

## HDR/EGS POTENTIAL OF THE VILKYCIAI AREA, WEST LITHUANIA

### Prepared by

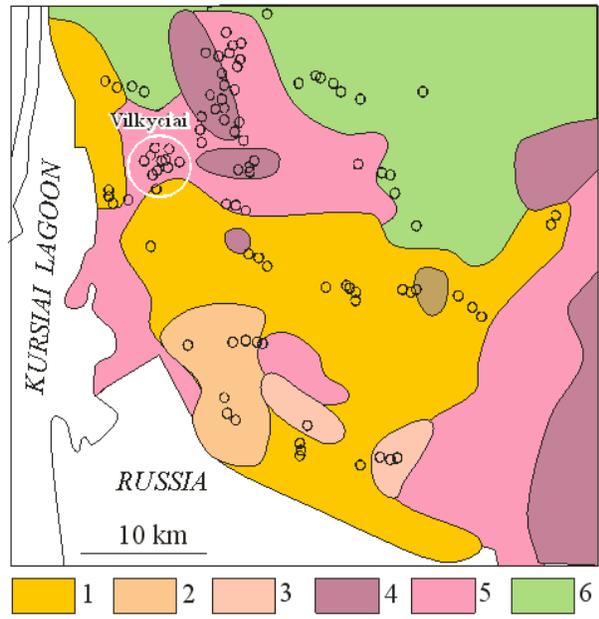
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West Lithuania is situated in the central part of the cratonic Baltic sedimentary basin of about 2 km thick, overlying the Early Precambrian crystalline basement. It is characterized by a high heat flow ranging from 60 to almost 100 mW/m<sup>2</sup>, owing mainly to the fertile crustal lithologies. Therefore it is considered as a potential area for the development of the HDR/EGS geothermal systems. The highest heat flow is related to the cratonic Middle Proterozoic “hot” granitoid intrusions, the largest Zemaiciu Naumiestis massif discovered in the south of west Lithuania (geothermal gradient 42-45°C/100 m, the average heat production of granitoids 7.5 μW/m<sup>3</sup>) (Sliampa et al., 2007). However, this area is devoid of detailed geophysical information and therefore is considered as the area of a high risk, despite that the available drilling information indicates the presence of the rather thick low-angle fractured zones that can be utilized for the development of a stimulated reservoir. Some areas of the slightly lower geothermal gradients were mapped in other parts of west Lithuania. The best geothermal parameters were identified in the **Vilkyciai** oil field area, where the geothermal gradient attains 40-42°C/100 m. It is covered by 3D industrial seismics. The efficiency of the 3-D industrial seismics for the mapping of the fractured zones in the basement was proved in the other Girkaliai-Vydmantai area (Sliampa et al., 2007). The Cambrian oil play overlies the crystalline basement. A number of wells were drilled into the basement with drill core sampling.

The distribution of the geotherms was modeled in the Vydmantai area based on the heat production, thermal conductivity and heat flow data. The heat production of the basement rocks (metapelitic granulites migmatized at different extent) in the Vilkyciai area has apparently too low values (1.5 μW/m<sup>3</sup>) to explain the high heat flow. Therefore, it was assumed that hot granites of the Zemaiciu Naumiestis intrusion extends under the Vilkyciai area below the granulites. 2<sup>3</sup>/<sub>4</sub> modelling of the gravity and magnetic fields was carried out to identify the depths of hot granites. The obtained geovimagnetic model was used to correct the geothermal model.

