Geological and geophysical criteria for selecting the potential HDR/EGS sites in Lithuania

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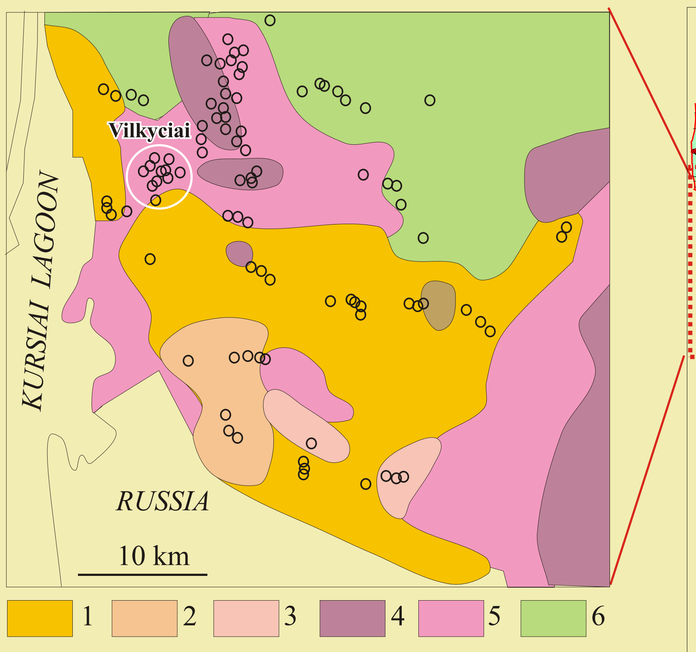
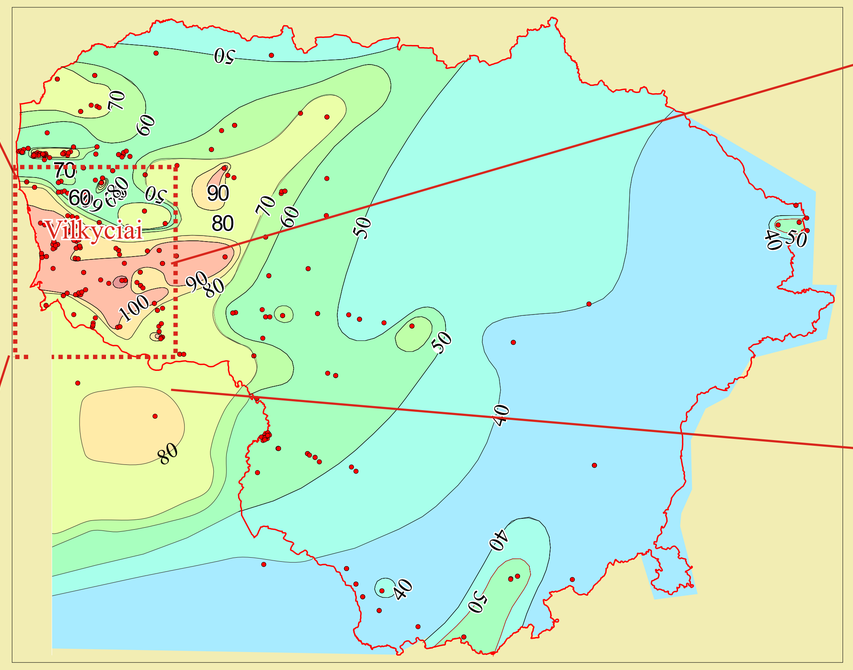
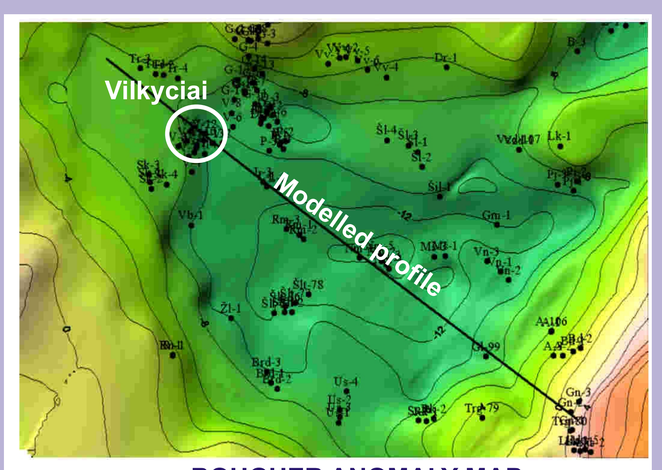


