventional seismic displays. Only large chimneys can be recognized. To also detect more subtle disturbances we will transform the data into a new cube that highlights vertical disturbances. A neural network does this by classifying the data into classes: chimney versus non- chimney.

Example locations are chosen inside interpreted chimneys as well as outside.

Chimneys, in most cases, also demonstrate radial patterns on time slices of chimney cubes, Figure 2. This is caused by the friction generated from vertical migration of hydrocarbons and possible fracturing of near by rocks. These fractured rocks are subsequently filled with hydrocarbons. Once the chimneys are identified, they can be displayed in conjunction with the structural model or other reservoir property information.

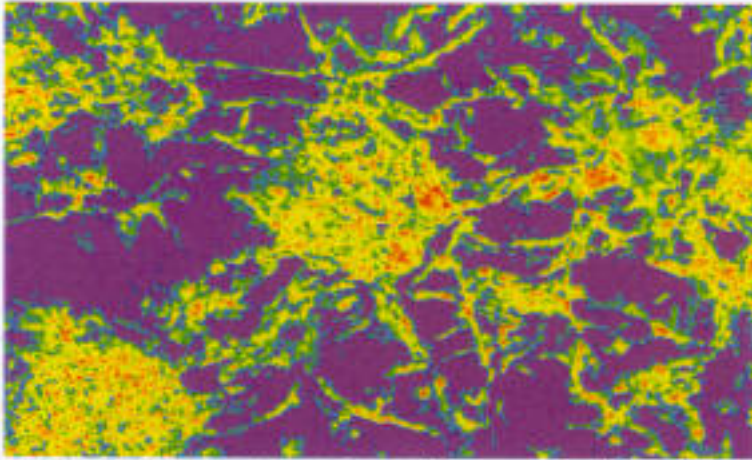


Figure 2- Radial patterns in a chimney slice (Courtesy of Statoil)

This helps validating certain geologic interpretations such as the origination points of hydrocarbons, spill points, reservoir accumulation and gas seepage to the surface. Although these radial patterns are subtle at times, they can be helpful in making proper diagnosis of the chimneys. Figure 3 shows one such example with the hint of radial patterns going outward from the chimney.

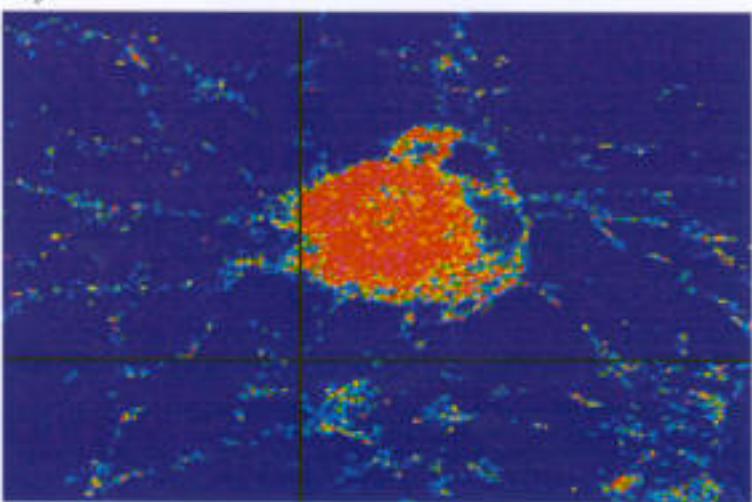


Figure 3- Subtle radial patterns in a chimney time slice

Evidence of leaking faults can also be seen in some cases from chimneycubes. Figure 4 shows a case where some of the chimneys can be traced back to known faults where leakage occurs.

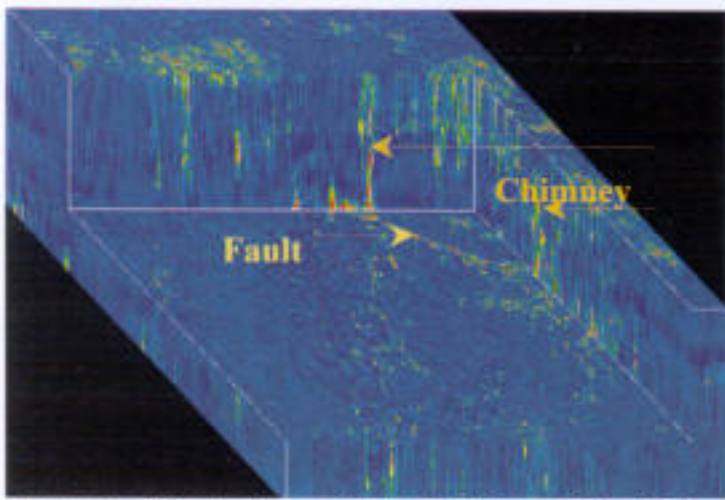


Figure 4- A fault plane with two leaking points highlighted

In general, leaks on the fault are characterized by a collection of small circular patterns of high probability chimney aligned along a fault. Figure 5 shows a clear example of such suspected leaking fault. The most useful results of chimney processing are realized when they are used in conjunction with other conventional or advanced geologic and geophysical interpretation.