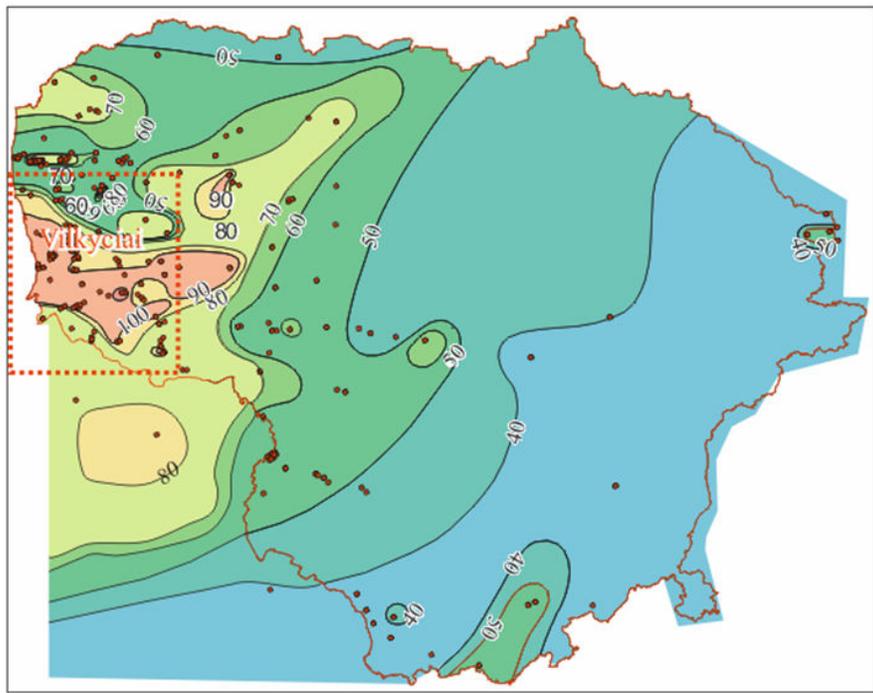
The distribution of the basement lithologies was identified from industrial 3-D seismics combined with drilling data. It was noticed that different lithologies have quite distinct reflection characteristics. Accordingly, it was possible to delineate the different geological bodies in the upper part of the basement.

The major exploration step is recognition of the tectonic structures and identification of a potential target(s) for the drilling. The transformations of the gravity and magnetic fields revealed the prevailing NW-SE structural trend in the basement. This trend is well visible in the 3-D seismic data and is represented by a set of parallel narrow lineaments (faults). They are also traced in the overlying sediments that suggests the fault reactivation (and a high probability of the open fractures). A pervasive roughly north-south trending anisotropy of reflectors is observed that resembles the one noticed in the above mentioned Girkaliai-Vydmantai area. It is hypothesized to be related to the high-angle foliation (and migmatization). Several major W-E and N-S (NNE-SSW) trending high-angle reverse faults are identified in the sediments that control the oil-bearing uplift. 3-D seismic data show that they extend into the basement. The NNE-SSW family of faults is considered as a most prospective target for drilling, taking into consideration the recent stress field. West Lithuania is subject to the uniaxial WNW-ESE extension, therefore the fractured zones of NNE-SSW direction can be most efficiently stimulated for fluid circulation in the basement (the permeability of fractures also strongly depends on the stress field).

