New Opportunities Offshore West Egypt

SIMON BAER and ØYSTEIN LIE, PGS;
AYMAN ALMORSHEDY, EGAS

Hydrocarbon exploration success offshore Egypt to date is mainly associated with the prolific Pliocene sequence in the Nile Delta Basin, but as the recent Zohr discovery shows, there are other potential plays to follow. Here, we look at the relatively unexplored area of offshore West Egypt.

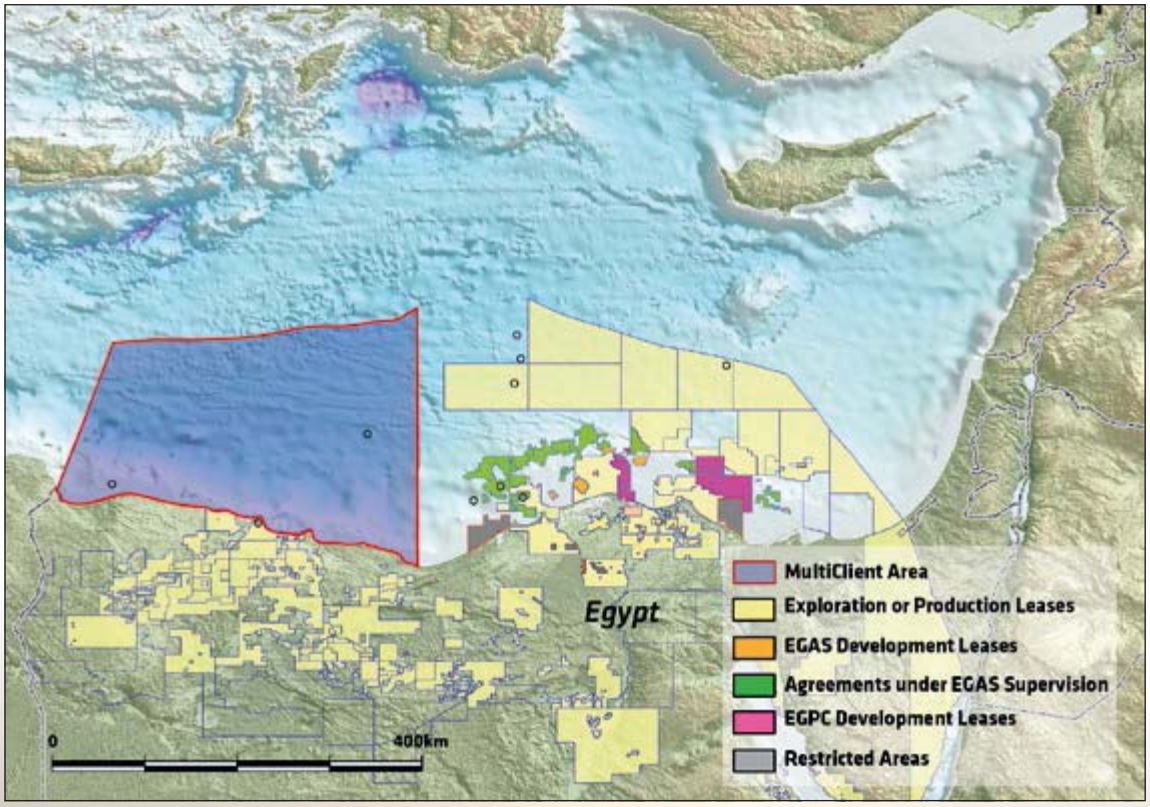


Figure 1: Location map of Egypt's Mediterranean Sea area showing licensed acreage together with the 80,000 km² frontier area west of the Nile Delta.

123rf.com/Mohamed Hanno

The lighthouse in Alexandria looks out over thewaters west of the Nile Delta, an area as yet poorly explored for hydrocarbons.

