Complex vulnerability and loadability assessment report to Recsk II. copper ore proposed area for concession

(abbreviated version)

based on the Report as of 11.03.2016. of the same title

Principal:
Hungarian Office for Mining and Geology (MBFH)

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On the basis of point 1. of Section 3. of Government Decree 103/2011. (VI. 29.), the Hungarian Office for Mining and Geology *(MBFH)* mandated the Geological and Geophysical Institute of Hungary *(MFGI)*, the General Directorate of Water Management *(OVF)* and the Hermann Ottó Institute *(HOI)* to prepare a vulnerability and loadability assessment report to the Recsk II. copper ore area, under conditions provided in Annex 2. to the Government Decree.

After revision, in September 2015., in accordance with point 1. of Section 4. of the Government Decree, the MBFH submitted the report to the public authorities listed in Annex 1. to the Decree, for opinions and data. All requested authorities replied. No disagreement was arisen on the part of the MBFH.

The Draft Report compiled in view of the opinions of the authorities was made public on the website of the MBFH. Within the set period no response was received. The Final Report was compiled by the MBFH within the deadline of 11 March 2016.

The full version of the report includes the following chapters:

1. Description of the Recsk II. study area

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3.3. Listing mining technologies restricted or prohibited due to environmental impacts on the area and the subsurface region

3.4. Assessment of the mining activity with regard to the protected natural and NATURA 2000 sites, determination of expected changes of status, description of expected regional impacts

The report also includes the list of the responding public authorities and administrations, and the prohibitions and restrictions to be imposed on the basis of the vulnerability and loadability assessment and that of the opinion of competent authorities. Appendix of the report contains the most important public data of the administrative units of the area, a list of boreholes, data of the ore sections in the boreholes, as well as a list of classified documents. Annexes include thematic maps of the area and its environment.

Short summary of the most important chapters of the report is provided here. Due to contraction, the original structure has been modified. Exceptionally, the full version of sub-chapters disclosing important information is maintained. *References are usually removed from the contracted chapters, in any other case, referenced person and date of publication are given. List of references can be viewed in the full version*. Chapter numbering differs from that of the original document.

Contracted version does not include the opinions, prohibitions and restrictions of authorities.

1. Geographic description

The concession area, covering 24.3 km^2, is situated in the Mátra region in the North Hungarian Mountains. The bulk of the area belongs to the Parád–Recsk Basin, a dual basin-hill region (Figure 1.). The average relative relief is 95 m/km^2. The northern boundary of the area is the Mátralába, the piedmont of the Mátra Mts. In the south, it joins the eastern part of the High Mátra, the southeast-dipping surface of which is characterized by periglacial formations. Since unconsolidated, lithic sediments cover the surface, impacts of slope movements are significant.

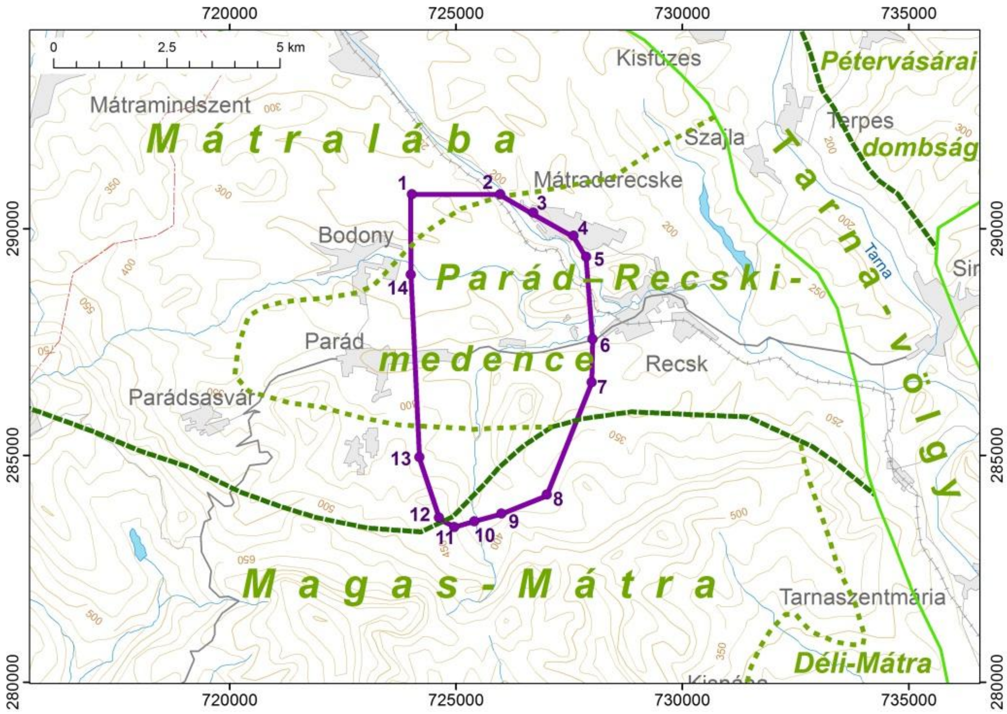


Figure 1. Location of Recsk II. study area for concession

Climate is moderately cool and moderately dry, showing a transition to the south, towards the cool–wet zone of the High Mátra. Climatic conditions are suitable for forestry, medical and classical tourism, as well as for less high-temperature-intensive agriculture.

According to the Census in 2011., the population density is 60.3 people/km^2 on the average, which is greatly behind the country's average (106 people/km^2). Age structure is unfavourable; number of children does not exceed that of older people (65+) in any settlements. The ageing index was 155% on the average, in contrast with the country's average (93%). No extremities can be outlined within the area. Level of education is behind the country's average. There is not a single settlement where the proportion of highly educated people would be higher than country's average; number of high-school graduates is also under country's average. The economic activity rate of the population is far behind the country's average. The unemployment rate calculated for the whole area was 17%, in contrast with the 12.6% value of the whole country.

The surface of the area is covered with brown forest soil with clay illuviation. Soils have been developed on the soil-forming sediments, which cover the volcanic and sedimentary rocks in various thicknesses. Soils are variably acidic; their mechanical composition is mostly clayey loam, loam. As a consequence of the grain size, they have moderate-to-weak water transmissivity, and good or large storage capacity. Attention must be paid to the gravity movements of steeper slopes and the soil erosion of areas where thin unconsolidated sediments cover the surface. Soil vulnerability is moderate. Special attention must be paid to soil conservation on the whole area.

Natural vegetation of the area consists primarily of forests; both zonal associations and planted forests are characteristic. In valleys and depressions wet meadows and bogs are developed, while in the northwest there are also agricultural lands. Primary function of forests is economical; forests with public welfare function occur in the middle and eastern part of the area. Number of forests with defensive function is low. Forests of the area fall in moderate-to-low flammability category; sporadically high-risk category forests may also appear.

Considering land use, the bulk (60%) of the area is forest; the proportion of agricultural areas, meadows and grazing lands, as well as non-irrigated arable lands is altogether cca. one-third, while the proportion of inhabited areas does not reach 3%.

The area can be easily reached from the main road system of the country. The road system has more quality deficiencies than quantity problems. Public connections are mostly ensured by secondary roads, the condition and surface quality of which, as well as the section and track line properties result in low-grade service level and insufficient traffic security. Topographic conditions are not suitable for a denser road network.

The *No.84. Kisterenye–Kál-Kápolna line* is the closest railway line to the area. It starts from Kál-Kápolna and its track line draw an arc of a quarter circle towards N–NW. It runs through the area over a short section at its northeastern corner at Mátraderecske. It is a non-electric, single, 55 km-long secondary line. Passenger transport is suspended on the line; freight traffic is maintained between Kisterenye and Mátramindszent, as well as Recsk–Parádfürdő and Kál-Kápolna. The No. 324/325 Gyöngyös–Mátrafüred/Gyöngyös–Szalajkaház forest railway runs to the southeast, ca. 8–10 km from the area. One branch ends at Mátrafüred, the other, at Szalajkaház. Reaching the area by train has difficulties.

Power supply of the area is ensured by the Detk–Bátonyterenye (Nagybátony) I–II. line, which starts 15 km south of the area, from the Detk sub-station. It runs towards north, enters the area at Recsk, and runs through it in northwestern direction. It leaves the area at its northwestern corner, at Bodony, and goes further towards northwest, and from Mátramindszent, towards west, till Bátonyterenye. There are no transformer sub-stations on the area.

Gas supply is ensured by the Mátraderecske gas transfer station, from where low-pressure local lines supply Parád, Recsk, Bodony, Parádsasvár and Parádóhuta. They supply the middle and northern part of the area with natural gas.

2. Nature conservation

In the course of planning of major investments in Hungary, the importance of regulations concerning environmental protection and nature conservation is high. One of the basic principles of Act No. LIII. of 1996. on nature conservation sets out that "the interests of nature conservation shall be taken into consideration during national economy planning and regulation, in the course of any economic, land and settlement development as well as land-use planning and also while taking authoritative measures". Government Decree No. 275/2004. (X. 8.) on nature conservation areas of European Community importance declares that before adoption/permission of a plan or investment, impacts on the conservational status of species and habitats forming the base of Nature 2000 sites have to be examined. If any significant adverse impacts are identified, permit can be granted only for plans/investments of public interest, but even so, the investment must be implemented so that it would minimize impacts.

Every stage of the concession activity must be examined and compared to the activities described in Government Decree 314/2005. (XII. 25.) on the environmental impact assessment and the single permitting procedure for the use of the environment. If any stage is listed in Annexes 1–3. to the Decree, the permit must be obtained as described in paragraph 3. of Section 1. prior to the licensing procedure,.

There is landscape protection area on the study area (5.3%). The minority of the Natura 2000 sites belongs to Special Areas of Conservation (SAC) (6.7%), while Special Protection Areas (SPA) cover one-third of the area (36.2%). Among the elements of the National Ecological Network mostly core areas occur (37.4%); 6.6% are ecological corridors, while the proportion of buffer areas is small, only 2.9%. Altogether, areas of this category cover 46.9%; *this value at the same time shows also the proportion of all the protected areas, as different protection categories overlap with each other.*

A smaller sub-area extends from the northern part of the landscape protection area to the Recsk II. area. In case of areas with a protection category such as this, one must comply with strict regulations.

If the activity has adverse impact on species, populations or habitats of community interest, neither exploration, nor exploitation can be conducted. Taking into account the circumstances, the clause, according to which on the areas of the Natura 2000 network no linear elements can be built, nor mining activity conducted, must be revised.

In accordance with the general directives of the ecologic network, it is prohibited to locate foreign objects and facilities which might disturb the landscape in the zones of the ecologic network. Topographic changes adversely changing the landscape and afforestation contrary to the objectives of nature conservation is prohibited. Building high buildings (> 10 m) is to be avoided; however, on the basis of visual plans, permit from the nature conservation authority may be granted.

No "ex lege" category is known from the area.

Protected sites of local importance are situated on the administrative area of Parád and Recsk. The area of the botanical garden of Recsk is 70 ha.

Loadability of the landscape is the level of recourse by which the flora and fauna, the air, the soil, as well as the ecosystem (the community of living organisms in conjunction with the non-living components of their environment) are permanently damaged. During the examination of the loadability, it must be specified how the planned mining activity (as for Recsk: impact of waste heaps, material transport, impact on surface water) might affect the landscape, the protected and unprotected landscape elements and the element-ensembles.