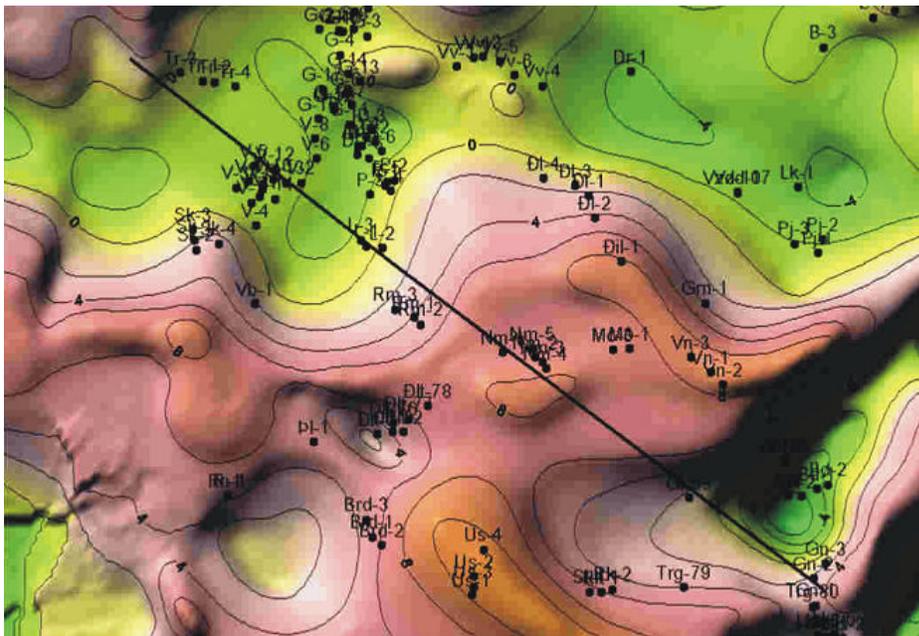
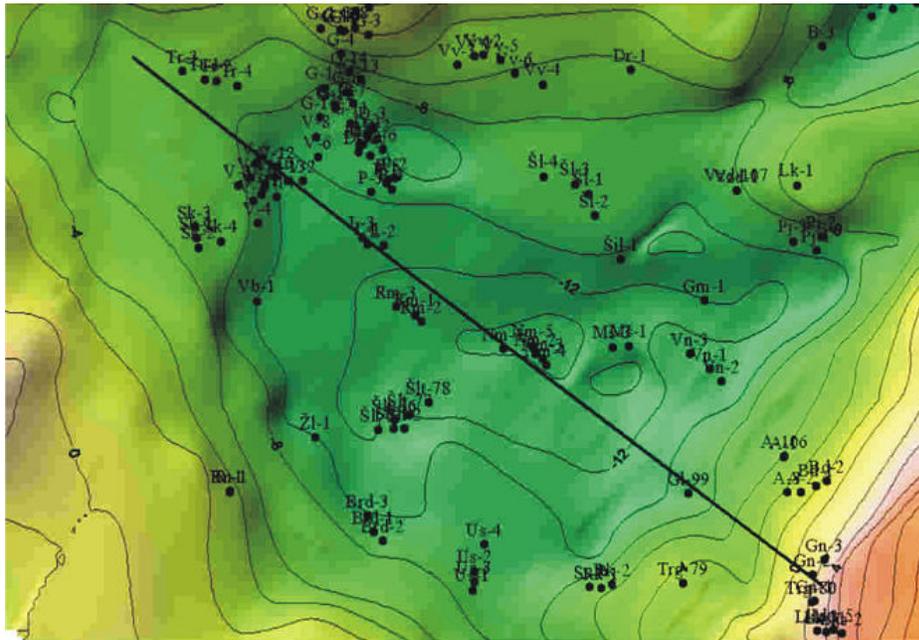


Geological map of crystalline basement. 1-monzogranites, 2-syenogranites, 3-quartz moncodiorites, 4-metasedimentary granulites, 5- migmatites, 6-charnockitoids (after Motuza et al., 2004).

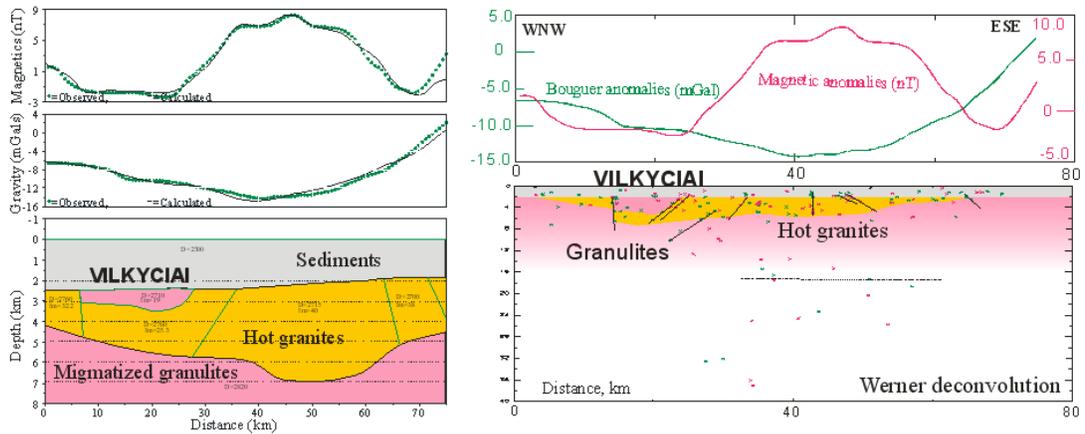
Geological map of the crystalline basement of Zemaiciu Naumiestis cratonic granitoid intrusions and hosting lithologies. Vilkyčiai area, according to drilling data, is located in the granulite block.



