A Fresh Look at the Oil and Gas Potential of Greece

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With a working petroleum system in place, proven by the Katakolon discovery and a number of oil shows, seeps and gas leaks, Western Greece is ready to be explored.

Petroleum Geo-Services (PGS) in collaboration with the Greek Ministry of Environment, Energy and Climate Change conducted a 12,500 line km offshore 2D MultiClient GeoStreamer GS™ seismic survey during late 2012 to early 2013, which included the Ionian Sea, West Peloponnese, and south of Crete with total area coverage of 225,000 km^2 (Figure 1). GeoStreamer GS acquisition technology increases data bandwidth and improves illumination of deeper targets. Marine gravity and magnetic data were also acquired and will be integrated into the interpretation work.

At least 6,000 km of key legacy data lines are being reprocessed to complement and enhance the new seismic coverage in shallow/coastal areas and tie with onshore stratigraphy. Seismic data processing of the PGS data continues with the PSTM stacks available by the end of 2013. All of the data, including vintage 2D data, will be conditioned and matched into the Greece MegaProject which will form the basis for the seismic interpretation and data packages for the 2014 bid round.

Greece is preparing for a new offshore licence round. The nearby Italian and Albanian discoveries and fields may be valid analogues since they share much of their geological history with offshore Greece.

Exploration Activity in Greece

Exploration work in Greece began in the late 1930s. In the 1960s, the Greek state and its advisor I.F.P. conducted geologic studies that resulted in the drilling of two exploratory wells targeting the top carbonates and the pre-Triassic evaporite sequence (IGRS-IFP, 1966). In the late 1970s the Prinos oil and gas field was discovered and then in the 1980s more exploration work carried out by the Public Petroleum Corporation of Greece (DEP, DEP-EKY) led to the Katakolon and Epanomi oil and gas discoveries. In 1995 the First Licensing Round was launched with further onshore and offshore exploration work and surveys in four concession areas continuing until 2000. The 2012 'Open Door Invitation' for blocks onshore Ioannina, offshore West Patraikos Gulf and Katakolon in Western Greece attracted several international and domestic operators and partners. Currently, Greece has offshore oil and gas production in the Kavala and Prinos fields in the Northern Aegean Sea.

Geological Overview and Petroleum Systems

Western Greece belongs to the **Hellenides**, part of the Alpine Mediterranean Orogenic Belt (Alpes, Dinarides, Albanides and Hellenides). The External Hellenides consist of north-north-west to south-south-east trending geotectonic zones that are part of the fold and thrust belt system of Western Greece (Marnelis et al., 2007). After vast deposition of Triassic evaporites and platform carbonates, basin development began in the Early Jurassic due to crustal extension affecting the southern Tethyan margin. To the west, play types are controlled by thrust belt tectonics and related foreland basins, while to the south and south-western offshore play types are controlled by the Hellenic accretionary prism, including the forearc and Mediterranean ridge of the Hellenic subduction zone.

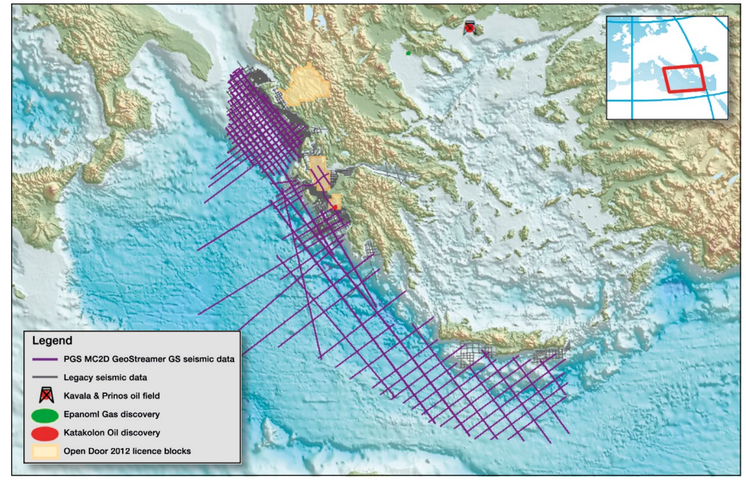


Figure 1: A map of Greece illustrating the 2D GeoStreamer GS™ seismic data (purple), the legacy data (grey), the 'Open Door Invitation' blocks (orange), in addition to oil and gas discoveries and the producing field.