3. Geology

Level of exploration of the area

There is no evidence for non-ferrous mining activities in the Parád–Recsk area (East Matra ore region) from the medieval times. First attempts to exploit the ore deposits of the area date back to the early modern period. In 1767. Henrik Fazola expanded the previously initiated ore explorations to the area of the Mátra. At the turn of the 18th/19th centuries, lower-quality ores were exploited in the vicinity of Parád and Parádfürdő, on the Fehérkő Hill, on the Vörösvár Hill and in the Bánya Valley. After the depletion of deposits, explorations were re-launched when the copper ore in the Báj Valley was discovered in 1844. In the 1850s and 1860s a large number of mining companies conducted research and exploitation in the area, among others, on the Lahóca Hill. From the beginning of the 1860s, however, only the production of the Lahóca Hill site was economical.

In the beginning only copper and silver was extracted from the ore, but from 1876 mining also aimed at extracting gold. At the turn of the 19th/20th centuries, production showed decreasing tendency and in the beginning of the 20th century exploitation was suspended for many years. Exploration and exploitation were re-launched only in the 1920s. In 1926., the mine was nationalized. A modern ore dressing facility was built by which 416 t copper, 174 kg gold and 1,965 kg silver were extracted from 70,000 t raw mineral ore in 1937. After WW2, in November 1945. production was re-launched. By 1946–1947. the explored mineral resource of the mine was depleted, so the Economic High Council terminated the production on 20 April 1948. New explorations discovered new mineral resource and thus, production was re-initiated in 1950. In 1970. an ore body was explored in the northern foreland of Lahóca Hill, which was then exploited till 1984. The Lahóca Mine itself was closed in 1979. due to economic reasons.

Ore exploration was conducted on Lahóca Hill in the 1990s, resulting in the discovery of an important gold occurrence of the continent. Due to the low ore concentration and the difficulties of ore processing, no investment has been initiated so far.

In order to clarify the depth relations of the mineralization, a deep-drilling project was initiated at the end of the 1950s. The 1,000–1,200 m deep drillings were installed in a NNW–SSE line, perpendicular to the "Lahóca Great Fault". During the exploratory research stage (1961–1970.) an 500×500 m grid was used, covering a 20 km^2 large area. On the most prosperous parts, the grid was densified up to 350×350 m. In this stage of the exploration, the exact size of the deposit was determined and the skarn copper ore bodies were also discovered. From the 1970s, during the preliminary exploration stage, new 250×250 drilling grids were delineated on the northern and southern ore sites, fitted to the main structural lines. Results of the pre-, exploratory and preliminary researches of the northern site are disclosed in a summary report (1971.). On the basis of this report the preliminary open-cast deep-drilling research of the southern site and with the drilling of shafts I. and II. the detailed mining research stage of the northern deposits was initiated. The results of the preliminary research of the whole site were summarized in 1984.

Financing the planned ore exploration programs was terminated in 1984. but smaller mining research programs continued till 1987. Report of the mining research was compiled in 1988. For the exploration of the deep-level mineral resource of Recsk, altogether 134 1,200 m-deep exploratory drillings were deepened from the surface, in 156,000 m length. 552 drillings were deepened underground, in 92,000 m length, with an average depth of 200 m (FÖLDESSY, SZEBÉNYI 2008.). Detailed reports, reserve estimations, core samples, analysis results have been resulted from the explorations. The mine was closed in 2002.

In the Core Repository of MBFH (at Rákóczibánya and Szépvízér) core material of 23 drillings of the area - at least partially - is available to study (304 cores and 1,084 core crates; total estimated length is 7,660 m); the revision and re-organization of the cores have not yet been conducted. At Recsk (managed by the Nitrokémia Zrt.) ore sections of core material of 1,015 drillings are available to study (halved cores). There is also a 15,833-line inventory of them in the Repository of MBFH. The standard collection of the sites of the Recsk Ore Mines Rt. is accommodated in the attic of the Community Centre and Mining Museum of Recsk. There is also a 3,245-line illustrated catalogue compiled in 2013 by students and volunteers of the ELTE University.

Geologic build-up of the Recsk Magmatic Complex

Regional geologic situation

The Recsk Magmatic Complex is a member of the discontinuous, mostly buried Paleogene volcanic arc situated along the Periadriatic–Balaton–Darnó Line. Other members of the arc (made up of intrusive and effusive rocks) have been explored in Hungary in the Zala Basin, on the southern shore of the Lake Balaton, in the Velence Mountains, in the vicinity of Budaörs, and along the Darnó Line in deep boreholes (BENEDEK 2002.; MOLNÁR et al. 2003.; FÖLDESSY et al. 2008., MOLNÁR et al. 2008.). The radiometric age of the Paleogene magmatites of the zone is Late Eocene–Oligocene (26–35 million years) (BENEDEK 2002.), but according to paleontologic and stratigraphic results even older ages are assumed (32–44 Ma; DARIDA-TICHY 1987.). Rocks of the Paleogene volcanic arc in a stand-up formation can only be found on the surface in the Recsk Magmatic Complex and in the Velence Mountains. The Paleogene magmatic bodies in this zone are in close genetic relationship with those explored in the Alps, along the Periadriatic Line (e.g. Biella, Bergell complex, Adamello complex, southern tonalitic pluton line of the Karavankas, Rieserferner pluton), as well as those explored in the northwestern part of the Száva-Vardar Belt of the Dinarides (BENEDEK 2002., PAMIC et al. 2002.), with age varying between 43 and 28 million years. Due to the rapid uplift and denudation, plutonic rocks are already on the surface in the Alps. Volcanic complexes and mineralizations can be studied only in the Dinarides and in units escaped from the Alps (Velence Mountains, Recsk Complex).

Geology of the Recsk Magmatic Complex and its environment

Pre-Mesozoic basement

The Pre-Mesozoic basement is covered on the area of the Recsk mineralization. In the broader environment limestone–slate–radiolarite series is known to outcrop on the Darnó Hill, and on the Kis-Várhegy and Nagy-Várhegy Hills of Sirok. According to KOVÁCS et al. (2008.) these rocks belong to the Jurassic *Mónosbél Unit*. In the Mesozoic magmatic (basalt, altered basalt) and deep-marine series of the Darnó Hill Triassic (Ladinian, Carnian) and Jurassic (Bathian–Callovian) radiolarians have been described in the sedimentary horizons (DOSZTÁLY, JÓZSA 1992., KOVÁCS et al 2005.). Borehole RM–135 explored igneous rocks, more precisely microgabbro and gabbro of MOR characteristics, which, according to K–Ar dating (175–165 Ma), are Middle Jurassic. Basalts in higher horizons also show Middle Cretaceous (110–95 Ma) metamorphic effects (DOSZTÁLY, JÓZSA 1992., JÓZSA 1999.). Two types of basalt can be distinguished on the Darnó Hill. The first is a red pillow lava basalt with pink and white calcite vesicles and red calcareous mud inclusions. This reddish calcareous mud is also present between the "pillows" of the pillow basalt. This type of basalt is considered to be of Triassic age (KOVÁCS et al. 2008.). The other pillow basalt is green and can be related to the pillow lava basalts of the *Szarvaskő Unit*. Its age is presumably Jurassic.

According to recent geologic-paleontologic and structural geologic investigations, the Upper Triassic *Felsőtárkány Limestone Formation* known from the Bükk is represented in the area in the form of grey micritic, cherty limestones (PELIKÁN 1999., 2005., VELLEDITS 2000.). On the basis of conodonts from rocks, the age of the limestone is Late Karnian–Rhaetian (GECSE 2006.). Rocks of the Jurassic *Mónosbél Unit* in the area (KOVÁCS 2008.) represent marine slope facies. Three kinds of sediments can be distinguished within this unit; these were deposited as a result of gravity movements (KOVÁCS et al. 2008.).

Eocene sediments

Relatively thin, dark, grey Upper Eocene (Priabonian) Szépvölgy Limestone is deposited onto the Mesozoic rocks with significant unconformity. The limestone is overlain by dark grey rocks not containing large foraminifera; these can be related to the Late Priabonian–lowermost Oligocene *Buda Marl*. Products of the andesite volcanism are deposited on the Buda Marl or on the *Szépvölgy Limestone*. From the drillings of Bükkszék and Fedémes BÁLDI (1983., 1986.) described re-deposited sandy tuff interbeddings. This type of rock is found partly under the volcanic rocks, partly interfingering with the oldest volcanites, or interbedding within them.

Paleogene magmatism in the vicinity of Recsk

The geological map of the broader environment of Recsk shows outcrops of younger formations deposited on the Mesozoic basement (Figure 2.). Among the outcropping rocks the Paleogene magmatitic and related sedimentary rocks are the oldest. The thickness of the Paleogene volcanic series varies between 30 and 770 m, showing a decreasing tendency towards NE.

Due to the high-level weathering and alteration characteristics of the rocks, the radiometric dating on the rocks of the Recsk Magmatic Complex is uncertain. By radiometric dating FÖLDESSY et al. (2008.) and BAKSA (1975, 1984) determined an age between 37 and 27.9 Ma. More reliable ages have been determined by U–Pb dating (29–30 Ma) on zircon minerals of 5 volcanic rocks by Arató (2014.). On the basis of the underlying and overlying sediments, and the sediments interfingering with the magmatic bodies, volcanism began at the Eocene/Oligocene boundary, and ended in the Late Oligocene. On the basis of foraminiferas, the age of the sediments underlying the magmatic rocks is Priabonian (LESS et al. 2008.). Tuffic beds, however, appear only in the lowermost Oligocene beds and are not known in the Priabonian series of the area.

The tuffic, glauconitic, sandy limestone, which overlies the andesite volcanites contains a characteristic assemblage of Oligocene, Lower Kattian large foraminiferas. Similar age has been determined on the basis of the nannoplankton assemblage of the *Kiscell Clay*, deposited directly on the large foraminifera-bearing bed. Tuffic intercalations occur in the Rupelian and in the first third of the Kattian. According to the stage division of the Middle Paratethys, this interval corresponds to the Kiscellian. According to stratigraphic and palaeontologic evidence, the Recsk volcanism occurred in the Early–Middle Oligocene and lasted for 7 million years, from 34 Ma to 27 Ma.

Sedimentation after the Paleogene volcanism

The Middle–Upper Oligocene–Miocene series (typical of North Hungary) is deposited on the tuffic, glauconitic limestone–sandy marl series overlying the last volcanic phase. The rock series begins with the 200–250 m thick *Kiscell Clay*. At the bottom, as well as at the top of the Kiscell Clay tuffic–clayey bends are found, indicating volcanic activity. These beds are overlain by the Egerian *Szécsény Schlier* (Báldi et al. 1999), then the Eggenburgian *Pétervására Sandstone*. After that those andesite rocks are deposited which make up the bulk of the Mátra Mountains (Figure 2.).

Geologic and economic-geologic characteristics of the mineralization

Development of mineralization at Recsk

The Recsk Magmatic Complex was affected by many hydrothermal activities during the multi-phase intrusive and extrusive magmatic activity of the Paleogene, to which rock alterations and/or mineralizations can be related. From the surface, till the bottom of the explored region different types of mineralizations have been developed, showing differences in the temperature interval and the associated element and mineral assemblages. These mineralizations can be well-fitted to the system of the copper porphyry mineralization (FÖLDESSY, SZEBÉNYI 2008.). Most summary documents (pl. KOMLÓSSY et al 2001., FÖLDESSY, SZEBÉNYI 2008.) suggest distinguishing the ore types according to depth. On this basis, two kinds of mineralizations occur on the Recsk area: the surface-near surface epithermal, and the deep-seated (>500 m) mineralization:

1. Surface–near-surface epithermal mineralizations

a) high-sulphidation epithermal copper-gold mineralization with enargite, luzonite and gold-bearing pyrite. The mineralization is known in Lahóca Hill and its vicinity.