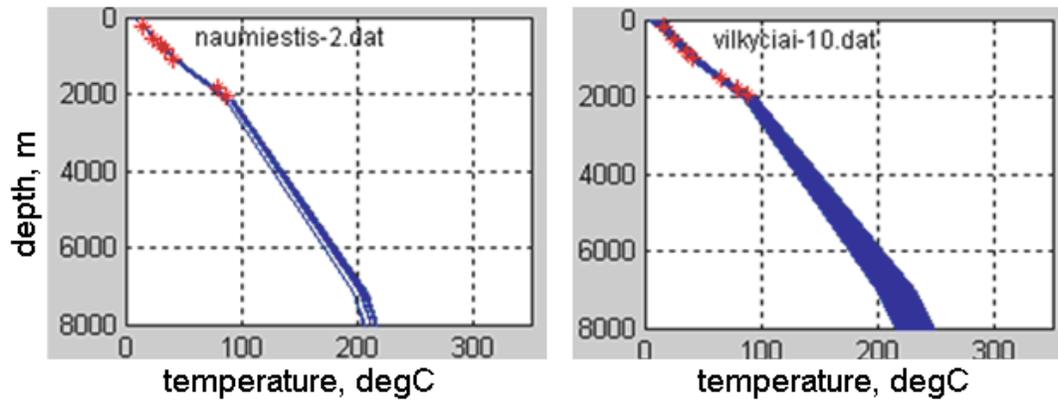
Heat Flow Map of Lithuania. Vilkyčiai area is indicated. Dotted line delineates the gravity and magnetic field map area (see below). Vilkyčiai area is characterized by high heat flow exceeding  $90 \text{ mW/m}^2$ .



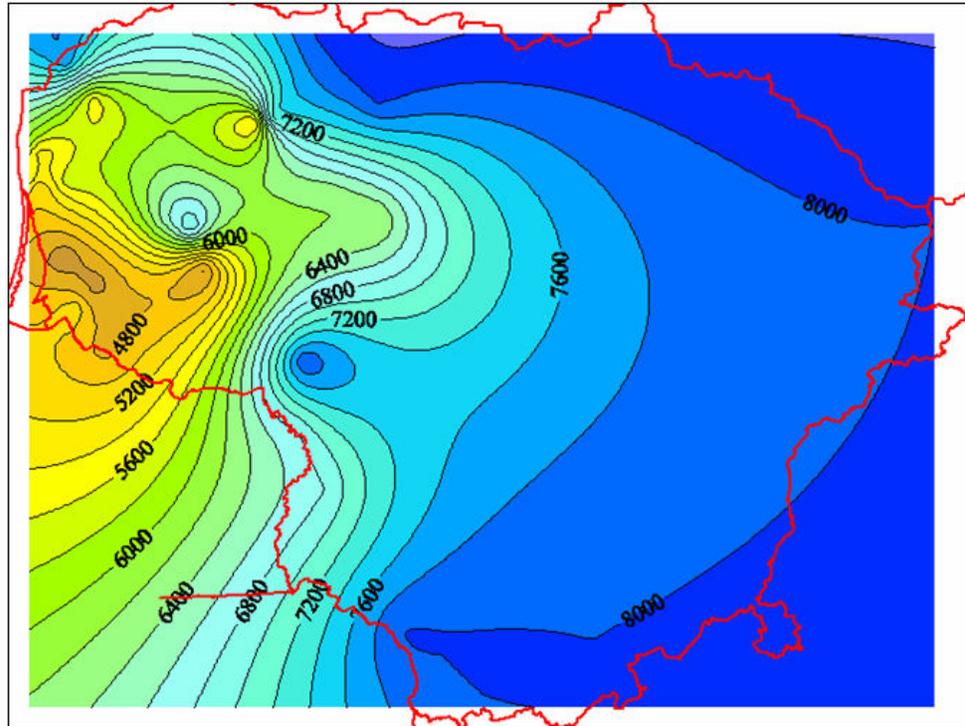
Bouguer anomaly (upper figure) and magnetic field (lower figure) maps. The group of oil exploratio wells drilled to the crystalline basement are marked „V“ (northwestern part of the profile). Zemaiciu Naumiestis granitoid intrusion is confined to magnetic high and gravity low. Vilkyčiai area is situated at the northern margin of the anomaly. The line of the modeled profile is indicated.