The **Ionian** geotectonic zone is the outermost deformed part of the External Hellenides fold and thrust belt. It comprises three stratigraphic sequences documenting the evolution of the Ionian from a neritic carbonate platform environment to a pelagic basin that are attributed to pre-, syn-, and post-rift stages (Karakitsios, 2003). The lowermost sequence consists of a thick Triassic evaporite series, in parts brecciated, overlain by Upper Triassic to Lower Jurassic shallow-water limestones. The syn-rift sequence reflects a general deepening of the area, i.e. the formation of the Ionian Basin, with shales (Posidonia) and limestones being deposited into differentiated basins with half-graben geometries and subject to differential subsidence. The post-rift sequence consists of Lower Cretaceous to Eocene basinal limestones and paleo-margin ward thickening brecciated limestones overlain by a clastic succession of uppermost Eocene to Lower Miocene (Flysch deposits, Bellas et al., 1995; Bellas, 1997), a Mid-Miocene molassic series and younger sediment cover (Figure 2).

The **Katakolon** oil discovery located in Upper Cretaceous to Paleocene/Eocene carbonate reservoirs of the Ionian Zone is sealed by Plio-Quaternary shales (Figure 3). The Albanian Marinez discovery may serve as an analogue here, extending the area of interest from Western Peleponnesus in the south up to the northern tip of Western Greece.

North-west Greece offers folded and well-sealed anticlines. Similarities are seen in the Albanian Delvina gas condensate discovery in Cretaceous-Paleogene carbonate reservoirs, which are trapped in Oligocene Flysch sealed fold-belt anticlinal structures (Figure 4).

The **Apulian** geotectonic zone, including the Apulian Platform and the Paxi (or Pre-Apulian) zone, is the westernmost undeformed part of the External Hellenides and is being overthrust by the Ionian geotectonic zone to the east. The Paxi zone on the eastern margin of the Apulian carbonate platform is composed of three primary packages. The first is alternating strata of Upper Triassic to Middle Jurassic dolomite, limestone and anhydrite deposits overlain by Upper Jurassic to Lower Cretaceous slightly cherty and marly limestones deposited contemporaneously with the Ionian Basin development (Figure 5). The second is Cretaceous through Paleogene to Lowermost Miocene locally brecciated shallow-water carbonates with slope and basinal marlstones, sands and shales. The third package consists of Langhian to Recent molassic sediments which are alternating marl, sand and shale. Main tectonics occurred at the Miocene/Pliocene base. The Apulian Platform and its marginal areas offshore Northwest Greece offers several targets. Further to the north of the platform the Italian Rospo Mare heavy oil discovery is found in karstified limestones of the actual platform and the Italian Aquila oil discovery is structurally trapped in redeposited carbonates off the Apulian platform margin.

The south of **Crete** is a frontier area exhibiting the complete

Figure 2: A stratigraphic column of the Western Greece, Ionian zone. (After Bellas et al., 2012)

Geologic time	Geology/Formation	Source	Reservoir	Seal
Plio-Pleistocene	Clays/Sandstones/Conglomerates			X
L. Miocene-E. Pliocene	Marls/Clays/-Sandstones		●	X
E. Miocene	Shales/Sandstones	◆		X
Oligocene	Flysch (Claystones prevail/Silt-Sandstones alternations)			X
L. Cretaceous-Eocene	Breccias Limestone		●	
E. Cretaceous	Pelagic limestones with intercalations of cherts & marls (VIGLA)	◆		
M.-L. Jurassic	Posidonia Shales	◆		
E. Jurassic	Shallow-water carbonates		●	
L. Triassic	Evaporites - Breccias (Andrite & salt with intercalations of Dolomite, limestone & shales	◆	●	X

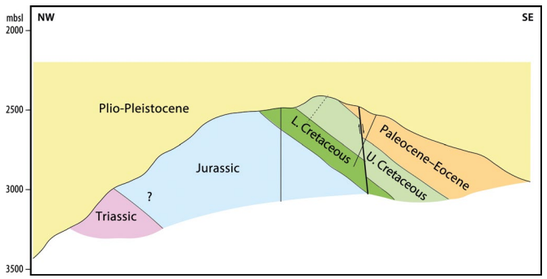
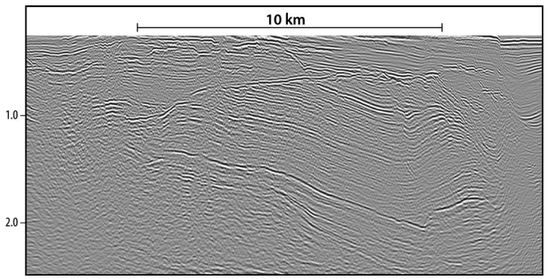


Figure 3: A schematic cross section through the Katakolon discovery. (Modified from Public Petroleum Corporation, 1995)



An analogous example (preliminary reprocessed PSTM seismic stack) from the North Ionian area.