Hydrothermal processes altered the quartz–biotite–amphibole andesite (dacite) and the biotite–amphibole andesite of the second and third volcanic phases, as a result of which gold, enargite–luzonite high-sulphidation mineralization has been developed in the rocks of the third phase, related to the hydrothermal breccias of Lahóca Hill. Gold mineralization is hosted in the silica bodies (vuggy silica), in the black, microcrystalline quartz stockwork veining, as well as in the monomikt and polymikt siliceous and/or the clayey hydrothermal breccias (MOLNÁR et al. 2008.; BAKSA 1975.).

b) low- or medium-sulphidation epithermal Au-Ag-Pb-Zn mineralization. This type of mineralization occurs on the southern part of the area and can be characterized by tetrahedrite and gold tellurides.

The low-sulphidation mineralization affecting the quartz-biotite-amphibol andesite of the second volcanic phase and its pyroklastites occurs in the vicinity of Parád-Parádfürdő. The ore zone can be observed along a north-south-striking axis north of Parád, at Fehérkő, and south of the settlement, at Veresvár, Hegyeshegy and Veresagyagbérc (KISVARSÁNYI 1954; NAGY 1983; MOLNÁR et al. 2008.).

At the base of the volcanic complex, at a depth of 150–400 m, hydrothermal–metasomatic, brecciated polymetallic (Pb–Zn±Cu) mineralization has been developed as a part of the epithermal mineralization and in the clayey–sandy rocks stratiform, near-continuous ore bodies. Characteristic ore minerals include sphalerite, galenite, pyrite and kalkopyrite (SZEBÉNYI, FÖLDESSY 2002.).

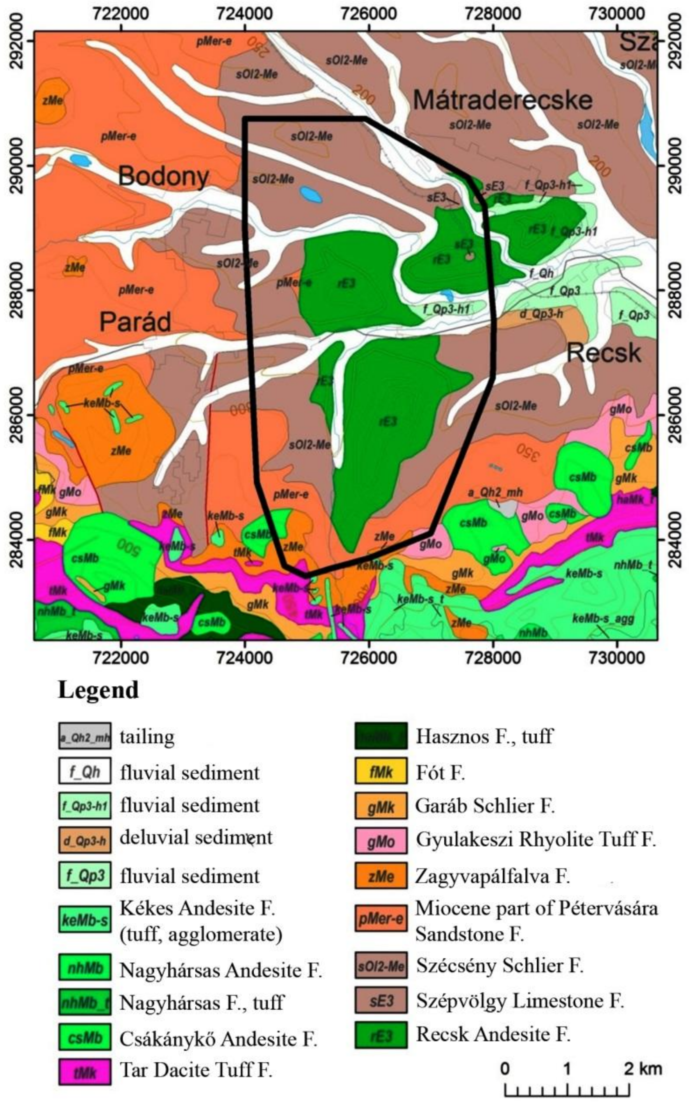


Figure 2. Geologic map of Recsk and adjacent areas (GYALOG 2005.)

2. Deep-level mineralization (>500 m)

These are the deep-level mineralization types of Recsk Deeps. They are mostly related to those small subvolcanic intrusions which penetrate the Triassic carbonate rocks at the lower part of the volcanic structure.

1. Cu-Au (Mo) porphyry mineralization, hosted in the porphyritic quartz diorite body, in associated dyke complexes, and in the metasomatically altered surrounding rocks. The top of the porphyry copper ore is at 500 m; the enrichment zones are vertical, annular–columnar-shaped. The depth of the main enrichment zone is 700 m–900 m. Main ore minerals are chalcopyrite, pyrite, molybdenite, magnetite, hematite, and sphalerite. At some places mineralizations are gold-bearing (0.2–1.5 mg/kg) (KOMLÓSSY et al. 2000.).

2. Skarn-related mineralization. As a result of physical-chemical reactions between the Triassic–Jurassic limestone–quartzite–slate surrounding rocks of the intrusive body and the high-temperature dioritic–quartz dioritic magma, so-called calc-alkali-silica skarns have been formed. Skarn ore of Cu–Au (Mo) enrichment is hosted in zones close to the intrusions. The

ore forms disseminations, patches, veins or smaller ore bodies. Skarn copper ores can be characterized by chalcopyrite, bornite, pyrite, sphalerite and magnetite. There are two main depth intervals of skarn mineralization, at 500–700 m and at 900–1,100 m. Mineralization is developed mostly at the triple contacts of the magmatic porphyry diorite intrusions, and the brecciated sandstone and limestone (dolomite) alterations.

3. Zn-Cu skarn ores are found — similarly to the Cu–Au skarn ores, at the triple contacts — at the outer margin of the contact zone. Mineralization forms massive or irregular ore bodies and disseminations. Main minerals of the skarn zinc ores include sphalerite, pyrite, magnetite, pyrrhotite and galenite. In the most outer zone of the skarn mineralization pyrite enrichment can be observed. Here the characteristic ore minerals are pyrite, chalcopyrite, pyrrhotite, magnetite and sphalerite.

Registered resources and reserves of the deep-level mineralization at Recsk

Mineral reserve calculations were part of the final reports made at the end of each exploration stage (ID. GAGYI PÁLFFY et al. (1971.), CSEH NÉMETH et al. (1984.), BAKSA et al [1988., 1990.]). Reserve calculations disclosed in the final reports of 1971. and 1984. were made by polygonal method. Calculations in the final reports of the mining explorations were made by ore body contouring (using different cut-off values), and in the less-studied regions, by the method of mineralization coefficients.

In 1991, the RÉV–DCI made a resource calculation for the area of the mining exploration and to the whole copper ore area. In the first case contoured geologic block method, in the second case, geostatistic calculations were used with 1.5% Cu cut-off value, thus accounting the most enriched skarn ores (KOMLÓSSY et al. 2000.). As a consequence, HOLLÓ (1991.) calculated a 42,807,105 t copper ore resource for the whole area of Recsk Deeps.

KOMLÓSSY et al. (2000.) calculated B, C_1, C_2 [1] resources in the RECSK II. (Deeps) complex geologic final report, using data of previous reports, and calculating with 2 m min. deposit thickness, max. 3 m subgrade dilution, and a Cu cut-off value of 0.4%. For the calculations, the area was divided into four subunits.

Calculated as described above, total geological and marginal copper ore resource is 824,589,000 t (geologic resource (0.4 % Cu cut-off) + marginal resource (1.5% Cu cut-off), 781,781,000 t + 42,808,000 t), the polymetallic geologic and marginal ore resource is 132,590,000 t (geologic resource (1.3% Pb cut-off) + marginal resource (2.5% Zn cut-off), 129,880,000 t + 2,709,000 t). Geologic resource is detailed in Table 1.

Table 1. Resource data for Recsk Deeps by KOMLÓSSY et al. (2000.)

COPPER ORES – GEOLOGIC RESOURCE									
	Category	Geologic resource (kt)	Cu (%)	Pb (%)	Zn (%)	Fe (%)	Mo (%)	Au (g/t)	Ag (g/t)
Recsk II. mine property	$B+C_1+C_2$	563,659	0.72	0.00	0.06	6.85	0.008	0.11	1.98
Recsk Deeps study area III.	C_2	54,262	0.61	0.01	0.05	4.98	0.006	0.15	2.32
Lahóca – Lejtakna expansion		0	-	-	-	-	-	-	-
Recsk free area	C_2	163,860	0.49	0.02	0.11	7.30	0.008	0.19	1.36
Recsk Deeps total	$B+C_1+C_2$	781,781	0.66	0.01	0.07	6.81	0.008	0.13	1.87

[1] Russian classification system used in Hungary since WW2

POLYMETTALIC ORE – GEOLOGIC RESOURCE									
	Category	Geologic resource (kt)	Cu (%)	Pb (%)	Zn (%)	Fe (%)	Mo (%)	Au (g/t)	Ag (g/t)
Recsk II. mine property	$B+C_1+C_2$	51,088	0.27	0.55	3.02	8.59	0.003	0.06	9.3
Recsk Deeps study area III.	C_2	2,737	0.41	1.01	2.27	5.40	0.00	0.05	13.15
Lahóca – Lejtakna expansion	-								
Recsk free area	C_2	76,056	0.21	1.13	1.97	6.04	0.001	0.08	14.51
Recsk Deeps total	$B+C_1+C_2$	129,881							

According to the State Registry of Mineral Raw Materials and Geothermal Energy, the ore resource of Recsk Deeps has two categories: copper ore (Table 2.) and non-ferrous ore (Table 3.); data is disclosed for Recsk Deeps North and Recsk Deeps South. No cut-off values are indicated in this inventory.

Table 2. Registered copper ore and lead-copper ore resource of Recsk Deeps, according to the State Registry of Mineral Raw Materials and Geothermal Energy

site	ore type	category	geologic resource (kt)	extractable resource (kt)	ore type	category	geologic resource (kt)	extractable resource (kt)
Recsk Deeps S	copper ore	A			lead-zinc ore	A		
		B				B		
		sum C_1a				sum C_1a		
		sum C_1b				sum C_1b		
		sumC_2	89,463	83,200.6		sumC_2	25,900	28,490
		total	89,463	83,200.6		total	25,900	28,490
Recsk Deeps N	copper ore	A				A		
		B	0	0		B		
		sum C_1a				sum C_1a		
		sum C_1b	358,598	333,496.1		sum C_1b	2,373	2,610.3
		sumC_2	300,554	279,515.2		sumC_2	56,294	61,923.4
		total	659,152	613,011.4		total	58,667	64,533.7
		sum	748,615	696,212		sum	84,567	93,023.7

4. Hydrogeology of the area

Shallow aquifers

Shallow aquifers are generally located in the upper part of the Late Oligocene–Early Miocene rock series of sandstone, glauconite, clay, silt, clay marl and marl (*Pétervására Sandstone* and *Szécsény Schlier Formations)*. In the middle part of the area, the fracture system and the weathered close-to-surface parts of the Recsk Andesite Formation store the groundwater. At a smaller extent shallow aquifers have been developed in Holocene alluvial sands and pebbly sands (and gravels).

