COAL EXPLORATION FOR UNDERGROUND GASIFICATION (UCG) – IT'S ALL ABOUT PLANNING

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1. Introduction

The unconventional use of coal to supplement Natural Gas (NG) in the power and chemical industry makes Underground Coal Gasification (UCG) an important technology in economically producing unconventional gas. Present day exploration and production technologies pave the way "*from a potential to actual production*".

A 3D seismic survey has been applied in Southern Hungary for the site selection of UCG resource blocks, as well as in the design of the most optimal exploration drilling program. The latter exploration techniques directional drilled injection and production wells are planned in the coal seams to sustain the burning front.

Wildhorse UCG Kft is a pioneer in the design and introduction of environmentally friendly coal-based syngas for electric power generation in East-Central European countries. Additionally the syngas can be utilised to supplement national gas supplies as an alternative fuel gas. In this paper the role of 3D seismic measurements is discussed in defining the "Mecseknádasd UCG project".

Wildhorse UCG Kft completed 3D seismic measurements in April and May of 2011 in the Mecseknádasd UCG project area. The goal of the seismic measurements is to image and clarify the structural conditions and to reveal faults and other discontinuities in the coal formation explored previously by historic deep drilling in the area.

1. Mecsek Hills Project

The Mecsek Coalfield is located in south-west Hungary approximately 220 km from Budapest on the northern edge of Pécs. This city is a regional centre at the coalfield's south-west corner. A number of smaller towns are also located around the coalfield's periphery. The region is well connected to other parts of Hungary and surrounding countries by national road and rail networks.

The project covers an area known as the Mecsek Coalfield, a Mesozoic coal complex which is a remnant block of pre-Tertiary rocks within the Tertiary Pannonian basin. The area has seen significant historic coal production over a period which ended in 2004 and yielded approximately 300 Mt. However government data suggest that significant coal deposits remain below the limit of underground mining.

2. Regional and local geology

The coalfield forms a regional topographical feature rising above the surrounding hilly plains to over 600 m above sea level. There is a general radial drainage pattern with gentle valley sides with mostly re-growth and mature forest with some farmed areas.

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The regional tectonic history is complex and four major extensional and compressional deformation phases have been identified between the Late Permian to Late Tertiary periods [1]. Structurally, the field comprises an easterly plunging complex faulted anticline/syncline fold system comprising Triassic, Jurassic and Cretaceous age rocks overlain unconformably by Tertiary age sediments and volcanics. There was a period of igneous activity from the Early Cretaceous to the Miocene with injection of sills and dykes into the sedimentary sequence, which in places intrude into the coal seams. Normal and reverse faults are common in the Mecsek Coalfield and have divided it into a series of discrete fault blocks (see Figure 1).

The MCF was formed during the Upper Triassic Rhaetian stage and the Lower Liassic Hettangian and Lower Sinemurian stages. It is a 120-1200 m thick, limnic and paralic sequence comprising inter-bedded coal, siltstone, sandstone and limestone. The coal does outcrop in the south-western part of the tenement package (Pécs-Vasas), where it has been partially exploited by open cast mining [2].

The MCF is underlain by the Late Triassic age Karolinavölgy Sandstone Formation, a 500-600 m thick deltaic sequence. The overlying Cretaceous sediments cover only small areas and were generally formed in pelagic depositional environments. The Jurassic and Triassic stratigraphy of the MCF is shown in Figure 1.

