Migration Pathway Evaluation through Analysis of Hydrocarbon Seeps in the Green Canyon/Ewing Banks Area, Gulf of Mexico

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Offshore data sets afford the possibility of direct migration pathway detection in areas where faults cut directly to the ocean floor. Integration of 3-D seismic surveys, high resolution (3.5 kHz) reflection profiling, gravity-core data, and satellite imagery provides a means of tracing natural oil slicks on the ocean surface to their point(s) of origin on the seafloor and establishing their relationship to fault geometries in the subsurface. The systematic occurrence of seeps along specific structures may be used to delineate effective migration pathways on a prospect scale, particularly where seismic data do not image down to source levels. In this case, mapping the distribution of thermogenic hydrocarbon seeps relative to potential cross-stratal migration pathways is one of the few ways to establish which pathways are likely to be charged from the source.

To ascertain whether certain segments of faults, types of fault geometries or salt diapirs are more conducive to seepage, we constructed a map of seafloor features from seismic and seep intensity data in the Green Canyon/Ewing Banks area (Figure 1, Green Canyon area). Over an approximately 1400 mi^2 area, 135 seafloor mounds were recognized, many of which are associated with strong seafloor amplitude anomalies. Gravity core data in several areas where seafloor mounds were identified from 3D seismic show very high (50,000) MFI values (maximum fluorescence intensity), confirming their interpretation as hydrocarbon seeps. Seafloor mounds lacking gravity core confirmation of hydrocarbons are given the more generic name of “fluid expulsion feature”. In addition, sea surface hydrocarbon slicks occur over many of the seafloor mounds; the slicks indicate activity within weeks of satellite image acquisition, the typical time necessary for surface slicks to be dispersed by evaporation and/or dissolution.

The seafloor features map (Figure 1) shows that seeps generally occur as clusters of individual vents along faults, forming point (rather than line) sources in map view. The clusters consistently occur over areas where salt has ascended to shallow depths. Short, arcuate faults appear to be preferential conduits for hydrocarbon migration from the top or flanks of salt

