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# WORLD ENERGY

Monthly Review



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# The Next El Dorado

by William A. Bartling

## Geology and Petroleum Potential of Israel and the Levant Tectonic Province

Israel is part of a tectonic province at the eastern end of the Mediterranean Sea referred to as the Levant, which was formed by the rifting of the Tethys Sea, convergence of the Eurasian plate and eventual rifting of the African continent. Besides Israel, the Levant includes the countries of Lebanon, Syria and Jordan. The area is today focused along the Dead Sea and Jordan Rift Valley, which is about 360 kilometers long, trending roughly north-south, and is the depression in which the Jordan River and Dead Sea reside. In addition, the regional Syrian Arc fold belt created a series of northeast-southwest structures of which the Judean and Samarian Mountains are a part. This region has been dominated by carbonate, evaporate and clastic deposition since the pre-Cambrian, with major structural development and volcanism in the Mesozoic and Neogene.

## Petroleum Production History, Discoveries and Activities

Unlike its neighbors to the east, Israel does not have a history of prolific petroleum discovery and production. With its production of 80 barrels per day from proven reserves of 3.9 million barrels – and little hope of improvement – and its 260,000 bbl/day consumption, it is likely to remain a net importer of petroleum products.

In 1952, Israel established legislation to govern exploration and development, revising these laws in 1965 to encourage

foreign investments. In support of this, the country has leased a number of regions both on and offshore.

Since 1947, 470 wells have been drilled in Israel, the deepest reaching 21,000 feet. The first exploratory efforts tested surface geology and major gravity anomalies. Various reports by major oil companies considering entering Israel for exploration have estimated potential reserves in Israel to be as much as 2 billion barrels. In 1986, Israel created a comprehensive basin analysis study, compiling all of the data and maps related to the historic efforts, and they made only a few copies available to certain companies in 1988. Current drilling is being done dominantly by small, Israeli publicly traded firms and U.S. independents.

There have been two notable discoveries in Israel since 1999 by Samedan Mediterranean, an affiliate of Noble Energy, which found economic gas production in the Mari A and B offshore fields. Ultimate reserves from these two fields are estimated to be 1.5 trillion cubic feet of gas. The operators began production in December of 2003, and their platforms are expected to produce a maximum of 170 million cubic feet per day. An exploratory well on an adjacent concession operated by BG was abandoned as noncommercial.

Onshore, two American oil companies (Zion Oil and Gas and Ness Energy International) have been exploring around the Dead Sea areas based on historical marginal discoveries, new imaging and interpretation technologies and clues from the Old Testament. Ness has recently acquired the rights to 30,000 acres under the historic Zoar gas field, which produces from Jurassic mixed carbonates and clastics.

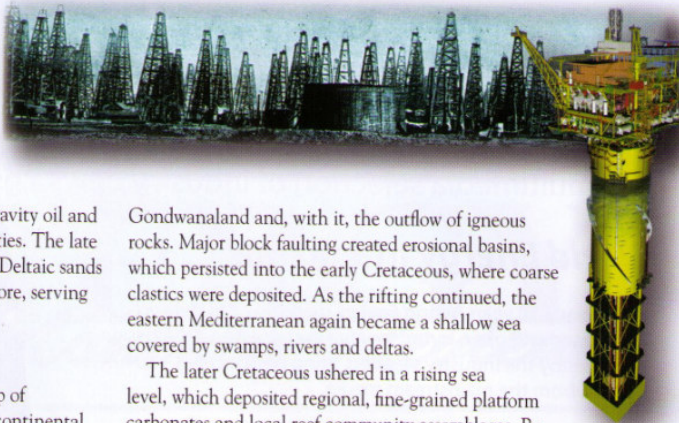
## Market

Israel is a thriving economy, and its consumption of 260,000 barrels per day earns the nation the rank of 45th largest oil-consuming country in the world. With self-sufficiency still so far out of reach, it seems unlikely Israel will achieve exporter status anytime in the near future. If major oil discoveries were made that exceeded Israel's consumption capacity, however, ready global markets would be available. Notable among these would be the United States, to whom the country currently owes a debt of nearly \$70 billion, and Europe. The country's local geographic neighbors are mostly net petroleum exporters, thus are not a ready market.

## Reservoir and Fluids

The established petroleum-containing reservoirs onshore and in the Dead Sea are in Jurassic sandy limestones (gas), Upper Cretaceous mixed submarine-fan clastics and carbonates (oil) and Pliocene submarine-fan sandstones (offshore gas). The first offshore wells drilled in the Mediterranean targeted Cretaceous to Jurassic formations. The deepest well drilled in the country bottomed in Triassic rocks and produced limited asphalt. The dominant and most economic hydrocarbon fluid





discovered to date is natural gas, although high-gravity oil and asphalt have also been discovered in small quantities. The late Pliocene saw rising sea levels, which allowed Nile Deltaic sands to run down submarine canyons into today's offshore, serving as natural gas reservoirs.