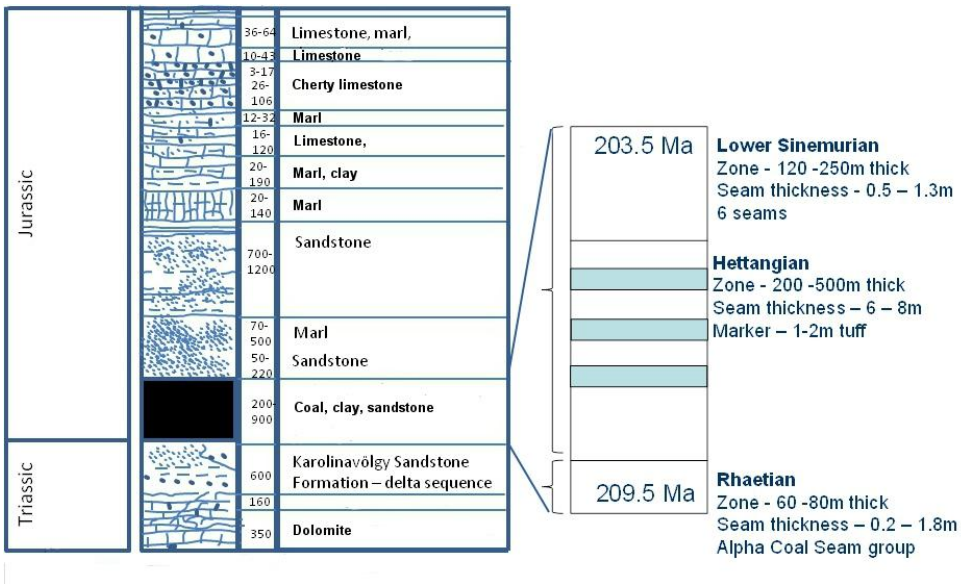

Figure 1. Mecsek coal formation [3]

On the basis of lithology and sedimentary facies the formation is divided into three members that can be traced across the entire Mecsek area (see Figure 1):

1. The Upper Member (Sinemurian lower part), a marine facies which developed as the basin was inundated

2. The Middle Member (Hettangian), a fluvial flood plain facies with some brackish marine facies in the upper parts
3. The Lower Member (Rhaetian), a lacustrine and alluvial freshwater sequence.

These three coal bearing members contain between 10 and 42 individual seams with greater than 0.5 m thickness with seam dips ranging from 20º-80º depending on their structural position in the basin. The Middle Member contains the thickest seams. The coal formation occurred in a half graben or monoclinal basin with thickest coal accumulation occurring in the south [4].

The Middle Member is 200-500 m thick and contains the seams of main UCG interest. Seams are of greatest thickness and lateral extent in this member, although seam correlation across the entire basin is difficult due to complex geological structure. Further exploration focused on this seam package.

3. Varalja exploration target

This area is on the northern margin of the Mecsek Coalfield (see Figure 2) and has the basin's largest known unexploited coal deposits.

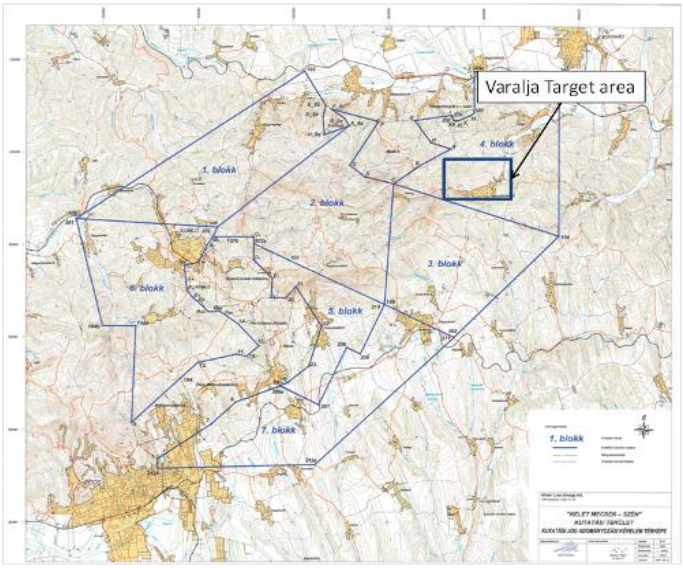

Figure 2. Location of the Varalja exploration target

The area is the most structurally complex in the coalfield. There are three main fault types; basin margin normal growth faults; a series of reverse faults resulting from compressional events; and a series of late stage thrust faults associated with Miocene compressional events.

The area of greatest complexity occurs in the adjacent exploration block (Calamites KFT area), where the faulting and thrusting are the most intense. Moving eastward into

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Wildhorse Coal Block 4 the structural complexity is reduced. The coal deposits occur as a series of large, relatively uncomplicated thrust blocks.