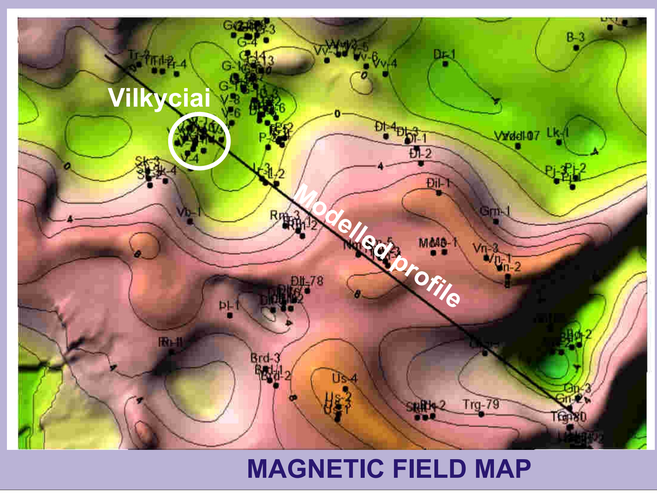
Geological map of crystalline basement. 1-moncogranites, 2-syenogranites, 3-quartz moncodiorites, 4-metasedimentary granulites, 5- migmatites, 6-charnockitoids (after Motuza et al., 2004).



HEAT FLOW MAP OF LITHUANIA (mW/m2)