Water table fairly follows the topography; the groundwater flows towards the valleys of the Baláti Creek, Parádi-Tarna Creek, Ilone Creek and Köves Creek, where the shallow aquifer is the alluvium itself.

The "original" chemical type of shallow groundwaters is $CaMgHCO_3$, with characteristically low, ca. 450–800 mg/l TDS. However, actual composition may differ in each formation (Quaternary sands, Miocene volcanic formations, clastic, or Oligocene–Eocene clastic formations) — TDS content of waters may reach several 1,000 mg/l TDS and sulphitic waters may also appear, due to the specific chemical composition of the hosting rocks. Quality of groundwaters is also affected by urban pollution, as a result of which higher K, NH_4 and NO_3 concentration values may appear. CO_2 upflow and outflow activities, which are common on the area, have also effect on the chemistry of waters. These CO_2-bearing acidic waters — called csevice by locals — are abstracted from springs and wells. In Recsk and Mátraderecske contaminated csevice-type urban groundwater commonly appears. Mining exploration, exploitations and production activities of the last centuries also modified the quality of shallow groundwaters at the place of the activity.

Paleogene aquifers

Among the Paleogene formations, the thinly developed grey Eocene *Szépvölgy Limestone* is a local aquifer. It is deposited on the Mesozoic basement with significant unconformity. Its importance is high in places where it forms one flow or hydraulic system with basement carbonates or other aquifers. According to previous research, due to its fractured and karstified characteristics, it forms one flow system with the broken, fractured andesite and the karstified, fractured basement carbonates. Its transmissivity, similarly to that of basement carbonates, is in terms of size 10^{-4}–10^{-5} m^2/s, whereas the pore volume is around 1%. There is no data available on the water chemistry of the Eocene carbonates of the area.

Aquifers of the magmatic complex

The Recsk Magmatic Complex is mostly altered, highly weathered and fractured, as such, it can be characterized by moderate transmissivity. Locally, waters of the complex form one flow system with the waters of the fractured and karstified carbonates. In the regional flow system of the area the general flow direction is SW–NE (from the Mátra). The average transmissivity rate of the subvolcanic series and the skarn margin is in terms of size 10^{-5}–10^{-6} m^2/s, whereas the pore volume is around 0.1–0.3%. It is important to note, that the groundwater flow is mostly related to fractures and cavities, as such, concentrated water inflow and water outputs could be observed during mining.

The Eocene–Oligocene volcanic complex was penetrated in whole length by the drillings of the area. Total dissolved content of the examined water samples generally ranged between 2,660 and 11,300 mg/l. In some cases, however, concentration values of 14,000–19,000 mg/l were measured, too. Similarly to TDS, water chemistry shows high variability as well; general water types are $NaHCO_3SO_4$ and $NaSO_4HCO_3$, but CaCl, CaNaCl, $CaNaSO_4$, $CaNaSO_4HCO_3$, $NaHCO_3$, $NaHO_3Cl$ waters may also occur. The higher sulphate content is resulted from the oxidation of the sulphide minerals of volcanic rocks. Higher dissolved content indicates a stagnate state, related to the isolated situation of the aquifer.

It should be noted, that there had been significant changes in the composition of the groundwaters of the area as a result of the mining activities of the last several decades (premining activities, active phase of exploitation, after-termination (re-drowning) phase of the mining activity).

Formations above the magmatic complex

Formations overlying the magmatic complex are partly (on the southern areas) clastic, sandy, glauconitic, calcareous shallow water formations, partly clayey marl, deep marine rocks of Oligocene–Miocene age. The ca. 200–250 m thick *Kiscell Clay Formation* and the clayey marl rocks of the Egerian *Szécsény Schlier Formation* are aquitards (in rare case, the upper parts can be more porous).

The Eggenburgian *Pétervására Sandstone Formation* — with the exception of the more porous, more weathered zones of its upper horizons — can be characterized by bad and moderate transmissivity properties.

On the southernmost parts of the study area and in the southern parts of the 5 km buffer zone mostly volcanic rocks are known. The *Gyulakeszi Rhyolite Tuff*, the *Tar Dacite Tuff* and the *Mátra Andesite Formation* might be potential aquifers due to their fractured properties. On the other hand, the unfractured zones can be considered aquitards.

Aquifers of the basement

The basement on the study area is in large thickness made up of the Middle Jurassic *Mónosbél Formation*, and locally, of the fractured, karstified carbonates of the Upper Triassic *Felsőtárkány Limestone*, which underlies the andesite.

Previous studies showed that the transmissivity of the carbonatic formations in the vicinity of Recsk is in terms of size 10^{-4}–10^{-5} m^2/s, whereas the pore volume is 1%. In the northeastern continuity of the thermal aquifer, in the vicinity of Bükkszék, the formation has better transmissivity rate; values are ca. 10^{-3} m^2/s.

TDS of the waters of the *Felsőtárkány Limestone* in the Recsk area shows large variability; concentration values generally range between 7,500 mg/l and 14,000 mg/l, though lower and much higher values can also be detected. The highly variable TDS is due to that specific property of the aquifer, that it has isolated, and also, open parts. Generally, $NaHCO_3Cl$ waters occur on the area, though in many cases waters of higher sulphate content also appear.

The whole area, as well as ca. the two-third of the 5 km buffer zone, belongs to the Recsk–Bükkszék thermal karst water body. The main natural regional flow direction is SW–NE, N, thus from the Mátra towards Recsk and Bükkszék. Significant cold water abstraction was conducted on the area for the purposes of mining from the 1940-50s till the end of the 1990s (closing of the mine), and thermal water abstraction from the end of the 1960s and the beginning of the 1970s for the purposes of underground mining. Due to water abstraction, the thermal water system has been continuously changed. Water abstraction of the underground mining and that of the Mátraderecske thermal well have affected the wells of Bükkszék since the 1980s.

Recharge and discharge of the groundwater of the area

Recharge of the groundwaters on the area is achieved through the aquifers, from the infiltration of the 4-5% of the precipitation. Discharges are represented by the springs and watercourses of the alluvium of the valleys.

At the end of the local upward flows groundwater-dependent ecosystems are found, which are natural conservation sites under protection.

On the area and in its direct environment Quaternary, Miocene and Oligocene, on the southern part of the 5 km buffer zone Upper Pannonian aquifers are affected mostly by drinking water abstraction. The Mátraderecske thermal well utilizes the waters of the thermal karst body, which is made up of Later Triassic–Eocene carbonates. The mineral and bath water abstraction of Bükkszék (conducted since 1937.) must also to be counted with, since currently it is the most significant water abstraction on the thermal water body. Anthropogenic activities have had a significant effect on this specific water and fluid system for the last 150 years. In the beginning, water abstractions related to the exploitation of the near-surface ore bodies in the andesite of Lahóca modified local groundwaters. After that, since 1940., the sodium-hydrogencarbonatic medicinal water of Bükkszék has been intensively abstracted, causing regional water level decline of the thermal karst (more precisely, potential decline; at Recsk, the size of depression exceeded 10 m). Since 1968., the well of the Mátraderecske spa, formed from one of the exploratory drillings of Recsk, is intermittently used. Though well abstracts water from the basement, due to the relatively low volume, only local depression has been formed.

Significant water production was conducted from the 1970s till November 1999., related to the deep-seated cavity formation, mostly to that of shaft No.II. This is presented on the table of the yields of the transient flow model simulation of the Recsk–Bükkszék thermal system, made by MÁFI (Table 3.). Negative sign indicates production, values mean m^3/day.

Table 3. Yields of the transient flow model simulation of the Recsk–Bükkszék thermal system

Year	Bükkszék	Mátraderecske	Recsk
1940	–963.7	0.0	0.0
1968	–521.3	–144.0	0.0
1971	–447.9	–134.7	–288.0
1978	–313.9	–113.0	–3,024.0
1985	–240.5	–91.2	–3,600.0
1999	–166.0	–52.1	–2,448.0
2000	–166.0	–52.1	0.0

5. Water management of the area

The study area belongs to the catchment sub-basin of the Tisza river. The Tarna superficial subunit can be found on the area; beside it the Zagyva subunit also concerns its 5 km buffer zone.

The study area and its 5 km buffer zone includes 6 watercourse waterbodies of hilly and mountainous origin. The area is densely intervowen by non-categorized watercourses. Still waters are not present in the area; out of the non-categorized stillwaters there are 5 reservoirs.

Due to the mountainous nature of the area, there are mainly water bodies of mountainous origin in the underground water body category such as the Heves Hills – Tarna catchment basin, the Cserhát, Karancs, Medves Mountains Zagyva catchment basin and shallow mountainous and mountainous water bodies. Shallow porous and porous water bodies of rimland of the Northern Mountain Range found in regional downflow zone are porous aquifers.

Out of the karstic water bodies the west karst of the Bükk Mountains, out of the thermal karstic water bodies the Recsk-Bükkszék thermal karst and the karst of the Bükk Mountains affect the area. From the south the porous thermal water body of the north of the Hungarian Great Plain penetrates the 5 km buffer zone from the south.

Water abstraction for drinking purposes is from the Köszörűvölgy reservoir which is not considered as water body. Water of 5 water bodies is used for communal, industrial purposes and irrigation.

Based on the report on nitrates in 2008., there are nitrate-sensitive patches in the area. There is no any nutrient-sensitive area.

Ecosystems depending from groundwaters can be found in the area in question and within its 5 km buffer zone. These are nature protection areas as well (national park, landscape protection area, Natura SPA). Protective zones of potable groundwaters are also protected. Approxiamately one third of the settlements in the area is without a sewage system. Two third of the settlements transport communal liquid waste to sewage plant. Afterwards the purified sewage is led to watercourses from sewage plants. The impact of lead-in on recipient water bodies is not significant. Surface and underground water bodies of the area are not affected by other (non-communal) sewage lead-in.

Documented contaminating industrial activity is linked to the mineral industry at Recsk. Pb-contamination originating from the glass factory at Parádsasvár has also been indicated in the Ilona Valley, moreover the area of military installations next to Báj Stream (Recsk) used for fuel storage is contaminated as well. A petrol station is in operation near Parádfürdő. There is no any SEVESO plant in the area. We have no information on any damages concerning surface water bodies. There are patches of intensive agricultural activity accompanied by nitrate load in the area. The level of phosphorous load is below the national value of 10,000 g/year.

Vulnerability assessment has been made concerning the water resources of Bükkszék categorised as being at medium risk.

The area in quiestion is concerned by the certified health resort named ‘Parád’, however there is no any medicinal mud deposit nearby. There are several wells deepened in the area: the Mátraderecske K-3 well for medicinal water, in wider range the well on land registry numbers 435., 439. and 445. in Parád for ferrous and aluminous artificial medical water, the one providing medical water, as well as another utilised as source of mineral water. CO_2 gas released from the mofetta found in the area of Parád Erzsébet Park Hotel has been classified as medicinal gas. The only thermal well in the area is the one of the lido of Mátraderecske utilised as bathing water (medicinal water). The nearest thermal wells are in Bükkszék.

There are no monitoring locations for surface waters in the study area and within its 5 km buffer zone. There is only one monitoring point attached to protected areas. Five wells provide data linked to the monitoring program concerning underground waters.