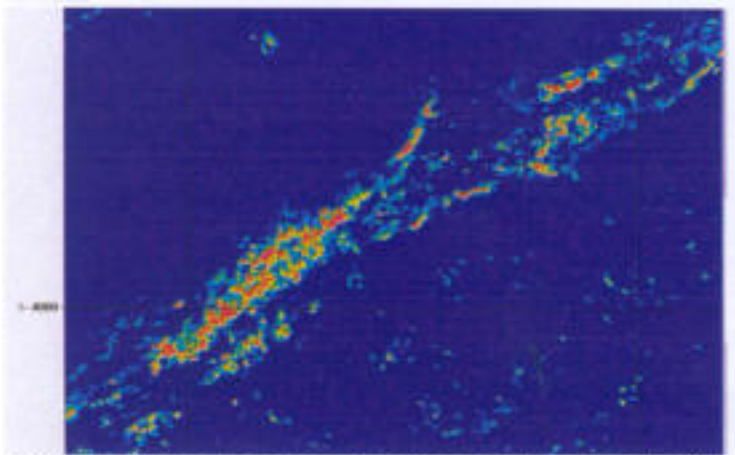


Figure 5- Cross Section of a suspected leaking fault surface

For example to further validate chimneys and their connection with the known faults and structures one can overlay them on geologic models derived from structural interpretation. Figure 6 shows the chimney cloud (in yellow) on top of the structure (red and blue). Here, a deep fault surface (left hand side of lower red structure) and the associate spill point where vertical gas migration (yellow gas clouds) is shown. This hydrocarbon migration could be linked to formation of the reservoir unit under the shallow red structure. Leaks from part of this reservoir create the shallow chimneys (in yellow) leading to possible shallow gas hazard.

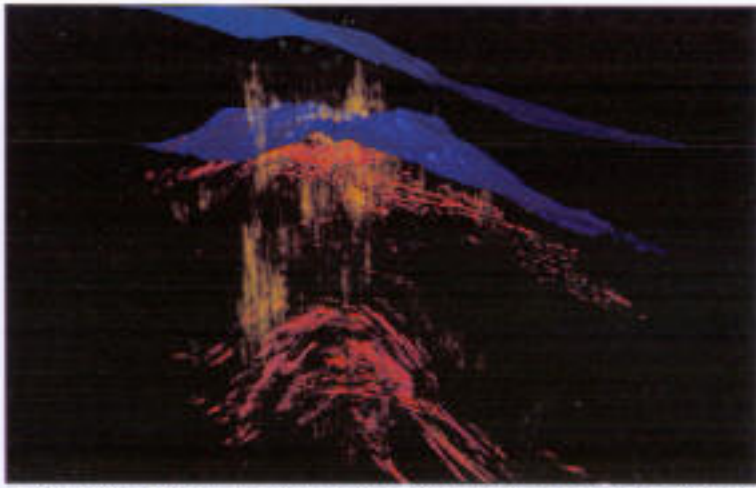


Figure 6- Chimneys (yellow) overlaid on structure (red & blue) (Courtesy of Statoil)

In this newsletter, only some aspects of chimneys are highlighted. Chimney interpretation can also delineate gas prone versus oil prone traps. Chimneys by degassing reservoirs increase the probability of oil reservoirs. The intensity and distribution of chimney anomalies can often be linked directly to the hydrocarbon phase of the reservoir. Chimney cube data can also corroborate, contradict, or provide input into 2D and 3D basin models.

Other applications of chimney interpretation are: ranking prospects, detect reservoir leakage, spill points & sealing versus non-sealing faults, identifying potential over-pressured zones & drilling (shallow gas) hazards and finding areas of suspected sea bottom instability. The same technology can also be used to detect a variety of other geologic objects such as faults, fractures, salt bodies and other seismic anomalies. Although services for these applications are available now, in a few months time a new seismic interpretation system that is developed around this technology will be released by dGB. There is also an industry supported consortium called dTect to further develop and utilize this new interpretation technology. For more details on how to start a pilot project, please contact the author at faz@dgbusa.com or + 1.713.789.2159.

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