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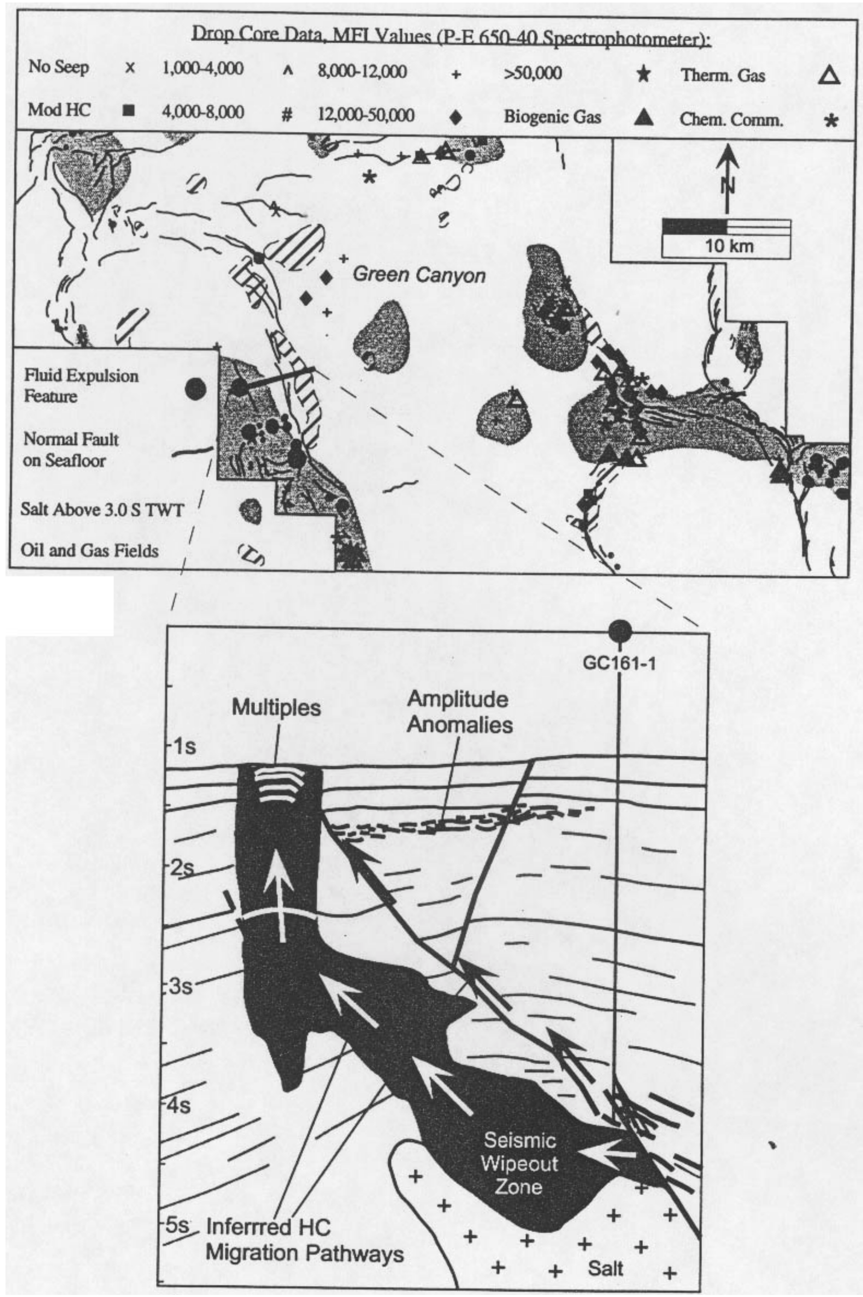
diapirs to the seafloor. Long, branching faults between salt highs do not show seismic evidence for seepage.

The majority of fluid expulsion features in the study area are either fault-tip features (29%) or fault-trace features (29%), with lesser percentage of fault-relay (12%) and fault-intersection (11%) features. Only 19% of the features were not fault related. Almost all of the fluid expulsion features (96%) are associated with a structural element (faults and / or salt) that provided a cross-stratal migration pathway from reservoirs and / or sources to the seafloor.

By correlating seafloor structure with deeper faults imaged by 3-D seismic survey, we present a 3D picture of an active migration system around Genesis (Vancouver) Field using state-of-the-art interpretation tools. Genesis (Vancouver) Field is located on Green Canyon Blocks 160, 161, and 205 and has an estimated 160 MBOE in place from the early Pleistocene Neb, 1, 2, and 3 reservoir intervals. The field occurs adjacent to a NE-dipping normal fault on the flank of a salt-supported anticline that developed on the western side of a major salt-withdrawal mini-basin.

The presence and distribution of hydrocarbon seeps on the seafloor near Genesis (Vancouver) Field is dependent upon the existence of viable source taps and shallow faults that allow hydrocarbons to migrate from salt ascension zones and reservoirs to the seafloor. Specifically, circular mounds indicative of seafloor fluid expulsion are present along the northern and eastern flanks of a salt diapir located south of Gensesis (Vancouver) Field. All of the mounds occur along or immediately adjacent to faults that cut the seafloor. Where mounds are adjacent to faults, seismic wipeout zones with irregular boundaries intersect the faults at depth. The spatial relationship between the seafloor seep, subsurface geophysical anomalies and the faults supports an interpretation of active hydrocarbon charge along and across the seafloor-cutting faults (Figure 2). Whether fluids are migrating up discrete slip surfaces or are being carried in diffuse, disturbed zones that occupy the entire wipeout volume is unclear. However, the systematic occurrence of seeps along seafloor faults lowers the risk for charge into traps in an area where seismic data do not image down to source.



Figures 1 and 2