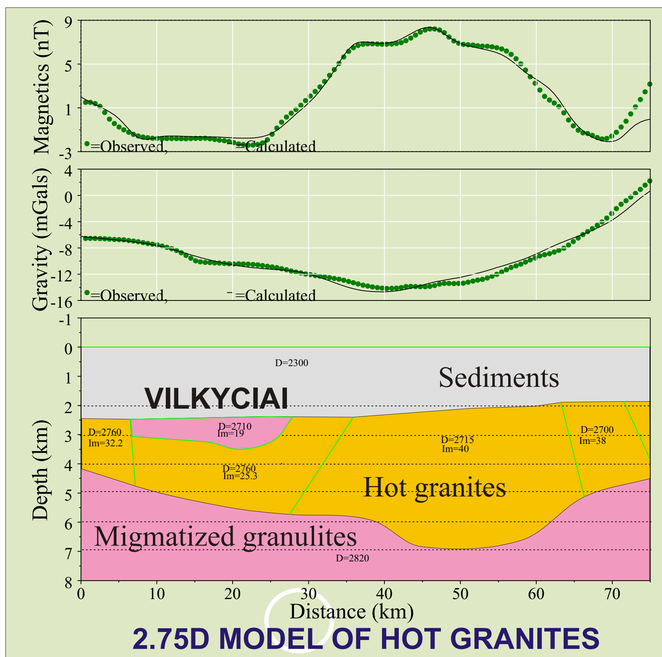


BOUGUER ANOMALY MAP

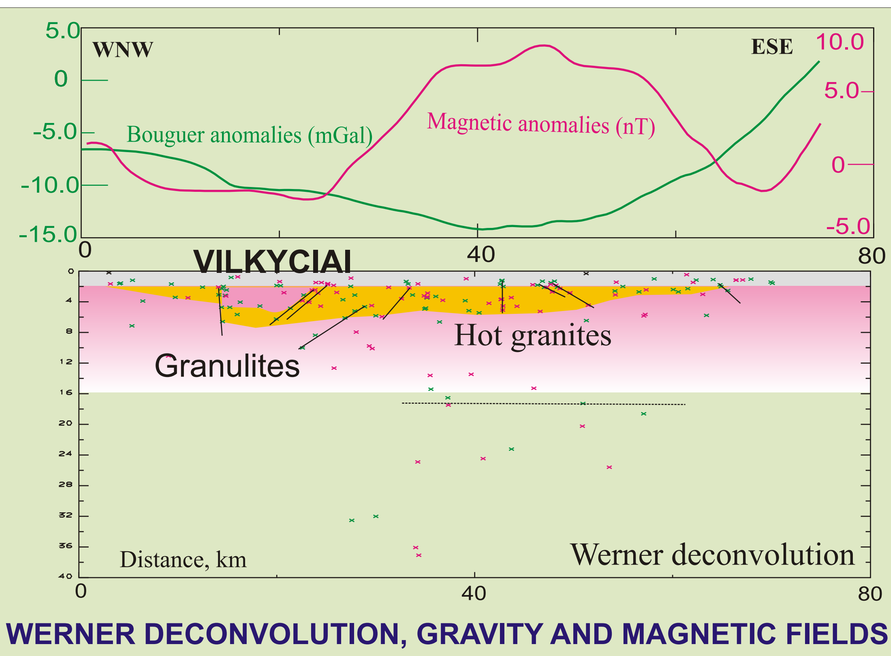


MAGNETIC FIELD MAP

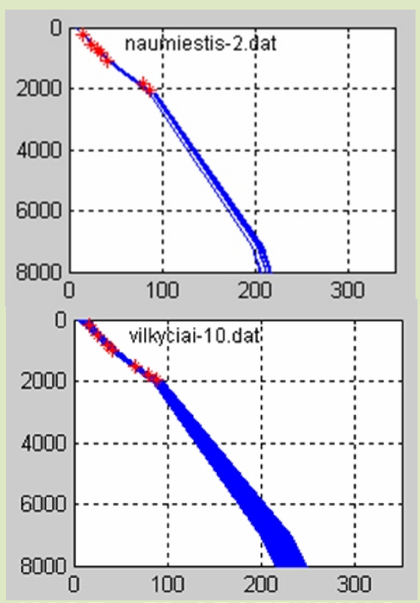
The maximum heat flow is related to the cratonic hot granite intrusion in southwest Lithuania in a background of generally higher heat flow of west Lithuania. Therefore the main prospects for EGS systems are related to this particular intrusion. However, it little studied in terms of seismic survey that makes the exploration and identification of the favorable structures rather difficult.
Surprisingly high heat flow was registered northwest of the intrusion in Vilkyciai oil field that contrasts to the low heat production of the basement rocks drilled in number of wells. It was hypnotized that hot granites underlay the low-radioactive migmatites.