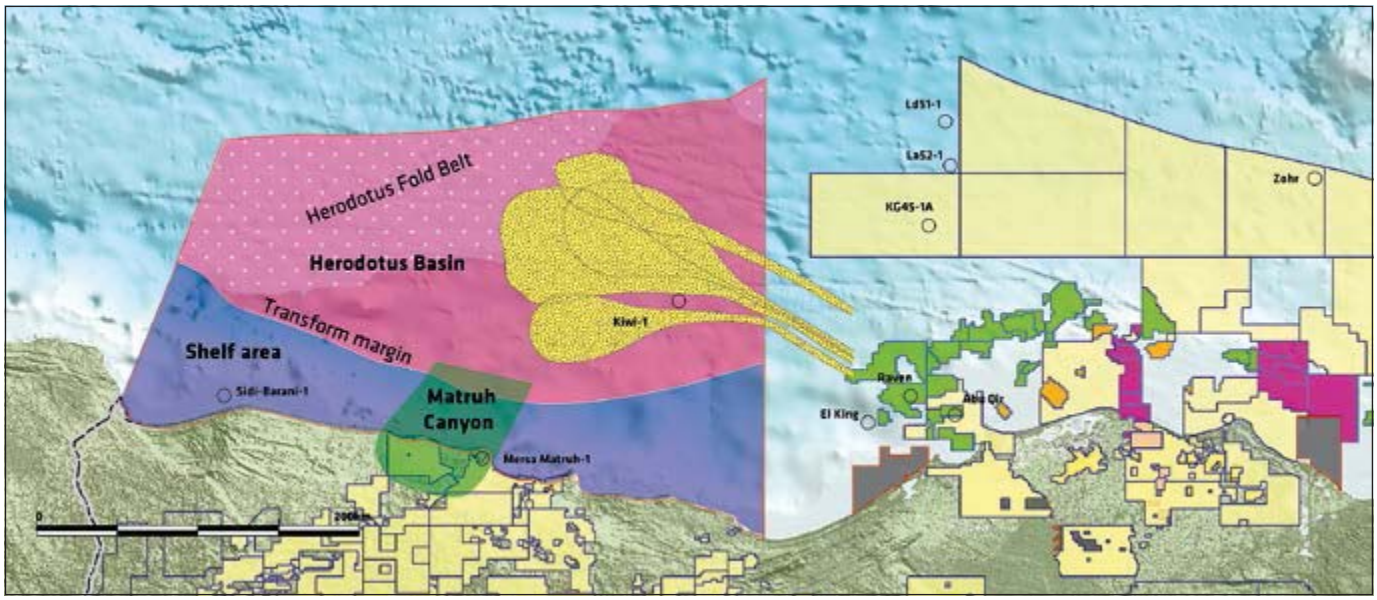


Figure 2: The study area, outlined in red, includes several different geological domains based on interpretation of existing data: the Shelf area, the Matruh Canyon, the Herodotus Basin and the Herodotus Fold Belt. The relevant exploration wells within the survey area and in the vicinity are marked on the map. The yellow stippled areas are potential basin floor fans from the Nile Delta.

The frontier exploration area offshore West Egypt (Figure 1) consists of several structural domains (Figure 2) including, from south to north, a comparatively narrow shelf zone; a west-south-west to east-north-east trending transform margin; parts of the Herodotus Basin; and the Herodotus Fold Belt to the north-west. The onshore extension of this area contains a proven petroleum system for both oil and gas, as evidenced by the Matruh and Emerald fields.

To date, exploration in this large area has been limited, and consequently the petroleum systems are currently not well understood. Only two exploration wells, Kiwi-1 (2010) and Sidi Barani-1, (1976) have been drilled, and both were dry, although Kiwi-1 did prove very good sandstone reservoir properties of Rupelian age (Figure 5). New seismic 2D data acquisition is currently being planned to enable a full assessment of the petroleum system in this area. These data will form the basis for a future licensing round tentatively planned for 2017.