The target area is within the Wildhorse Coal Block 4, where extensive historical drilling has demonstrated the presence of large coal deposits. This was conducted on grid lines spaced at ~600 m with hole spacing along lines at ~500 m. The drilling indicates that substantial deposits suitable for UCG may be present at depths from 800- 1200 m.

4. 3D seismic survey

A 3D seismic survey is complementary to a well-planned drilling program in exploration areas and gives more detail on the structural regime and thus the continuity of the seams.

Figure 3 indicates that the structural complexity due to extensional and compressional tectonics of the Mecsek Coalfield is the principal risk to the project. For a clearly defined UCG Project, an understanding of the distribution of the major faults is essential.

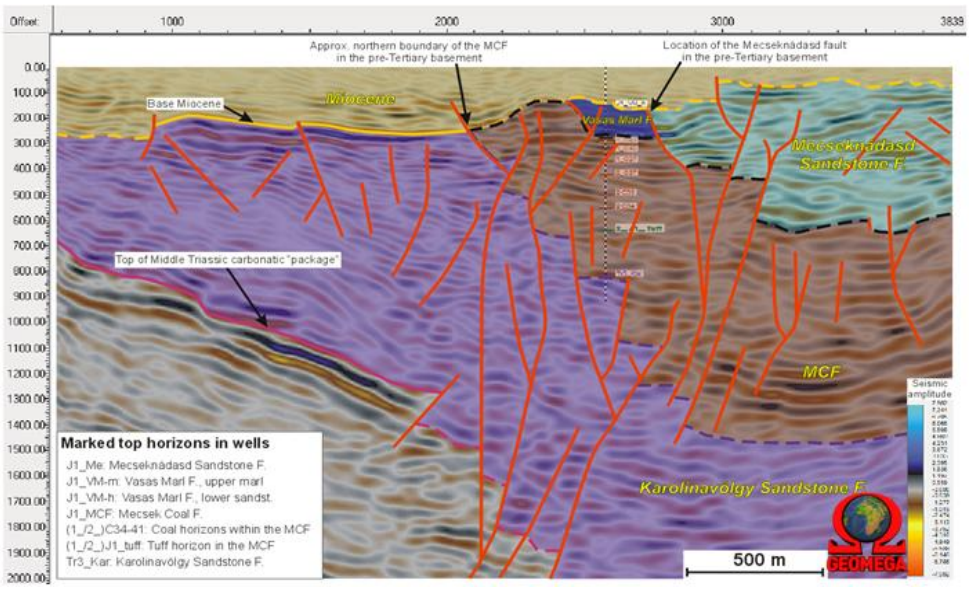

Figure 3. Seismic section - Interpreted Inline from the 3D seismics

Wildhorse contracted Geomega Ltd. to perform an integrated geological and geophysical evaluation of the Váralja South coal exploration area (Eastern Mecsek Mts., South Hungary). The aim of the study, which has been primarily focused around the newly acquired and processed 3D seismic survey shot beginning 2011, was to provide geological-tectonic support for this project as well as for its future drilling programs.

5. Conclusions

The work conducted concerning the Eastern Mecsek coal exploration block can be summarized in the following:
- a complete geological-geophysical evaluation of the area was covered by the 3D seismic survey
- this was performed using the integrated geological and geophysical database loaded into SMT Kingdom project evaluation software
- seismoctectonic block characterization: 20 seismoctectonic blocks were identified within the Mecsek Coal Formation, which seem not to be affected internally by significant faulting, at least in the scale of the seismic resolution. The boundaries of these blocks are usually tectonic. These blocks are recommended to be the primary focus of further exploration work (Figures 4 and 5).

