

# A clearer path in Lebanon

Amanda Jane, Project Manager Lebanon at NEOS Geosolutions, discusses Lebanon's emergence as a frontier hydrocarbon province and the results of a project to map regional prospectivity.

**T**HE EASTERN MEDITERRANEAN region has generated a great deal of interest in recent years, and not just because of the dynamic geopolitical situation. The petroleum industry has been watching the region with a keen eye, as exploration successes in the offshore waters of the EastMed have many intrigued by the potential riches to be unlocked in this newly emerging hydrocarbon province. Noble Energy's 2010 discovery of the Leviathan field, and the reported 16 trillion cubic feet of natural gas it contains, captured the attention of explorationists worldwide. Other discoveries in the EastMed, including Egypt's 'super-giant' offshore gas field last month and the 5-10 tcf Aphrodite field in Cyprus' territorial waters, have only added to the fervour.

While these recent offshore discoveries make it appear that the EastMed is one of the newest regions on the global hydrocarbon stage, it is, in fact, one of the oldest. Syria has a hydrocarbon history that dates back to the days of antiquity, when bitumen on the surface was used to lubricate stone tools and to waterproof crop baskets. Just a few years ago, Syria was producing 400,000 bpd. At 2.5bn barrels, Syria possessed the largest hydrocarbon reserves of any producer in the greater Levant region, except Iraq.

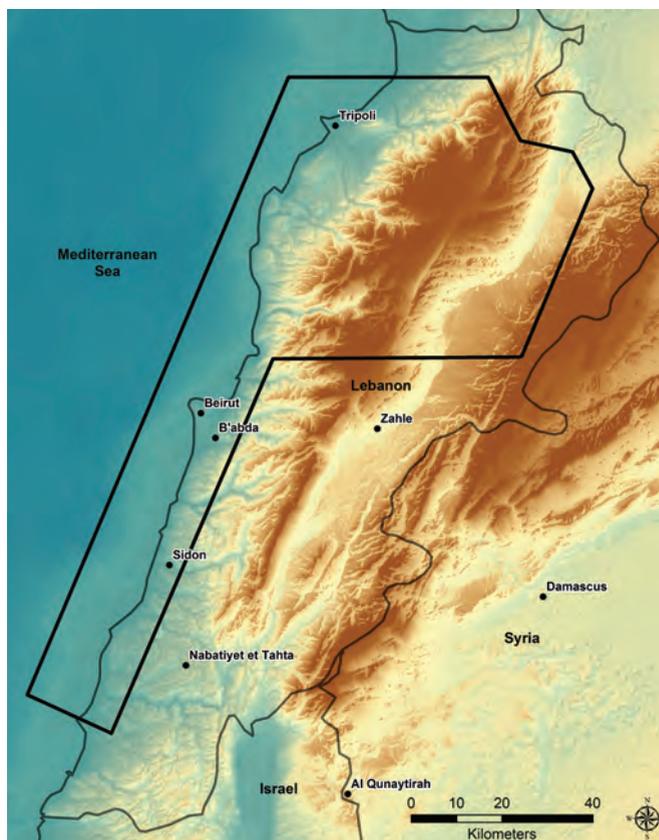
## Growing interest

Sitting squarely in the centre of all this activity is Lebanon, a country known for its rich cultural history, vibrant tourist sector and intriguing political mix, as well as its current role in hosting 1.5mn Syrian refugees. What Lebanon has not been known for, however, is the production of oil and gas. Only seven wells have ever been drilled in the country, all of them onshore, and none of them having ever produced in commercial quantities.

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Interest in Lebanon's hydrocarbon potential began to build several years ago, with the initial focus on the country's offshore prospects in the EastMed just northeast of the Leviathan and Aphrodite discoveries. Spectrum Geophysical and PGS collectively acquired 14,000 line-km of 2-D and 14,000 km<sup>2</sup> of 3-D seismic data. To date, not a single well has been drilled nor has a single lease block even been awarded as political wrangling has brought the entire offshore block bidding process to a virtual standstill.

Having enriched the country's offshore geophysical database, the Lebanese Petroleum Administration (LPA) turned its attention to gathering geophysical measurements and assessing the hydrocarbon



**Figure 1: 6,000 km<sup>2</sup> survey area covering the northern onshore region and near-shore waters of the Eastern Mediterranean**

potential of the country's onshore basins. Initially, the plan was to acquire several hundred line-km of 2-D seismic. However, those plans were scaled back and ultimately never implemented, both because of the geopolitical situation on the ground in certain planned acquisition locations, and because of the challenges to terrestrial geophysical acquisition posed by Lebanon's topography. The country's natural beauty – shaped by rocky hillsides, deep ravines and even snowcapped, 2,500m mountains – are not well suited to seismic vibrator trucks or dozens of juggernauts hauling tons of seismic acquisition gear.

To sidestep these challenges, the LPA turned to NEOS and its local Lebanese partner, Petroserv, to propose an alternative path. The Plan B option that was identified involved acquiring a suite of

airborne geophysical measurements – including gravity, magnetic, radiometric and hyperspectral – complemented by sub-surface regional resistivity data acquired using ground-based magnetotelluric (MT) receivers. The two-month acquisition operation over a 6,000 km<sup>2</sup> area of investigation in the northern onshore portion of the country and its near-shore coastal waters concluded earlier this year (Fig. 1). Once processed, the acquired measurements were integrated and simultaneously interpreted with other legacy geological and geophysical (G&G) datasets, including logs from two of the wells in the study area along with some of the offshore seismic data.

