An Intergrated Approach to Shallow Gas Exploration; A Case History of the Use of Electrical Methods, Thrace Basin, Turkey

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Summary

A broad range of exploration methods were applied to the search for shallow gas accumulations in the Thrace Basin, west of Istanbul. The methods ranged from satellite imagery, geomorphology, surface geology, through electrical to seismic surveying. At each stage areas were relinquished and efforts concentrated on those more prospective. Resistivity surveying was used to localize the prospective target zones, with Electromagnetic Imaging and 2D seismic applied to determine the target depth and geometry.

Introduction

The basin is located west of Istanbul, in European part of Turkey, and is a triangular intermontane basin, filled with middle Eocene to Pliocene deposits. Total sedimentary thickness is approximately 8,000 meters. The section is mainly a sand-shale sequence with some limestone stringers and occasional tuffs.

The Thrace right-lateral wrench fault system formed prior to the Pliocene and had become inactive by the Pliocene. Strike-slip fault zones with normal and reverse separation were detected by seismic reflection profiles and other subsurface data. As the system became inactive, the motion on the North Anatolian fault zone began to be accommodated in the Marmara Sea region. Thus, the Thrace fault system represents the oldest strand of the North Anatolian fault to the west of Istanbul. Releasing-bend extensional structures and restraining-bend compressional structures, are abundant along the fault zones.

The target is the shallow (300 to 1000 meter depth) fluvial deposits such as channel fills, point bars, distributary mouth bars, etc. These traps are subtle structural, stratigraphic and can also be a combination of structural – stratigraphic features.

Exploration Methods

Regional satellite imagery and geomorphological studies, and also using available regional gravity together with surface geological mapping, were used to select the most prospective areas, leaving approximately 50% of the original area for further investigation. The bulk electrical conductivity (inverse of resistivity) of the selected areas, was mapped by carrying out extensive roving dipole-dipole surveys. This method employs a fixed transmitter dipole, and one or more roving receiver dipoles. These receiver dipole stations are generally on a 500 x 500 meter grid pattern. Thus the bulk electrical conductivity of a large area can be mapped quickly and efficiently (Menezes et al., 2003, Zhdanov, 1994 & Spies, 1983).

The geological, or rather geochemical, feature sought, is the locally geochemically altered zone, or “plume”, often associated with the presence of gas accumulations. The presence of the gas in the rock, locally alters the reducing – oxidizing (Redox) environment, and causes various minerals such as, clays, pyrrhotite, pyrite, magnetite, etc. to be precipitated. These minerals change the electrical conductivity of the soil and rocks in the near surface (Barker, 1999 & 2000, also Eventov, 2000).

The most promising areas selected on the basis of the electrical conductivity information, are then tested using time domain ElectroMagnetic imaging (Tasci & Jordan, 1996, Tasci, et al, 1997 & Keller et al, 1984). This method uses a fixed transmitter dipole, which transmits an electrical current square wave into the earth. One or more roving receivers record the vertical component of the transient magnetic response of the earth. The EM imaging recording sites are generally at a spacing of 200 to 300 meters. Information from these data are used to define the location of the target, and give an estimate of its depth.

Simultaneously with the EM imaging survey, a geochemical gas analysis survey is carried out, with samples taken from a depth of 1.5 meters. Using the same sample holes, and crew, temperature measurements are also made.

Finally, should the target appear to be structural in nature, 2D seismic lines will be run over the target to define the geometry and depths.

The information gleaned from all these surveys is then used to assess whether the target found has a favourable geometry for the geological model envisioned, and whether it has an indication of a gas accumulation associated with it. A well may then be drilled.

Conclusions

The strategy utilized methods most efficient, in both cost and time, to localize a specific suite of subtle shallow targets. Each method, based on a detectable property of the target, was required to furnish information well within the capability of the method.

The overall 91% drilling success rate and low costs obtained using these methods in a well defined strategy, tailored to the local geological environment and targets, is probably its best recommendation.

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