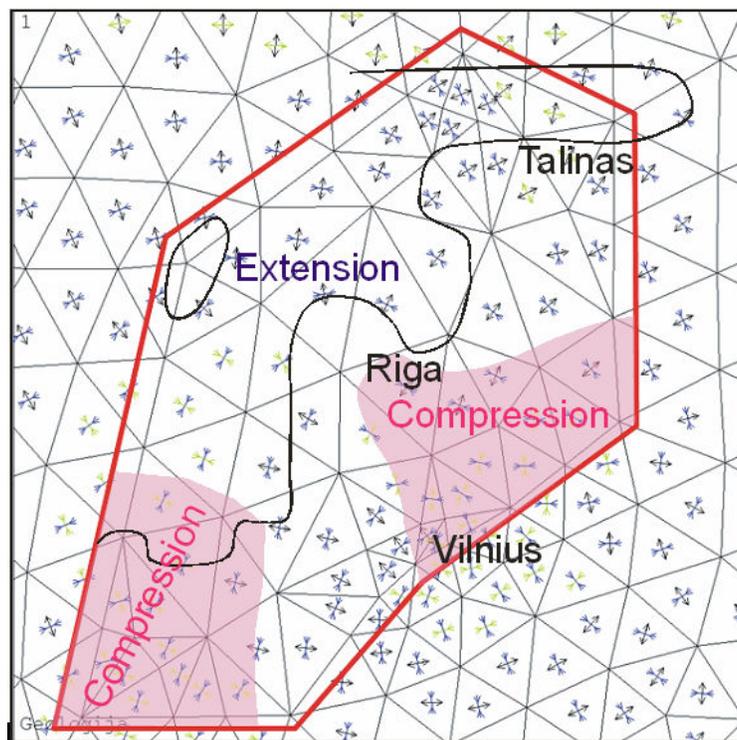
2.75-D Gravity - magnetic model (left) and Werner deconvolution model of the magnetic field (right) of the Vilkyčiai area.



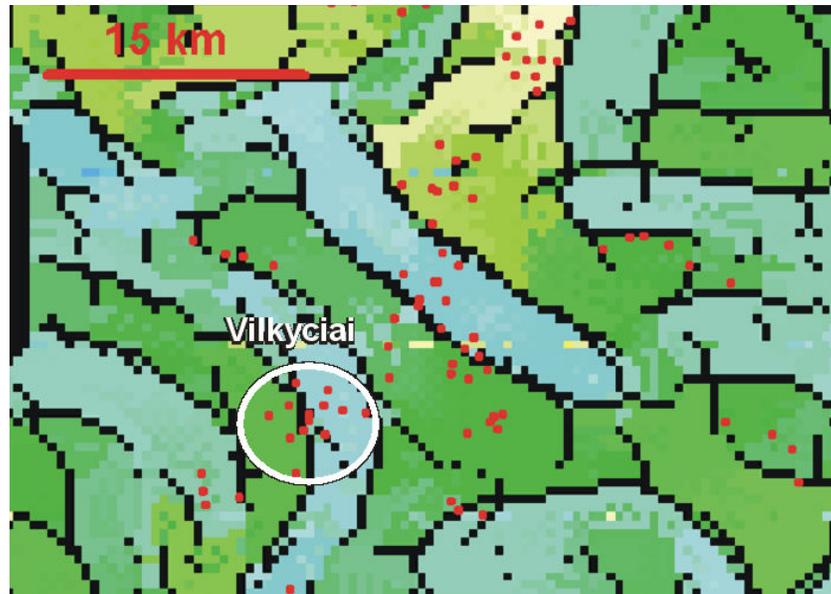
Modeling of geotherms of wells Vilkyčiai-2,10. Red dots indicate measured temperatures in wells.



Modelled depths of 150°C isotherm of Lithuania. Vilkyčiai area is located within the shallowest position of the isotherm.



Stress field of the Baltic region. Modelled from GPS data. Vilkyčiai area is located in the area subject to horizontal extension (Shmin oriented NW). It implies that high angle fractured zones oriented NE and NNE are the most prospective of the EGS geothermal systems.



Structural grain of the crystalline basement derived from terracing of the gravity field local anomalies. Vilkyčiai area is located at the intersection of N-S and NW-SE trending lineaments (faults?).