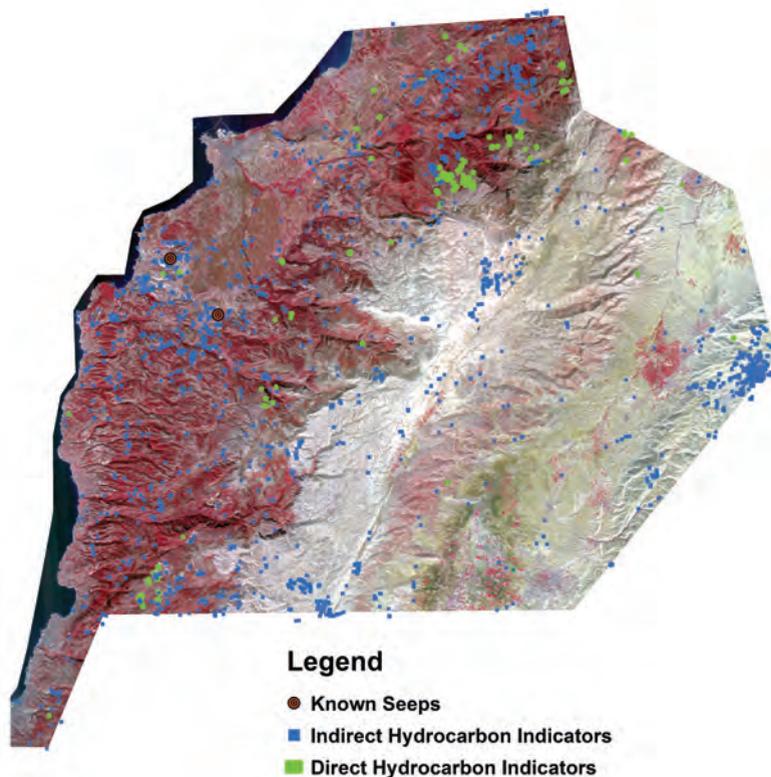
“ The initial results of the multi-physics project appear to support additional investments in data gathering and G&G analysis ”

**Promising results**

The results, which were shared with the LPA and several cabinet ministers in June, appear very promising. Perhaps the biggest surprise came from the hyperspectral measurements (Fig. 2), which are used to search for indirect and direct hydrocarbon indicators on the surface. The hyperspectral data identified mineral alteration zones often associated with hydrocarbon micro-seepage in large parts of the survey area. Even more telling, the hyperspectral data indicated a large expanse of oil seeps throughout much of the area of investigation. The sheer number of these seeps and their locations along newly mapped fault networks and along the boundaries of key stratigraphic intervals suggest we are dealing with an active (and potentially liquids-prone) hydrocarbon-generating system beneath Lebanon.

Peering down into the subsurface, the interpretation of the multi-physics measurements revealed some other intriguing attributes often associated with prospective frontier exploration areas. These include:

- Evidence of multiple source rock intervals, including those believed to be hydrocarbon-generating in Syria and in the Southern Levant immediately south of Lebanon;



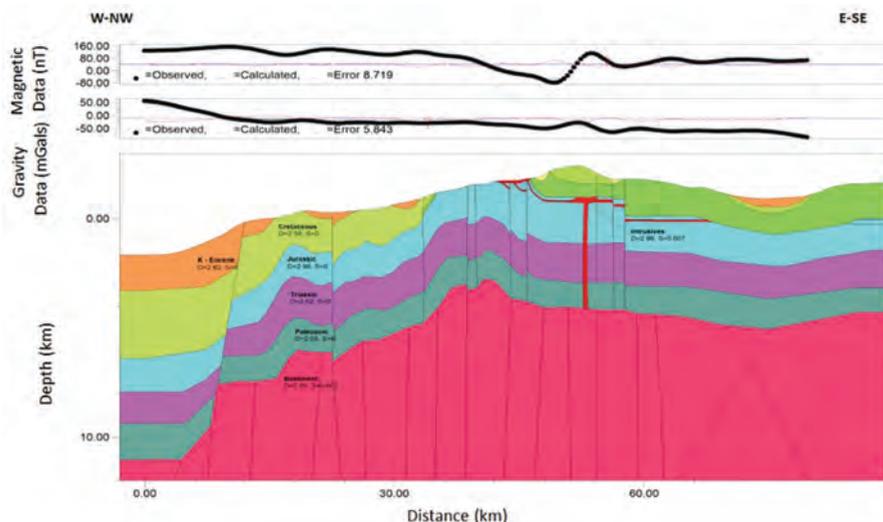
**Figure 2: Airborne hyperspectral imaging revealed direct and indirect hydrocarbon indicators, including oil seeps, over a large portion of the survey area**

- Evidence of sedimentary depo-centres, reservoir rocks, and typical structural trapping mechanisms such as anticlinal closures and prospective reservoir intervals abutting faults (Fig. 3);
- Evidence of resistivity anomalies within several of the structural traps, potentially indicative of hydrocarbon charge within the prospective reservoir intervals.

The features described were observed at different intervals within the geologic column and in different parts of the area of investigation – including along the nearshore coastal waters of Lebanon – suggesting a variety of potential exploration play types (including both gas and oil plays) might exist in the country. The multitude of plays and the stacked nature of a couple of them – all of them now highgraded following this project – serve to de-risk the overall exploration opportunity.

Although Lebanon is in the earliest stages of the exploration cycle, the initial results of the multi-physics project appear to support additional investments in data gathering – including targeted seismic acquisition – and G&G analysis to further highgrade the opportunity areas and to identify potential prospects for an initial wave of exploratory drilling, to extend the science ahead of formal tendering processes.

More remains to be done to de-risk the plays in Lebanon, but we may finally have a clearer path forward and be able to celebrate the birth of the country’s oil and gas industry. ■



**Figure 3: Multi-physics modelling work revealed several promising structural features, including anticlinal highs (adjacent to faults) in the thick Triassic and Paleozoic intervals**