Direct Hydrocarbon Migration Indicator, A Venting Feature in Equatorial Guinea

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Summary

Hydrocarbon venting and seepage features are associated with producing fields in Equatorial Guinea, including Zafiro and Alba Fields. The most recent discovery in Equatorial Guinea at CMS Oil and Gas, the Estrella #1, offsets a gas chimney and seafloor venting feature. The sea-floor expression of this vent feature is a crater 400 meters wide and 17 meters deep. A mound 6.5 meters high is present on the north-east side of the crater, and a broader low relief mound of ejected material 1.5 meters high extends over 1.5 km south-west out of site survey area. Pinger records show hydrocarbons within the water column rising from several streams within the crater.

Introduction

It has been stated that in general, hydrocarbon seepage can only effect the risk of encountering hydrocarbons in a basin wide scale (Thrasher, Fleet et al., 1996a). However, the active tectonism and high sedimentation rates present offshore Equatorial Guinea in the Rio Del Rey basin have resulted in seeps vertically near the focused accumulation of hydrocarbons at depth.

At CMS Oil and Gas, evidence of hydrocarbon venting or seepage over a deeper structural trap in Equatorial Guinea is considered a risk-reducing attribute for exploration plays. An exploration 3D survey showed a gas chimney associated with a structural culmination at depth of the Middle Miocene Isongo Formation. The culmination is associated with a toe-thrusted anticline. Offset well ties indicated the presence of good reservoir rock within the targeted interval, and nearby production at Alba indicated hydrocarbon generation in the basin.

A piston core surface geochemical program that concluded in February 2000 by TDI-Brooks International, Inc confirmed active hydrocarbon migration to the seafloor. Two of three cores targeting the seismic gas chimney recovered high levels of extractable hydrocarbons from piston cored samples.

Details of the venting crater were illustrated by the data gathered from a site survey over the Estrella Isongo culmination.

Method and Theory

Identification of venting hydrocarbons over the Middle Miocene Isongo formation structure is confirmed using a variety of data with a wide range of resolution.

A suspected gas chimney was first identified on an exploration 3D survey. This data was acquired in 1995 by PGS using five 3000m cables. 60-fold coverage was recovered over the bulk of the survey, except for an area around an installed platform at Alba field. Shorter 1500m cables were used to get nearer the platform, resulting in a drop of coverage to 30 fold.

The data was reprocessed in 1999 by JDK employing a pre-stack time migration algorithm. An incremental improvement was achieved which has aided in interpreting the highly deformed toe-thrust belt, where the Estrella seep has been identified.

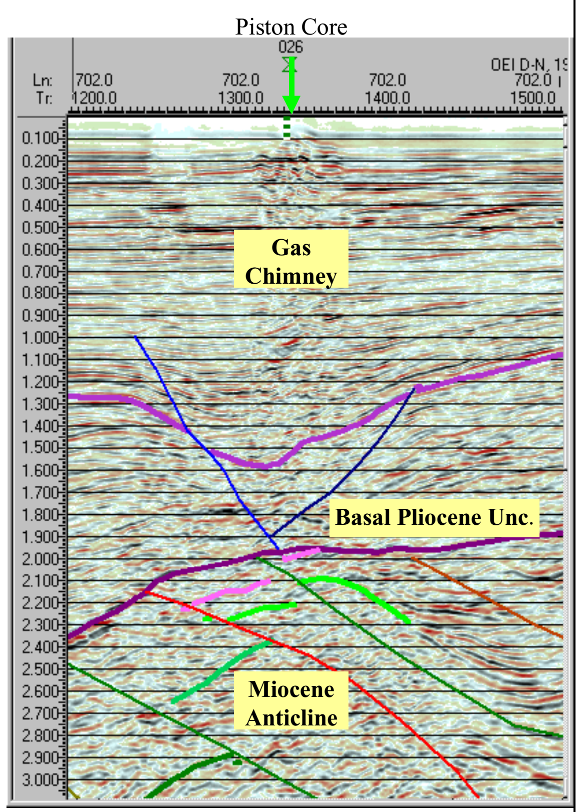

Figure 1: 3D Seismic data showing location of Piston Core #026

Structural interpretation of the 3D volume indicates the gas chimney is located in a Post-Pliocene syncline over a toe-thrusted, middle Miocene anticline. The “hole” on the "hill" apparently results from reactivation of the thrust faults with a normal fault, back slide movement. This counter-regional movement may be attributed to changing loads as the Pliocene section progrades from behind the toe-thrust belt, to loading over the thrust anticlines. As the overlying section slides back, a zone of dilation occurs in the middle of the syncline, which allows vertical migration up the shale prone lower to middle Pliocene section. Horizontal migration is evident in the shallower sand prone section, although much of the hydrocarbons continue vertically up to the seafloor, as is confirmed by piston coring.

On the basis of the 3D survey, an area-wide surface geochemical exploration program was outlined. TDI-Brooks International, Inc acquired 36 piston cores. Three of these piston cores were acquired over the Estrella gas chimney. Two of the three cores (cores #26 and 28) recovered high amounts of extractable hydrocarbon and headspace gas, which qualify them as containing migrated thermogenic oil and gas (Proprietary TDI-Brooks Technical Report).

Geomark provided further geochemical work incorporated with the TDI-Brooks study. Their findings showed core #26, which fell within the crater, with low levels of biodegradation suggesting a rather active seep of hydrocarbons from below.