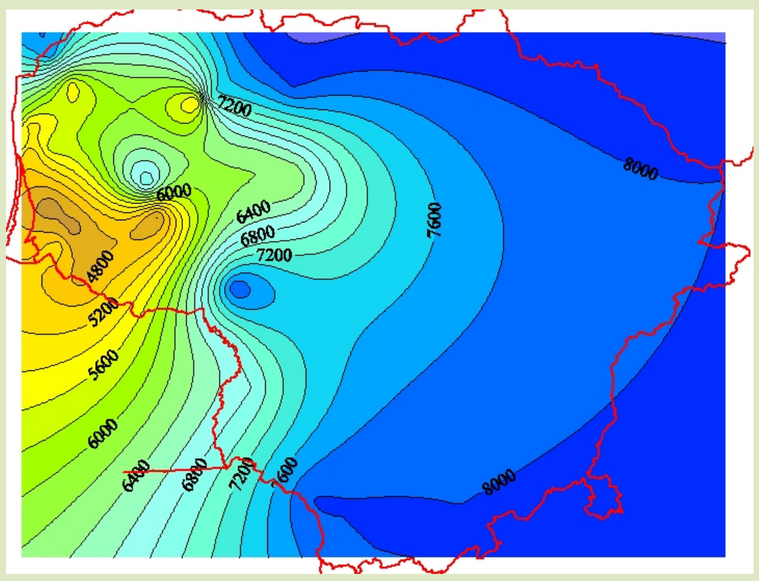
2.75D MODEL OF HOT GRANITES



WERNER DECONVOLUTION, GRAVITY AND MAGNETIC FIELDS



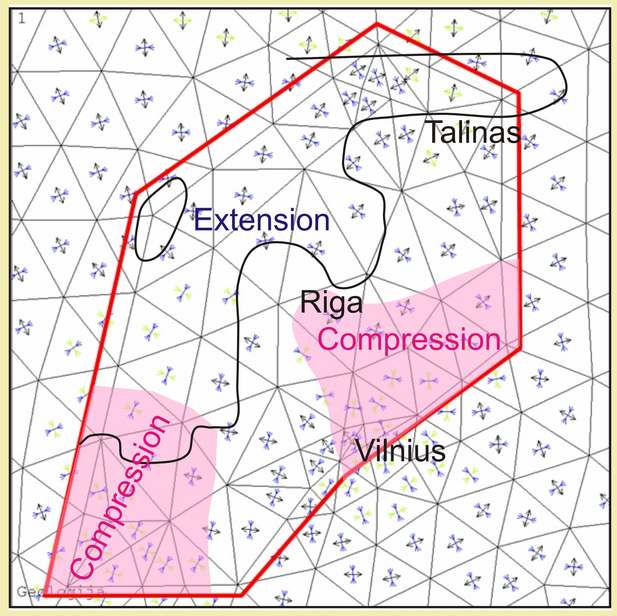
MODELLED GEOTEHRMAS



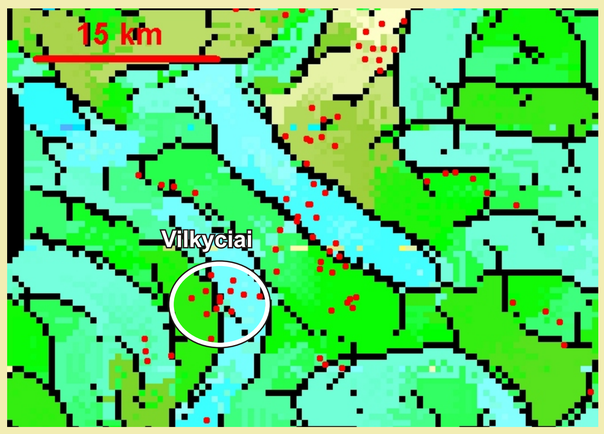
DEPTHS OF 150 degC ISOTHERM

The prediction of the thermal gradient is of primary importance for selection of the potential sites. In order to increase the consistency of the geothermal model, the gravity and magnetic fields were modelled to identify the distribution of the main basement bodies.

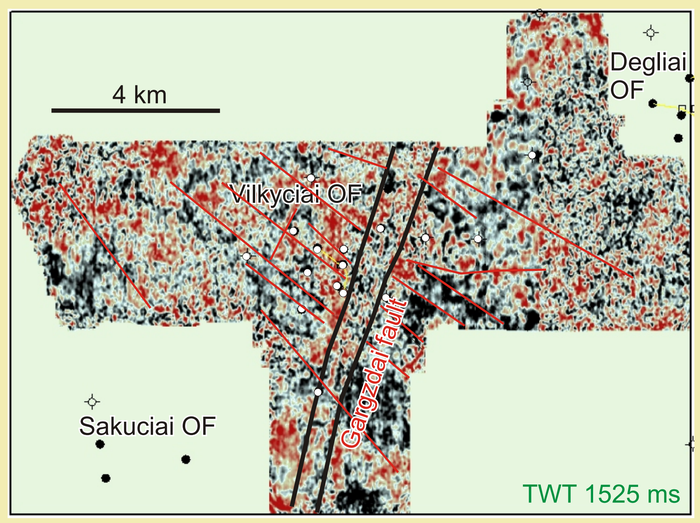
West Lithuania is situated in the central part of the cratonic Baltic sedimentary basin of about 2 km thick, overlying the Paleoporoterozoic crystalline basement. It is characterized by a high heat flow ranging from 60 to almost 100 mW/m2. Therefore it is considered as a potential area for the development of the HDR/EGS geothermal systems. The highest heat flow is related to the cratonic Middle Proterozoic “hot” granitoid intrusions, the largest Žemaiciu Naumiestis massif discovered in the south of west Lithuania (geothermal gradient 42-45oC/1km). However, this area is devoid of detailed geophysical information and therefore is considered as an area of a high risk, despite that the available drilling information indicates the presence of the rather thick 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 Vilkyčiai oil field area, where the geothermal gradient attains 40-42oC/1km. The area is covered by 3D industrial seismics that was shown to be an effective tool for the mapping the fractured zones in the basemen. Besides, a number of wells were drilled into the basement with drill core sampling.
The distribution of the geotherms was modeled in the Vilkyčiai area based on the heat production, thermal conductivity and heat flow data. The heat production of the basement rocks (metapelitic granulites migmatised at different extent) in the Vilkyčiai area has apparently too low values (1.5 μW/m3) to explain the high heat flow. Therefore, it was assumed that hot granites of the Žemaiciu Naumiestis intrusion extends under the Vilkyčiai area bellow the granulites. 23/4 modeling of the gravity and magnetic fields was carried out to identify the depths of hot granites. The obtained gravimagnetic model was used to correct the geothermal model.
The transformations of the gravity and magnetic fields revealed the prevailing NW-SE structural trend in the basement. This trend is visible in the 3-D seismic data as a set of parallel lineaments (faults). They are also traced in the overlying sediments that suggest the fault reactivation (and a high probability of the open fractures). Several major W-E and N-S (NNE-SSW) trending high-angle reverse faults are identified in the sediments that control the oil-bearing uplifted blocks. 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).



STRESS FIELD OF THE BALTIC REGION DEFINED FROM GPS (A.Stanionis, A.Zakarevicius, S.Sliaupa)



STRUCTURAL GRAIN OF THE BASEMENT DEFINED BY TERRACING OF THE GRAVITY FIELD



3d SEISMIC SLICE BELLOW THE BASEMENT

Stress field is important parameter in development of EGS systems. West Lithuania is subject to uniaxial WNW-ESE extension. Accordingly, high angle fractured zones oriented NNE-SSW are the target structures for exploration. A major tectonic zone of this direction is identified in Vilkyciai area.