Petroleum Systems

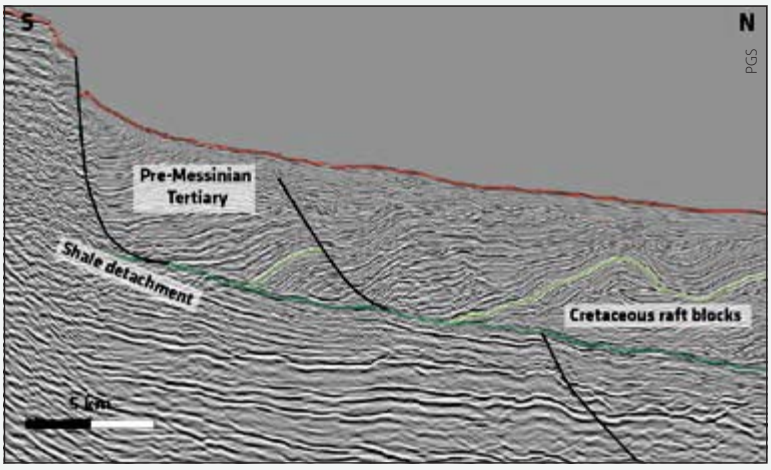
Different potential play types have been identified utilising seismic data, well information and existing discoveries from analogous geological settings such as onshore discoveries in Western Egypt, the recent Zohr gas discovery (Figure 2) or other giant discoveries in the Levant Basin. Play types can be identified in four different geological domains, which are described below and illustrated on legacy lines in time.

Matruh Canyon

The Matruh Canyon is a north-north-east trending Jurassic to Early Cretaceous rift basin, inverted in the Late Cretaceous – Early Tertiary, with a major Early Cretaceous depocentre. Cretaceous raft blocks from the Matruh Canyon can be defined as a structural analogue to the producing post-rift Cretaceous raft blocks from the Lower Congo Basin. The Cretaceous blocks in the Matruh Canyon are rafts on a shale decollement, as seen on the data example in Figure 3, and could potentially be sourced by a deeper source rock from the Khatatba Formation, which is a proven hydrocarbon source for the onshore discoveries. Based on its burial depth, the Khatatba Formation could be interpreted to be partially or entirely in the gas-generation window within this area.

The Matruh Canyon extends offshore down dip from the onshore discovery trend where the Mersa Matruh-1 well, with significant oil and gas shows, is located just onshore (Figure 2). Further seismic evidence for an active deepwater hydrocarbon charge is given by gas chimneys and active mud volcanoes.

Figure 3: Legacy seismic data example from the Matruh Canyon showing the Cretaceous shale decollement (green) and Cretaceous raft structures (light green) which could be sourced from the deeper source rock.



Shelf Area

The comparatively narrow shelf can potentially be linked to the onshore discovery trend, where most reservoirs are found within the Lower Cretaceous Alam El Bueib Formation and in the Jurassic Khatatba Formation. Potential traps can be observed in both formations within the Shelf area. Figure 4 shows a potential lead along a north-west – south-east trending fault that represents the general structural trend in the Shelf area. This trend is perpendicular to the stratigraphic dip, and thus provides potential fault-bounded traps for hydrocarbons migrating up-dip or acts as a vertical conduit for hydrocarbon migration into shallower traps.