The conditions of surface water flow bodies in the area and its surroundings differ markedly. Special requirements have been specified for the Parád-Tarna upper water system; it has been classified as ‘not suitable’ considering the abstraction of drinking water. Out of water bodies concerning the area, those of porous nature, as well as karstic thermal ones can be characterised as weak in terms of quantity, the others are quite in a good condition. Only the periphery of the North Hungarian Mountains got poor rating in the assessment of conditions due to diffuse nitrate load.

6. Valid exploration and mining entitlements to mineral raw materials

There is no valid ore exploration site in the area. Recently the area in question partly covers ‘Recsk I.-copper ore’ (closed, remediated) and ‘Recsk II. –non-ferrous metal ore’ (suspended) mining plots (MBFH Mining, February 2016.)

There is neither any valid coal, hydrocarbon or geothermal exploration sites, nor any coal, hydrocarbon or geothethermal mining plots and areas falling on the area.

There are seven operating mines for non-metallic mineral raw materials, such as clay, sand, building and decoration stones (andesite, diabase), as well as thermal salt in the area and within its 5 km buffer zone. Among them two are within, five are outside the area in question. The depth of majority of operating mines for non-metallic mineral raw materials is mainly about ten metres.

7. Exploitation methods, mining technologies

Exploitation methods in near-surface mines

The Parád-Mátra Mining Society operated in the area since 1852., drive mining was used up to 1926. In the beginning manual extraction with boring rods and hand-hammers were used by the oil lanterns. At first powder, later on dynamite was used for explosion.

Sections of veins rich in ore were extracted, the product was transported either in cages or by carts, bogies. Wooden planks were built in the entries. Less valuable parts were left down there in the mine, today such an exploitation is called ‘robber mining’. Ores were crushed with a steam engine, then roasted and transported to smelters in Gömör County (later Gömör and Kis-Hont county from 1802.). Costs of transport often consumed the profit from mining operations. According to records from Rozlozsnyik, 1,200 tons of copper, 1.3 tons of silver and 170 kilograms of gold were exploited from the area up to 1923. (Csiffáry 2009.) The Hungarian Royal Ore Mine Company at Recsk was established in 1926 and operated till 1944.

New explorations were launched in 1927. on Lahóca Hill at Recsk, both the mine and the ore-works have been rebuilt, new equipments have been commissioned in the new dressing works since 1928. The ball mill flotating equipment was considered as a modern, middle-sized plant at the time of establishment.

After World War II. there was a need for newer explorations and the restoration of the dressing works. The already explored ore volume have been exploited, the certain proportion of machinery has been destroyed (due to the war) or transported. The exploitation itself was carried out by cavity-widening flat back strope, then in 1951. the so called ‘boundary shrinkage stoping’ was introduced in Lahóca mine for the imporvement of efficiency. Some cavities exceeding 30 metres and 20 to 60 metres in width have been formed, the roof has been secured by mooring to rocks. The extracted ores have been stored in the formed cavity, waste rocks have been used for backfilling inside the mine. 27,992 metres of drive were established till 1955. The termination of ore exploitation was in 1979. when explorations were shifted to deeper levels (Csiffáry 2009.)

Mining geologic conditions determining exploitation methods at Recsk deep levels

Hydrogeologic conditions have been got acquainted with by applying data of examinations in surface drillings, of shafts and drives, as well as 250 drillings in mine. Characteristic parametres are the following:

The hydraulic conductivity of subvolcanic andesite is 8.8×10^{-6} m^2/sec., (A. SOMODY [2005.]: Hydrogeologic assessment of long-term suspension of the Recsk Deep Mines by inundation, doctoral thesis), the permeability coefficient is 6.5×10^{-8} m/sec., the sprung water is 34.8 l/min. Hydraulic conductivity of the scarnic mantle is 1.9×10^{-5} m^2/sec., the permeability coefficient is 1.2×10^{-7} m/sec., the sprung water is 46.7 l/min. Hydraulic conductivity of limestone complex is 1.1×10^{-3} m^2/sec., the permeability coefficient is 6.8×10–6 m/sec., the sprung water is 114.9 l/min.

Experience shows that the present mine is anhydrous by 2.5 m^3/min. water uplift and tapping drilling. To reach 900 metres depth by lowering of water level, the water flow rate of 6–7 m^3/min. and three to five years are required. The water flow rate on the whole area (6.7 km^2) is 23–24 m^3/min. The dissolved gas (CO_2, CH_4) content of sprung water is high (about 5–10 m^3/m^3). The water itself is K+Na and Ca+Mg-hydrocarbonated, or K+Na-bearing chloride sulphate. The dissolved salinity is 6–10 g/litre. On the periphery limestone is moderately endangered by water and has unclear connection to the karstic water system of the Bükk Mountains.

As for gas conditions, it was characterised by CO_2 and CH_4 gas content of sprung water and intense H_2S gas outflow in some surface drillings. In Rm-32. drilling pressure reaching 6 bars was detected at the well-head.

The climate in mine is determined by the geothermal gradient being 30 m/°C in depth between 900 and 1,100 metres. Temperature of rocks in depth of 1,100 metre is 50.1 °C. Mining is endangered by silicosis due to 15-50% free silicic acid in rock. Oxidation must also be calculated with. Intensive ventilation and cooling are required.

For clarifying rock mechanic conditions, samples have been taken from drillings, shaft and entry driving. Results of petrophyisical examinations for six rock types are varied, the dispersion and relative error rate are high. The rock mass is heterogenous, partly fragmented, cracked, dissolved. Upon examination on cracks, cavity width of stoping, as well as method of support may be specified. 55-70% of developing entries require self-supporting, 20-25% galvaized mesh, sprayed concrete and 10-15% - mainly in tectonic zones – TH or walled support.

Behaviour of rocks and geostatistic balance in greater depth are unclear. There is not enough experience concerning behaviour of open spaces and supports. A nagy mélységben a kőzetek viselkedése, a geostatisztikai egyensúly még nem kellően tisztázott, a nyitott térségek és biztosítások viselkedésére nincs elég tapasztalat.

Characterization of technical, technologic deployment of the Recsk Deep Mines

In the course of development and preservation of the ore mine various tecnologic methods (transport, ventilation, lighting, water supply system, pressured air and water supply) have changed permanently.

Explosive technology has been used for formation of mining spaces.

In shafts both the carriage of passangers and the transport of materials have been realized in buckets with velocities of 4.0 m/sec., as well as 6.3 m/sec.. Decanting devices have been used from hauling for hoist. Level loading and hauling have been carried out in bunker wagons and bogies towed by battery locomotive on a 750 mm track. In exploration drifts locomobile bucket transfer machines have been in operation. On the surface, rocks unloaded from buckets on the scaffolding of headwork have been sent onto the lorries through a tipping chute.

By completion of entry drivings, all entries have been open and cross-ventilated by artificial or natural depression. For improving ventilation, sites for main ventilation have been established between -700 and -900 metres, and operated by 10-10 ventilators with 1-1 reserve. The mine has been divided into two air categories, category I. for the open section from -700 metres and above, as well as category II. below -700 metres. Air brattices and air blocks have been installed for reducing expenditures on energy.

The 120/6 kV transformer station in the area of shaft II. has supplied electric power normally for the mine.

The water uplift has been periodical and carried out in case of certain works in five steps.

The supply of mine with compressed air has been ensured by the five compressor sites of shaft II. with capacity of 150 m^3/min. in total. Both hoists has had its own auxiliary compressor linked to the compressed air network of the mine.

Water supply of mining plant has been realized by a 4.5 km long pipeline with capacity of 500 l/min.

Technical development

Technical design of both shafts – according to experts - may be considered as an outstanding technical solution at international level as well. The deepening itself has been accomplished by applying a pit top. Deepening of shaft II. has been done by bobbin conveying device down to 404 metres, afterwards the final conveying technology has been used. In the course of deepening, rocks shooted on the tree have been placed in buckets by grader elevator and then sent to the surface. The average depth of cut has been 3.2 meters. The central element of works on shaft foot has been a two-level work-bench. Concreting has been completed by slide moulding in 4-metres sections. Waters sprung on the shaft foot have been uplifted into buckets by compressed air pump. The maximum temperature of 52–54 °C in depth of 900 meters (1,100 meters below the ground) in the course of driving the main entry has been decreased to adequate degree by applying ventilation.

In the history of mining in Hungary, it was at Recsk where the production line for driving the entry in full size – mainly units produced in Finland - has been applied.

The most modern instruments and measuring technology (gyrotheodolite, laser telemetering, etc.) have been applied.

In the course of deepening shafts and driving entries, exclusion of high-pressure sprung water (with highest pressure of 88 bars) has been an extraordinary task. Preliminary injection has had to be applied in the course of deepening shaft II. Water exclusion has been realized by the Kipko-type clayish pulp filling with rubbles. Cementing has been completed for the exclusion of water in ridge entries.

Volume of sprung water in the course of mining (approx. 2 m^3/min. uplifted volume) has not been a problem in general, it has been managable. The real problem has been the high solute content of water reaching 9,500 mg/l and consisting of calcium carbonate in more than its one-fourth. Aragonite and calcite have been segregated due to decreasing pressure at water discharge.

Implementation of exploration drillings has been carried out by DIAMEC 250 drilling machine equipped with diamond tipped drilling bit. Its theoretical drilling length is 250 meters, the external diameter of the diamond tipped drilling bit is 42 millimeters, the core diamater is 36 millimeters, the drilling direction may be between 0 and 360°. More than 90,000 metres of drilling have been realized with such type of a drilling machine.

Raise drilling works have been completed by the Swedish SKANSKA company in 194 meters in total with a RHINO 1000E machine.

Special mining conditions have made the application and introduction of modern, sometimes unique supporting methods necessary such as gunite cement, gunite plastic, cemented steel rock screws in diamater of 20 millimeters, synthetic mounted steel rock screws in diamater of 20 millimeters, split-set rock screws, sprayed concrete and mesh. The planned ore breaking technology has been the chamber-pillar breaking.

8. Expectable major mine hazards and damages

The following mine hazards (circumstances hampering production) shall be taken into consideration at Recsk:

1. Firedamp hazard

The National Technical Inspectorate for Mines (OBF) classified the then deep level mine as category I. considering firedamp hazard in 1984. due to the low methane content of the inflowing natural gases.

2. Water afflux

The National Technical Inspectorate for Mines (OBF) classified the then deep level mine as endangered by water afflux in 1984. There were considerable sprung waters within the limestone complex, the hydraulic conductivity of andesite body is considerably lower. Prior to shaft deepening and entry driving, averting of water afflux by preliminary drillings was realised, rock bodies were tapped. Occurring water imbibitions were mainly below 1 m^3/min. The maximum was 2.6 m^3/min. Water affluxes were excluded by cementing or clayish rock sealing.

3. Dust hazard

Breaking of rocks was considered as silicosis hazardous pursuant to the OBF regulation No. 745/1977. due to the free quartz content. Blasted rocks were sprayed with water for protection against dust hazard and dust concentration was monitored regularly.

4. Hazards of fire, landslip, outburst and radiation injury

Such hazards have not occurred in the course of mining operations. There is a potential risk of gas due to the potential release of gases from waste water if ventilation stops in case of power failure. The gas composition may be carbon dioxide, methane, some sulphur dioxide in variable proportion.