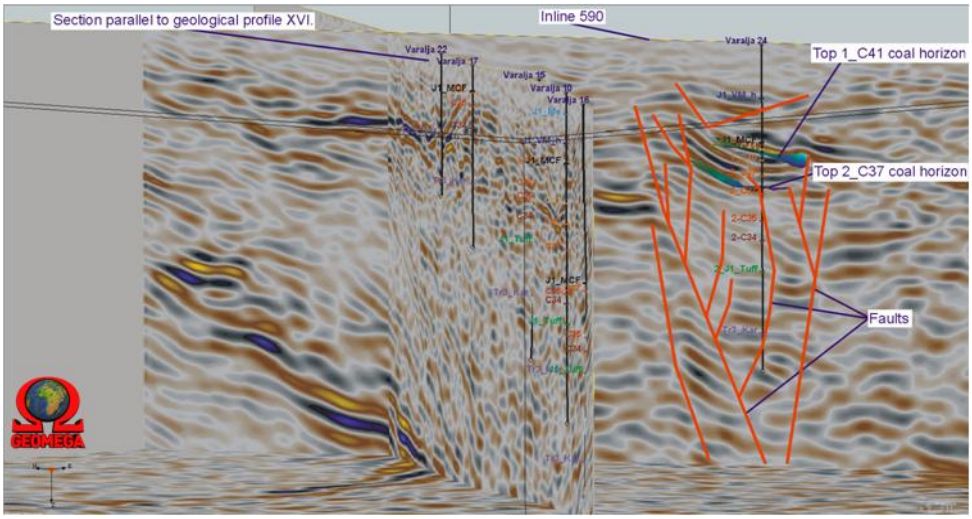

Figure 4. 3D section of an identified perspective block with the bounding faults

The quality of the seismic surveys is much better than expected considering the mountainous terrain. North of the area coherent and continuous reflectors can be identified, which are in agreement with geological sections inferred from earlier exploration wells. In the main target zone of the survey, however, the seismic image indicates that the sedimentary succession (including the coal-bearing sequence) is heavily tectonised. Comparison of the main tectonic zones seen in the seismic survey with the tectonised character of certain boreholes shows very good spatial agreement. This integrated analysis allowed us to construct a large-scale tectonic model of the area. This model implies that a regionally important strike-slip shear zone runs across the study area, which can be held responsible for the heavily tectonised nature of the coal-bearing sequence.

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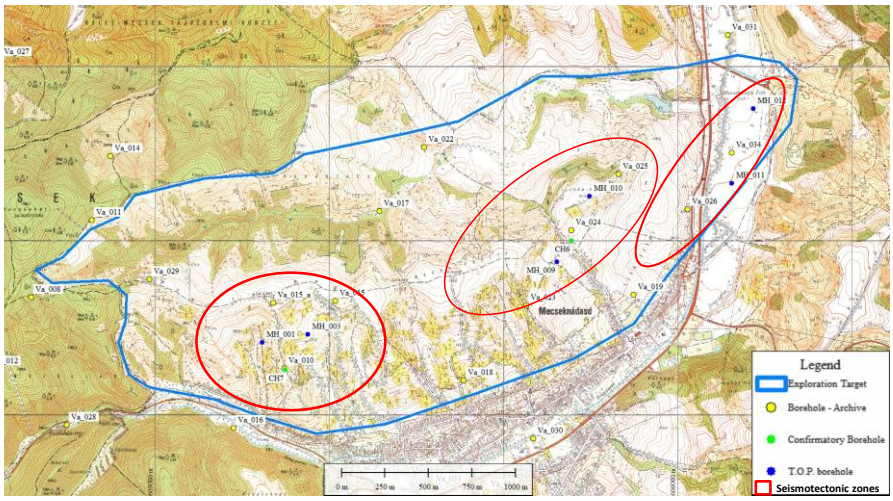

Figure 5. Contours of seismotectonic blocks within three zones

The new tectonic model and the heavily tectonised nature of the MCF in the Váralja South area is of utmost importance for the future planning of the UCG project, which relies on the presence of continuous and undisturbed coal bodies.

The above-mentioned data and model was taken into account during project implementation strategy (planning of directional boreholes and infrastructure) and to cross-check all future well locations against the seismic survey to reduce the technical and geological risk of the operations. It also assisted the focus of the indicated and measured drilling programs and substantially reduced exploration costs and complexity.

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