Armed with the optimism of live oil at the seafloor, two exploration locations were finalized and a site survey was acquired over the area. The survey utilized an echo sounder, sidescan sonar, hull mounted pinger, coring and high-resolution seismic data.

The bathymetry map shows a crater, as described above, associated with the venting of material including the hydrocarbons. The piston core with the highest readings of extractable hydrocarbons, core #26, fell in the middle of the crater. The two other gas chimney targeted cores fell on the flanks of the crater. One had only background levels of extractable organic matter (EOM), while the other contained elevated levels of EOM.

The pinger data showed a broad area of gas charged sediments below the crater, and hydrocarbons in the water column above the crater rising in several streams, Figure 2.

The high-resolution seismic data shows a history of gaseous eruptions recorded in the about 300 milliseconds of section below the seafloor. Data further below is masked by poor returns of the seismic signal.

Conclusions

The geology associated with this venting feature suggests vertical migration of hydrocarbon. The Estrella culmination focuses hydrocarbons within the Isongo sands that are feeding the gas chimney illuminated by the seismic data. Live oil at the seafloor documented by the piston cores highlights the active nature of the seep. The mud prone crater/mound feature suggests a prolific and rapid venting.

Reference

Roberts, Harry H., 1998, Evidence of Episodic Delivery of Fluids and Gases to the Seafloor and Impacts of Delivery Rate on Surficial Geology, 1998 AAPG Bulletin, Vol 82, Iss. 13.

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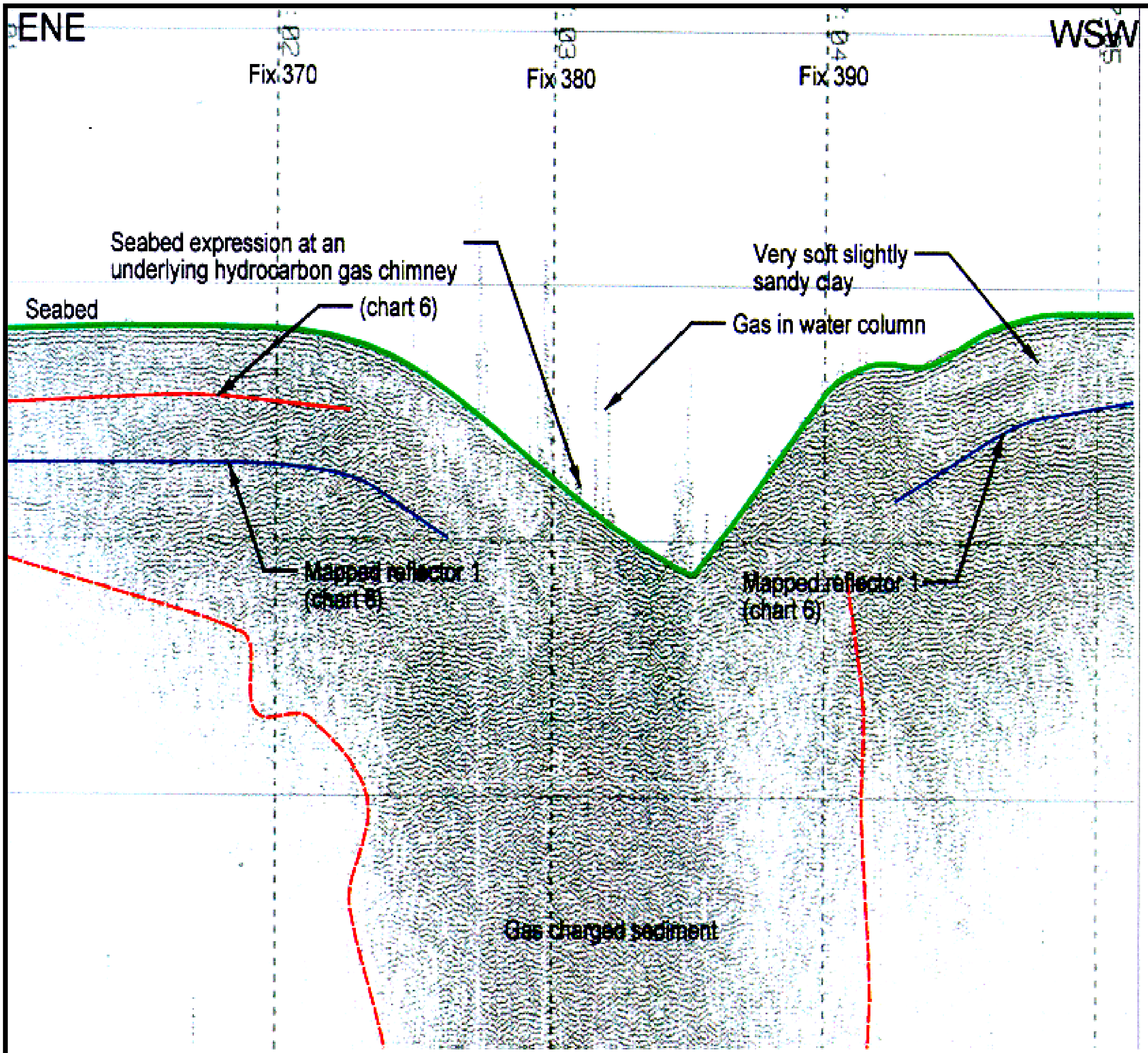

Figure 2. Pinger data showing gas in water column above the crater, and gas charged sediments below.