Subsidence on the surface due to underground mining is not expected. There is no threat of any injury outside the mining plot. Protective pillars have been designated to shafts I. and II. by the then Mining Inspectorate with a 1,000 meters radius down in 131 metres depth. The NE part of mining plot is overlapping with ‘Recsk I.’ mining plot. There is a 60 meters wide protective pillar on the overlapped area.

Locations of water and gas outbreaks, values of water discharge and temperature, as well as of gas pressure have regularly been documented in the active period of mine (BAKSA et al. 1990).

Mining geologic conditions prior to inundation are quite different from the one at the time of heading:

— the casing of entries has been multi-gunited,
— exploration drilling have been cemented, most of the primarily water and gas blowing holes have become imperceptible,
— yield and pressure of sprung waters detected in boreholes and entries have decreased in some days and veins have been filled by secondary mineral segregations,
— halite and/or carbonate segregations have filled the fissure system of rocks pursuant to the evaporation of sprung waste waters,
— oxygen content of mine air, heat, humidity and the presence of agressive gases have triggered an intensive oxidation process,
— in favour of preserving mine openings, removal of secondary mineral segregations from entry walls, conduits, tubes, entry foot and shaft have been regularly carried out
— in some cases there have been bottom surge and contraction of conduit.

Prior to the inundation of mine a video documentation has been completed on mine technical and geologic conditions (KOMLÓSSY et al. 1990).

In case of re-opening of deep-level mine and potentially the establishment of new excavation voids, occurrence of the above-mentioned mine hazards, got acquainted with upon contemporary mining experiences, is expected.

9. Waste management, waste rock disposal

Unlike green-field investments, three types of waste shall be taken into account as for re-opened mines:

1. wastes generated due to re-opening (one-time waste generation);
2. wastes generated in the course of operation (permanent waste generation);
3. wastes generated at re-opening, as well as in the course of operation.

1. Most of the supporting facilities of the former mine are reusable at re-opening but buildings with asbestos plates in poor condition shall be demolished. Such buildings used to be insulated with asbestos. Asbestos is a hazardous waste: it shall be separated and stored. Hazardous substances are not dissolved from the asbestos practically due to rainwater or weak acids, so it can be disposed in contamination sensitive areas without bottom sealing. Asbestos crumbles to a great extent that is why the temporary storage is realizable in a closed space.

Transportation roads need to be renewed.

2. Pursuant to the estimation by R.T.Z.C (1998.) the expectable volume of mining (rubble) waste shall be approximately 200,000 tons/year. Knowing the geologic structure of the deep level, there are five different rock types comprised in it such as:

- diorite variations (diorite-porphyrite, quartz-porphyrite, endoscarn, etc.);
- quartzite;
- limestone;
- dolomite;

- scarn (exoscarn).

Unlike the majority of mines, these are not considered automatically as inert wastes because they mostly contain sulphide minerals, even if their quantity does not reach the limit for exploitation. For qualification of the rubble waste rock its acidifying potential has to be assessed.

In superficial conditions, the sulphur content of waste heaps changes to (oxidise) acid (sulfuric acid). As pyrite is the most common among the sulfide minerals in the waste rock, it is not a fault at all to consider the whole sulfur content as pyrite (as well as marcasite). In this case (1) 98 g of sulfuric acid is formed from 32 g of sulfur:

$$4\ FeS_2+15\ O_2+8\ H_2O=2\ Fe_2O_3+8\ H_2SO_4\ (1)$$

Sulfuric acid is neutralised by carbonates, mainly the calcium carbonate. In the meanwhile, the calcium sulfate develops into gypsum by hydration. In this chemical reaction 98 g of sulfuric acid is neutralised by 108 g of lime.

$$H_2SO_4+CaCO_3=CaSO_4+H_2O+CO_2\ (2)$$

The waste material is considered as antacid if its calcium carbonate content (apart from the carbonates of magnesium, strontium. stc.) is at least the threefold of the pyrite's.

3. One of the substancial problems of maintaining the mine has always been the limescale formation, and it will probably remain the same. Inrush water to the mine contains much dissolved salt due to high pressure; the salt content of waste water was approx. 8 g/l in the past.

More than 90% of the precipitated salt is calcium carbonate; the second most important constituent is calcium chloride. The expected total annual volume can not be estimated. It strongly depends on the locations of breakings, as well as the way of transport of water to be sent to Mátraderecske and Parád.

There are separate regulations for sewage treatment and discharge. Direct and indirect lead-in of contaminants into geologic media, including lead-in into intermittent watercourses as well, are subject to permitting. Limit values of discharges of contaminants are specified in a government decree. The decree also covers the drain-flow.

We assume that the ore will be dressed by flotation subsequent to crushing. Prior to crushing the exploited ore is rock-piled separately. We assume that higher noble metal-bearing ores are not separated from the others. We render it likely that accessory elements such as Au, Ag, Cd are separated from the main recycled materials (Zn, Cu) only in the course of smelting. Because of the scarnic feature, the sulfide and carbonate content of the ore is considerably high. Due to the varied nature (and in lack of specific lab tests), it shall be considered as potential acidifier. The ore, broken in the course of exploration of the deep level, has been placed on the depots established on both sides of the course connecting mining plant and shaft I. (afterwards has been transported to Gyöngyösoroszi for enrichment). Such waste heaps did not cause any damage to the environment for 30 years in operation. Further usage for such purposes has to be permitted by the environmental authority. In the course of permitting procedure the competent authority may ordain that it should be partially engineered.

The following products shall be formed as a result of enrichment:

1. flotation waste;
2. sphalerite concentrate;
3. chalcopyrite concentrate;
4. polymetallic concentrate;
5. magnetite concentrate;
6. pyrite-pyrrhotine concentrate.

1. The flotation waste is a grey, fine-grained (mainly below 0.1 mm grains in size) sand. Its expectable sulfide mineral content is about 5% according to experiences gained at other locations (e.g. Gyöngyösoroszi). There are hardly any areas in the neighbourhood which are not sensitive to contaminations that is why the selection of area requires special attention. The flotation waste heap is likely to be partially engineered.

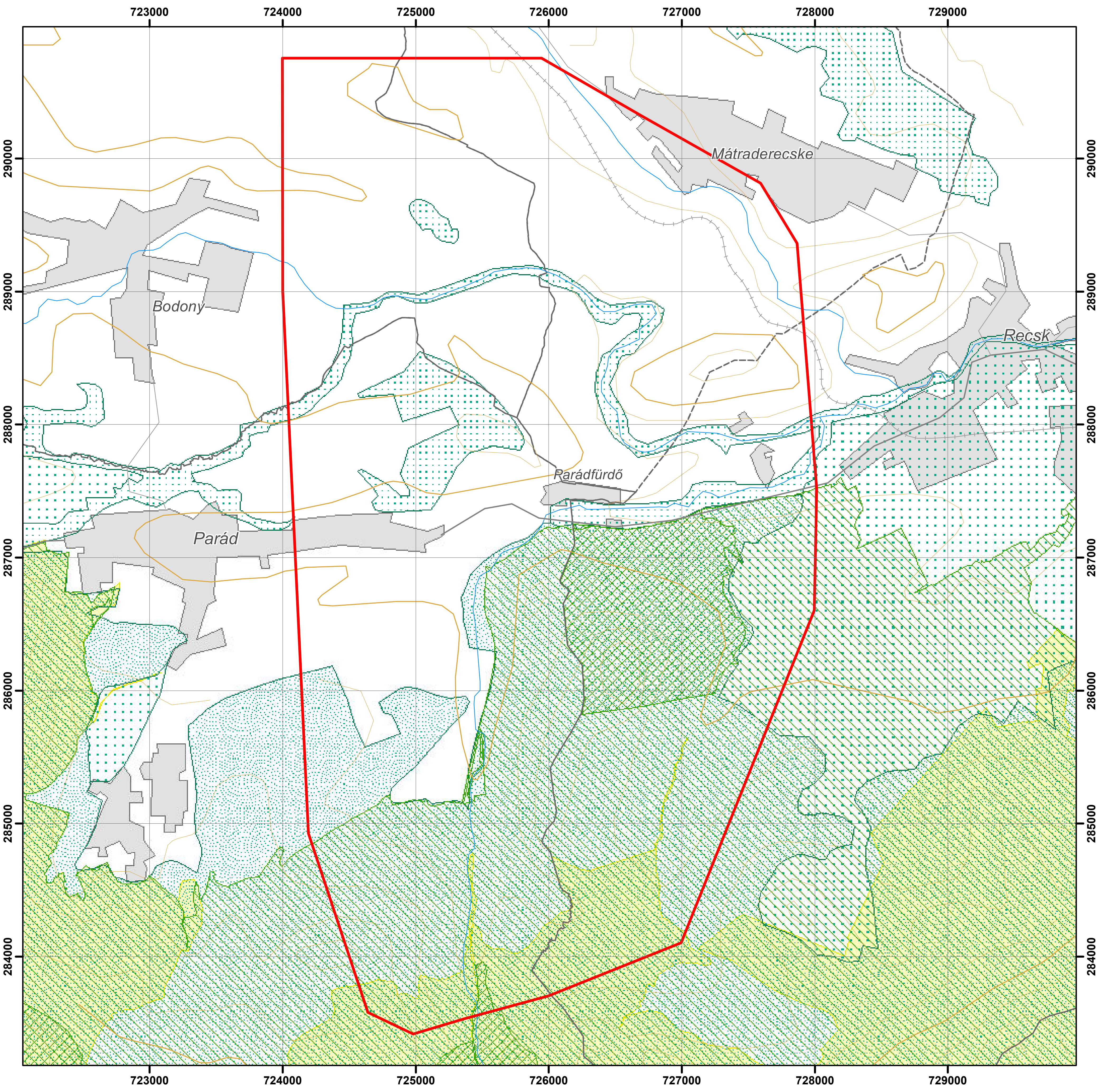
2–4. The sphalerite, chalkopyrite and polymetallic concentrates shall be stored in heaps between flotation and smelting. Sphalerite is rich in iron, so calling it as 'marmalite' would be more proper. Galenite proportion is significant in polymetallic concentrate beside marmarite and chalkopyrite. Both are fine-grained sand similar to the flotation waste but the majority of concentrates are sulfide minerals. Such minerals oxidise intensively in open storage sites (waste heaps) partly decreasing the efficiency of flotation, on the other hand producing much sulfuric acid. There may be great losses both in transportation and storage but mainly dustibility.

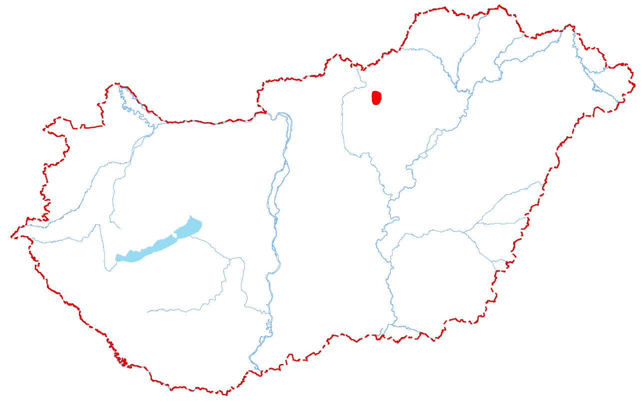
5. The magnetite concentrate is a side-product of flotation. The magnetite (Fe_3O_4) itself is inert considering its impact on the environment but the concentrate consists of accessory sulfidic mineral in some % (mainly due to the coalescences of grains). Practically there is no any antacid in it, so this concentrate shall be considered as potential acidifier.