### Tectonics and Structural Development

The Levant's structural origins date to the breakup of Gondwanaland, when it was situated as a passive continental margin at the edge of the Tethys Sea. This provided a stable tectonic environment until the Mesozoic, when thrusting from the north created regional folds. In the Neogene it was disrupted by rifting and lateral faulting, resulting in the Dead Sea Rift. The Dead Sea Graben is an extension of the world's largest graben system, the East Africa Rift zone, which is rapidly diverging in the Afar triangle to the east.

One of the major regional features is the Syrian Arc, which is a system of northeast-southwest, asymmetrical, anticlinal folds (with the steep side on the south) that began forming in the Upper Cretaceous, with subsequent stages in the Neogene that developed prominent structures in the Coastal Plain. Concurrent with this deformation was the development of east-northeast, west-southwest reverse faults with displacements of up to 1 kilometer, which form major folds and flexures.

The Africa-Arabia split, which broke Israel away from Arabia as a separate plate in the Oligocene, created the Dead Sea Rift and a transform fault that progresses Arabia northward relative to Israel. The Dead Sea Rift is bordered by faults with up to 2.5 kilometers of vertical and hundreds of meters of left-lateral displacement active after the Miocene and continuing through today. This prominent feature includes the Dead Sea, the Jordan Valley and the Sea of Galilee and has remained a topographic low since its inception, forming volcanic and sedimentary basins. The eventual closing of the eastern boundary of the Mediterranean Sea, isolating it from the Indian Ocean, was followed by a falling in sea level that enclosed the Mediterranean and created a large evaporite basin. Continued volcanism and rifting deposited lavas into the Mediterranean basin and across northern Israel.

### Stratigraphy

The base of the section is metamorphic rock of Precambrian age that forms the Arabian Shield, the northern tip of which is exposed in southern Israel. The early Paleozoic era was dominated by sands and gravels deposited on the Precambrian in fluvial environments and, in the early Cambrian, local dolostones. Non- and shallow-marine conditions persisted until the Jurassic, albeit with profound faunal changes at the beginning of the Mesozoic, with deep erosional channels developing and filling with deep marine sedimentary rocks.

The Jurassic marked the beginning of the breakup of

Gondwanaland and, with it, the outflow of igneous rocks. Major block faulting created erosional basins, which persisted into the early Cretaceous, where coarse clastics were deposited. As the rifting continued, the eastern Mediterranean again became a shallow sea covered by swamps, rivers and deltas.

The later Cretaceous ushered in a rising sea level, which deposited regional, fine-grained platform carbonates and local reef community assemblages. By the end of the Cretaceous, regional tectonism created highlands that contributed continental-sourced sediments to the deepening basins. This was a time of heightened organic accumulation in the deep basins, some of which achieved phosphatic states. Continuing lowering of sea level throughout the Paleogene deposited argillites, filling canyons and valleys over the Mesozoic carbonate marine rocks.

The Neogene introduced the Dead Sea Rift and the opening of a seaway to the Mediterranean along the Red Sea. Regionally, extensive erosion by the encroaching sea deposited conglomerate and shallow marine carbonates, alternating with sub-aerial deposits containing a rich array of mammals. Seaward, alternating clastics and chalks were being deposited in an area that is now offshore Israel in the Mediterranean Sea. In the latest Miocene, the sea was cut off, causing the deposition of evaporites intercalated with volcanics.

The end of the Miocene marked the closure of the seaway to the Indian Ocean, and the Mediterranean was born. Predominant deposition of evaporites was interrupted occasionally by volcanics. The rifting created a regional low in the Dead Sea, where a continued evaporitic process deposited more than 4 kilometers of salt.

### Oilfield Structures

The recent discoveries in the offshore of Israel have been on closed structural highs that were imaged using modern seismic methods. The setting of platforms by Noble and partners indicates a mature petroleum system complete with source, reservoir, trap and seal.

Even with the new discoveries, oil and gas exploration in Israel remains highly risky. While there are several efforts under way, a long history of studying these basins has uncovered only a small quantity of oil and, recently, two economic gas fields. Modern methods of exploration may, however, reveal some well-hidden secrets. Certainly Israel would benefit from any new discoveries, and there are at least two companies whose business mission is to provide them with new reserves. ♦

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