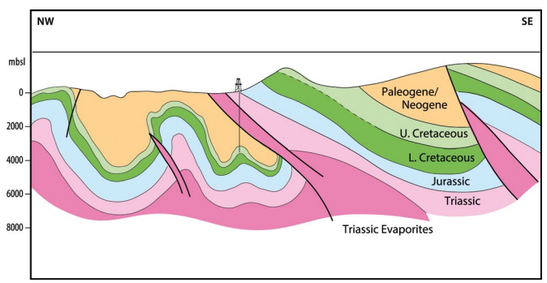
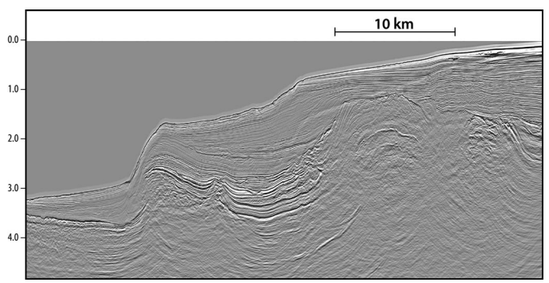


Figure 4: A schematic cross section through the Delvina discovery. (After Prenjasi et al., 2011)



An analogous example (preliminary PSTM seismic stack) from the North Ionian area.

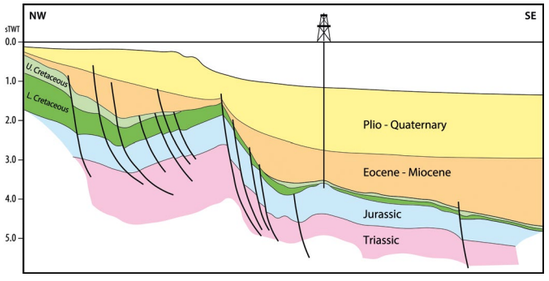
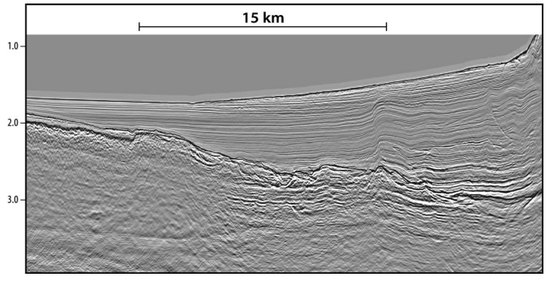


Figure 5: Interpreted cross section through the Aquila discovery. (After Casero, 2004)



An analogous example (preliminary PSTM seismic stack) from the North Ionian area.

lateral succession of an ocean-arc boundary: from the Mediterranean Ridge forming the outer part of the Hellenic accretionary prism with all its wedge-top basins to the forearc basins of the Hellenic trench system and finally the Hellenic fold and thrust belt. Mesozoic to Pliocene to Recent sediments, including Messinian evaporites, are found directly south of Crete. Published descriptions of mud volcanoes as well as gas emissions and their geochemistry indicate active thermogenic systems with potential for hydrocarbon accumulation.

2014 Bid Round

Greece is now preparing for an offshore licence round, expected to be launched in Q3 2014. The country offers political stability and an EU transparent framework for hydrocarbon exploration. Interpretation of the new geophysical data will be the basis for delineation of exploration blocks, which will cover all the areas from Western Greece (Ionian Sea) to the south of Crete. The oil and gas legal framework offers an investment-friendly platform and incorporates current developments and international best practices. The lease duration is 25 years with extension possibilities of five plus five years and a standard tax and royalty-based fiscal regime. ■

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For more information: www.ypeka.gr/Default.aspx?tabid=765&language=en-US and www.pgs.com/en/Data_Library/North_Africa___Middle_East/

References:

A complete list of references will be available on www.geoexpro.com