6. The pyrite-pyrrhotine concentrate is the other side-product of flotation. Most of its bulk are the mineralogically volatile iron sulfide. Practically there is no any antacid in it, so it is considered as strong acidifier. Pursuant to the expertise of R.T.Z.C. (1998.) a part of the pyrite-pyrrhotine concentrate is 'presumably' marketable. Such an optimistic standpoint is not confirmed by evidences. According to their opinion the rest of the concentrate should be used for filling the abandoned excavation voids. If the whole volume of concentrate is used for filling not resulting in the reflux to the waste water, it will not cause any problem to the environment.

Annex

Table of figures of the whole study





Study area
Nature CONSERVATION
Landscape protection area
National Ecological Network [VKGA 2009]
Core area
Ecological corridors
Puffer zone
NATURA 2000 Special Protected Area (SPA) for birds
NATURA 2000 Special Area of Conservation (SAC)

0 0,5 1 km

Layout, nature conservation areas: Recsk II.

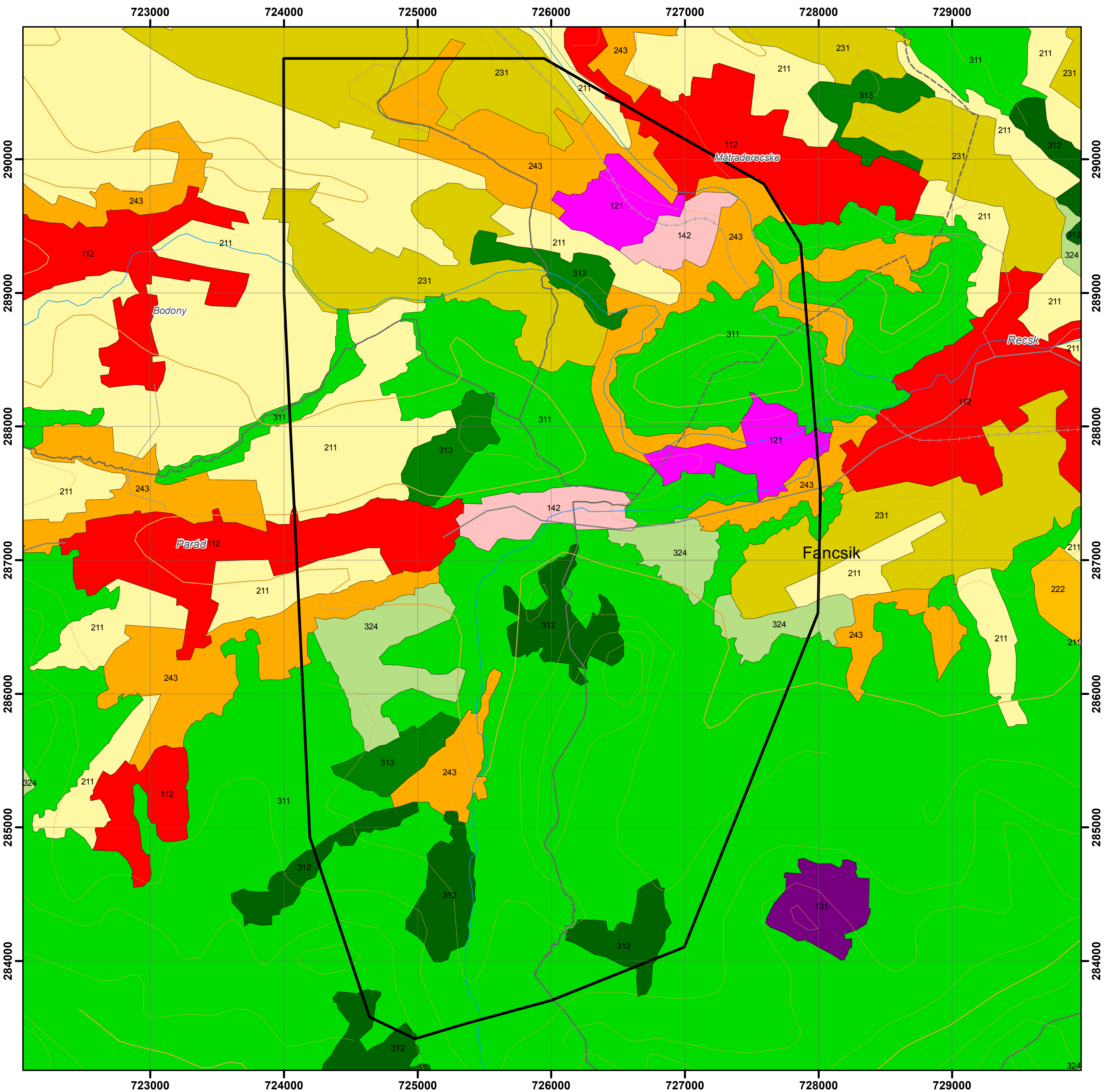
Complex sensibility and loadability assessment report to Recsk II. area

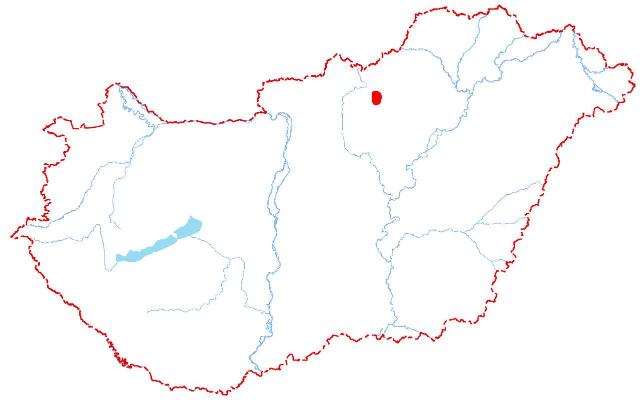
MBFH-MFGI cooperation, 2015.

Scale:	-	Principal:	MBFH
Projection:	EOV	Digital editing:	György Paszera
Date:	07.07.2015.	Supervised by:	György Gyuricza
		Endorsed by:	Tamás Fancsik

MFGI Magyar Földtani és Geofizikai Intézet

Annex 1.





☐	Study area
112	Non-contiguous settlement pattern
121	Industrial or commercial areas
131	Exploitation of mineral raw material(s)
142	Sport and leisure facilities
211	Non-irrigated arable lands
222	Orchards, berries
231	Meadow/pasture
243	Agricultural lands with significant natural vegetation
311	Broad-leaved forests
312	Coniferous forests
313	Mixed forests
324	Transitional forested areas and scrublands

0 0,5 1 km

Land use (CORINE): RECSK II.

Complex sensibility and loadability assessment report to Recsk II. area

MBFH-MFGI cooperation, 2015.

MFGI MAGYAR FÖLDTANI ÉS GEOFIZIKAI INTÉZET

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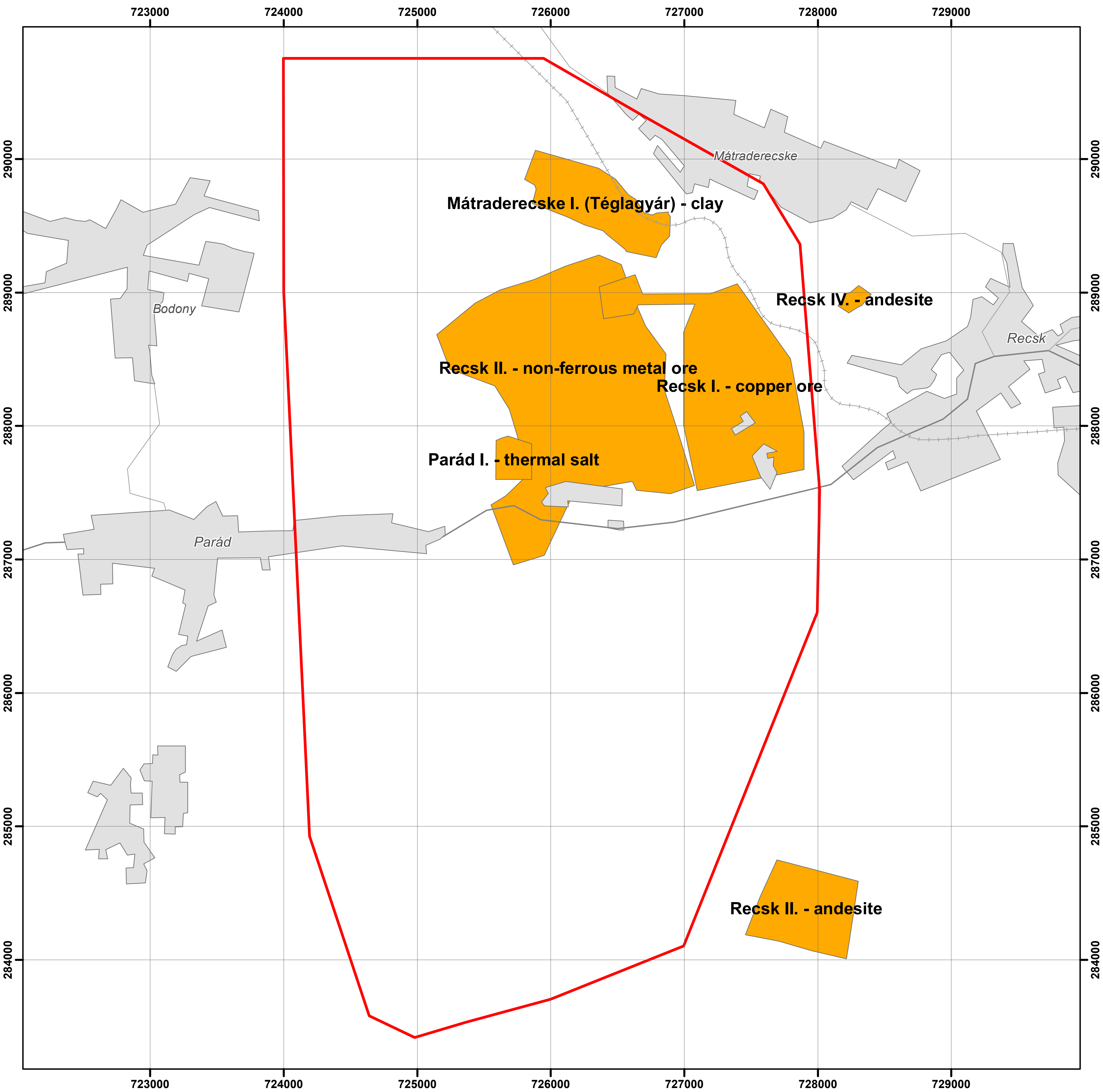
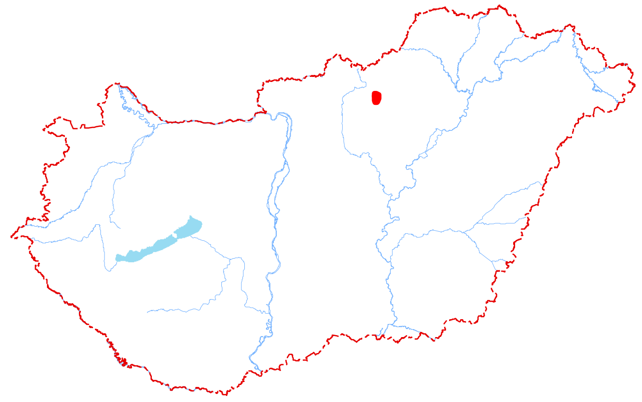
Date:	15.07.2015.	Supervised by:	György Gyuricza
		Endorsed by:	Tamás Fancsik

Annex 2.