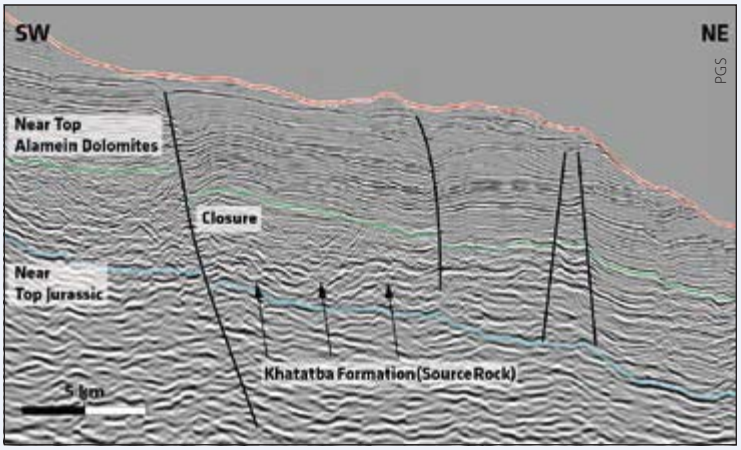


Figure 4: Legacy seismic data example from the Shelf area, an extension of the onshore Western Desert Basin with a proven petroleum system.

Herodotus Basin

The Herodotus Basin is a Tertiary sag basin resulting from the opening of the Neo-Tethys during Mid-Jurassic to Early Cretaceous times and is characterised by the presence of Messinian Salt over nearly the entire area.

The biogenic gas window in the Herodotus Basin is deep due to the low geothermal gradient as a result of the thick Messinian Salt and the old passive margin (20–25°C/km). These conditions allow biogenic gas to be generated and trapped deeper than in other basins, meaning that the reservoirs can contain larger volumes of gas, thus improving the overall economics. These conditions are exceptional but apply to all major gas discoveries offshore the Eastern Mediterranean Sea. Pre-salt structures are observed in the Herodotus Basin, all of which are located within the biogenic gas window. These could be analogous to the giant biogenic gas discoveries seen in the Eastern Mediterranean area such as the recent Zohr discovery, found in pre-salt carbonates. In addition, the cooler conditions also allow a thermogenic system that could generate hydrocarbon liquids and gas at greater depths than might be normally expected in such thick sedimentary piles.

The Zohr discovery appears to prove excellent porosities within parts of the carbonate reservoir and thus highlights the exploration potential in pre-salt carbonates. However, potential pre-salt sandstones could also have high porosities as a result of being subjected to fewer digenetic processes due to the low geothermal gradient. A Miocene sandstone fairway is proven on the western flank of the Nile Delta by wells from the Raven, Abu Qir and El King fields (Figure 2). A more distal down dip extension of this fairway is indicated by RMS attribute maps from a 3D seismic survey around the Kiwi-1 well in the Herodotus Basin. This well failed to find sandstones within the Miocene section, although it found good quality ones within the Oligocene.

Paleogene to Neogene pelagic sediments are considered to be the hydrocarbon source for the potential biogenic gas in the area. Seismic characteristics, such as continuous, layered reflectors, indicate that these pelagic sediments are likely to be well distributed in the Herodotus Basin, and unconformities may allow long distance lateral charge.

The thermal conductivity of the salt lowers the geothermal gradient in this area, which will deepen the generation window for both biogenic gas and thermogenic hydrocarbons. A potential thermogenic play can thus be found in deeper Jurassic carbonate and Early Cretaceous sandstone reservoirs sealed by interbedded shales (Figure 5) and within structural closures as a result of a Late Cretaceous to Early Paleogene inversion period.

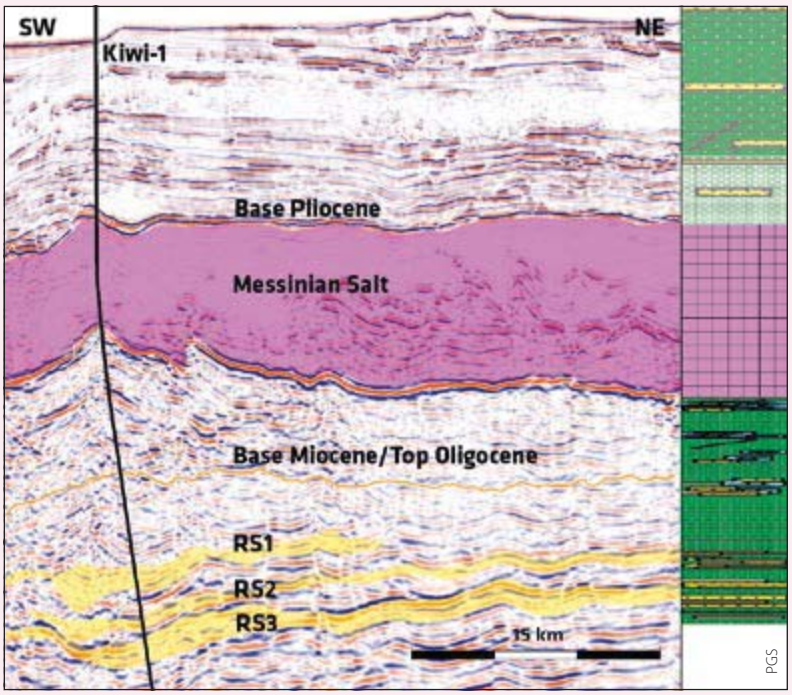


Figure 5: Seismic data example and lithology column through the Kiwi-1 exploration well. Sub-salt sandstones in Rupelian (Oligocene) age (RS1-3) with high porosity values were proven.

Herodotus Fold Belt

The Herodotus Fold Belt is associated with the Mediterranean Ridge and is located in the north-west part of the Aegean Plate (Figure 2). The Messinian Salt is thick and folded in this area as a result of tectonic compression and gravity-driven deformation. Salt-related anticlinal structures can be found within the Pliocene sequence and could form structural traps. The overburden here is sufficient to place any potential reservoirs in the prolific biogenic gas window, so that any traps could potentially contain biogenic gas in economical quantities, whereas the Pliocene sequence in other parts of the Herodotus Basin is likely to be too thin for this to occur. In this area, the Pre-Messinian is not well understood due to a limited amount of data and the challenges related to 2D seismic imaging of strata beneath the thick folded salt sequence.

New Geophysical Data Needed

The existing geophysical 2D and 3D data coverage is limited, and the 2D generally poorly images the subsurface in many areas where it has been acquired. Reprocessing of this legacy 2D data, which consists of three surveys from 1999, 2005 and 2007, is currently being undertaken using up-to-date broadband processing sequences, in which both receiver- and source-side deghosting will be applied. De-noise techniques including demultiple will be very important in addition to pre-stack depth migration to optimise the use of this vintage data.

A new 2D GeoStreamer® broadband data acquisition programme of approximately 5,000 line km has been planned. Combined with the reprocessed legacy data, it is hoped that this will improve the definition and understanding of the structural and lithological trends that have been interpreted using the old existing data. The new data will be positioned in areas where the legacy coverage is poor, such as the south-eastern part of the Shelf area and within the Herodotus Basin (Figure 2). Infill to the existing 2D coverage will also provide better control when identifying and quantifying potential leads. In this frontier area, tie lines to exploration wells outside the survey area will be highly important. Ties from the two exploration wells within the survey area to pre-salt gas discoveries (exploration wells Ld51-1, La52-1, KG45-1A) and an Upper Miocene – Lower Pliocene oil, gas and condensate discovery (exploration well El King) would be valuable (Figure 2). 2D gravity and magnetic data is included in the new acquisition programme planning to further enhance the geological understanding of the area.

Stimulating Further Exploration

The re-processed upgrade of the legacy data, combined with the new broadband data coverage, are essential for defining new play types and are expected to reveal similar potential to that seen in analogous geological settings like the deep Nile Delta and west Cyprus. The seismic data will be the basis for defining new exploration blocks and for future licensing rounds. The objective is to provide both EGAS (Egyptian Natural Gas Holding Company) and the industry with optimum geophysical data, allowing a better understanding of the complex geology and helping stimulating further exploration in the area. ■