Study area

Mining plot with valid mining permit and registered by MBFH

0 0,5 1 km

Mining plots in the study area: RECSK II.

Complex sensibility and loadability assessment report to Recsk II. area

MFGI Magyar Földtani és Geofizikai Intézet

MBFH-MFGI cooperation, 2015.

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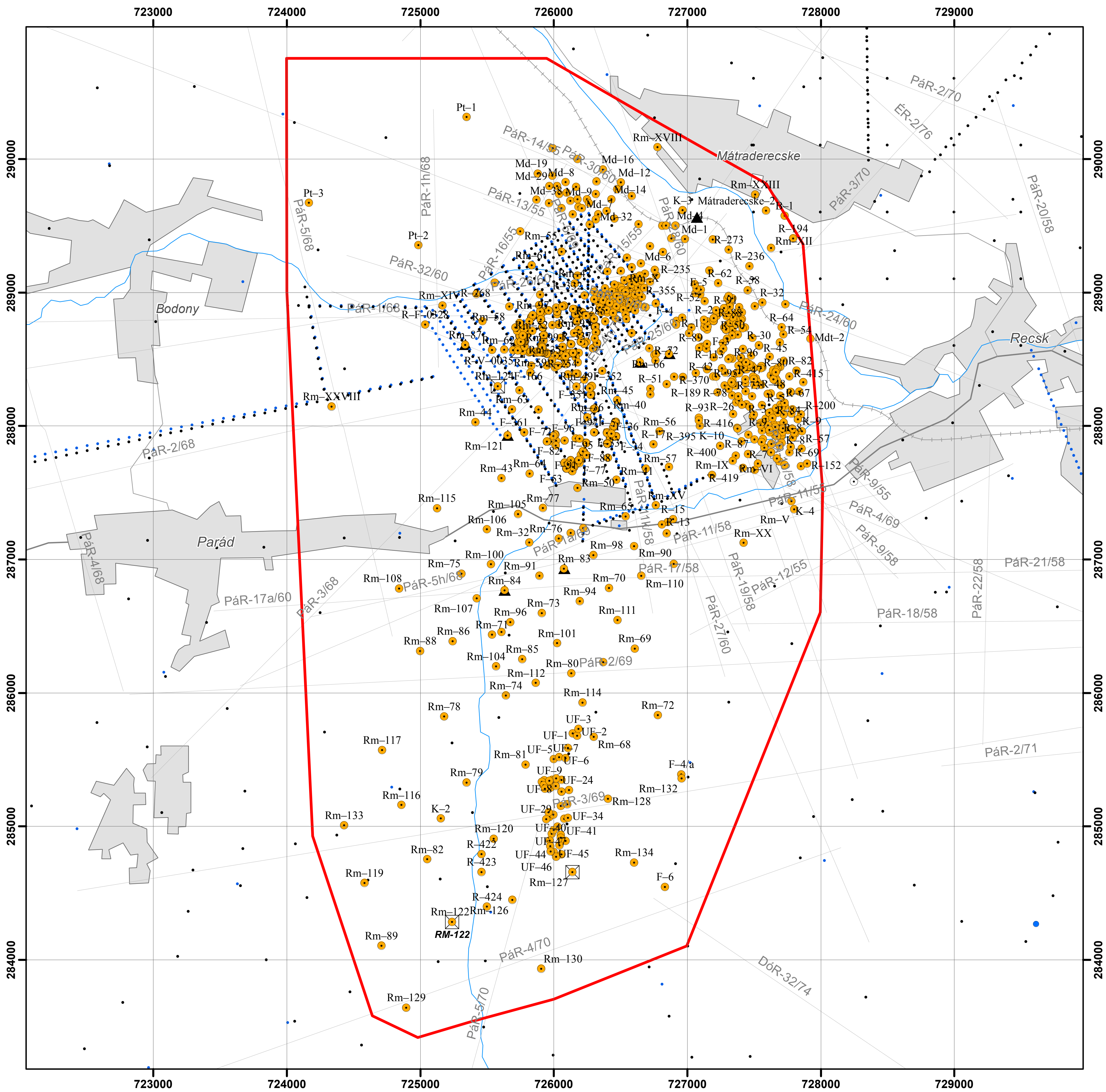
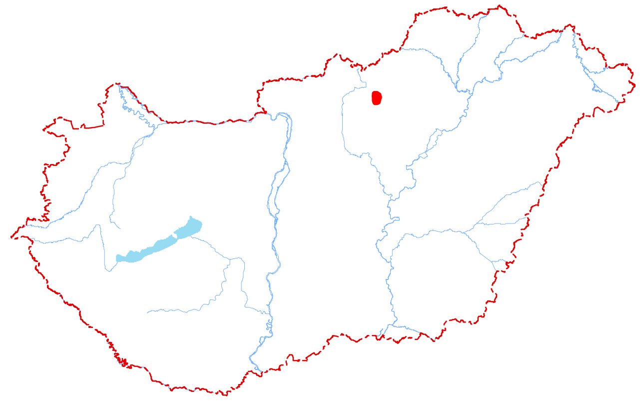
Date:	11.03.2016.	Supervised by:	György Gyuricza
		Endorsed by:	Tamás Fancsik

Annex 3.





- Study area
- Borehole (MBFH, MFGI, MFA, Szebényi et al. 2013, Komlóssy et al. 2000))
- Hydrocarbon exploration borehole registered by MBFH
- Digital deep borehole – geophysical data
- Heat flow and temperature data
- Gravity measurement
- Magnetic dz measurement
- Vertical electric sounding; AB > 4,000 m
- 2D refraction cross-section

Airborne geophysical measurements cover the whole area (1966., 1992.)

0 0,5 1 km

Level of survey in terms of drilling and geophysics:RECSK II.

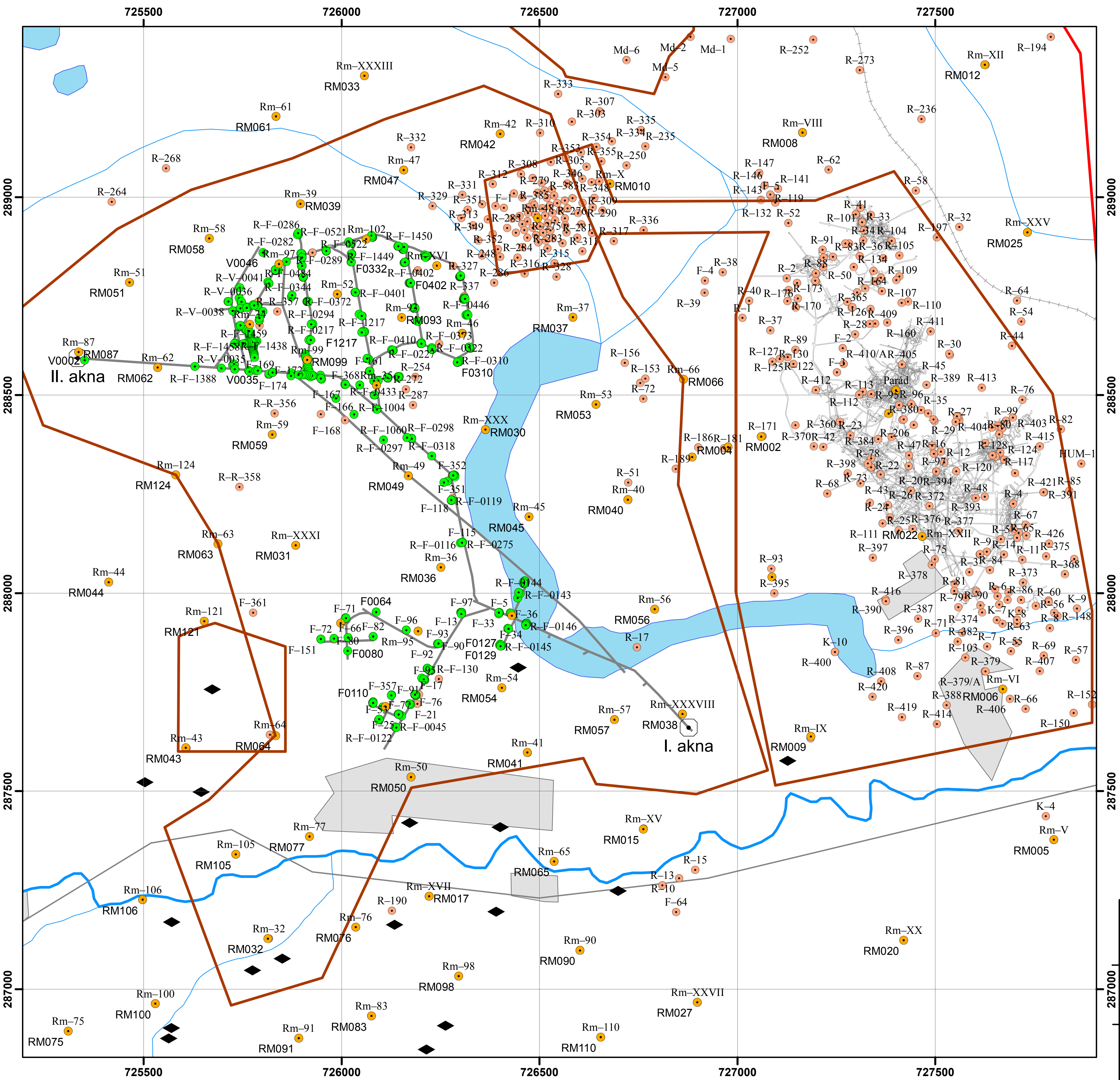
Complex sensibility and loadability assessment report to Recsk II. area

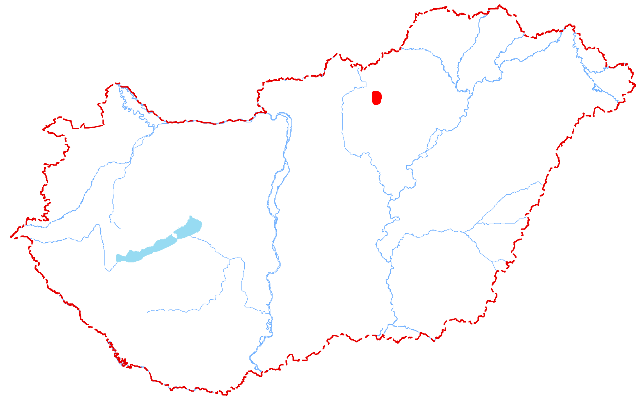
MBFH-MFGI cooperation, 2015.

MFGI MAGYAR FÖLDTANI ÉS GEOFIZIKAI INTÉZET

Scale:	-	Principal:	MBFH
Projection:	EOV	Digital editing:	György Paszera
Date:	15.07.2015.	Supervised by:	György Gyuricza
		Endorsed by:	Tamás Fancsik

Annex 4.





- Study area
- Mining plot with valid mining permit and registered by MBFH
- Borehole (MBFH, MFGI, MFA, Szebényi et al. 2013, Komlóssy et al. 2000)
- Surface borehole (Komlóssy et al. 2000)
- Borehole at deep level (Komlóssy et al. 2000)
- Shaft (EOV map in scale of 1:10,000)
- Entry at deep level (Szebényi et al. 2013)
- Entry at Lahóca Hill (Polgár 2009)
- Drive (Szebenyi et al. 2013, Komlóssy et al. 2000)

0 0,5 1 km

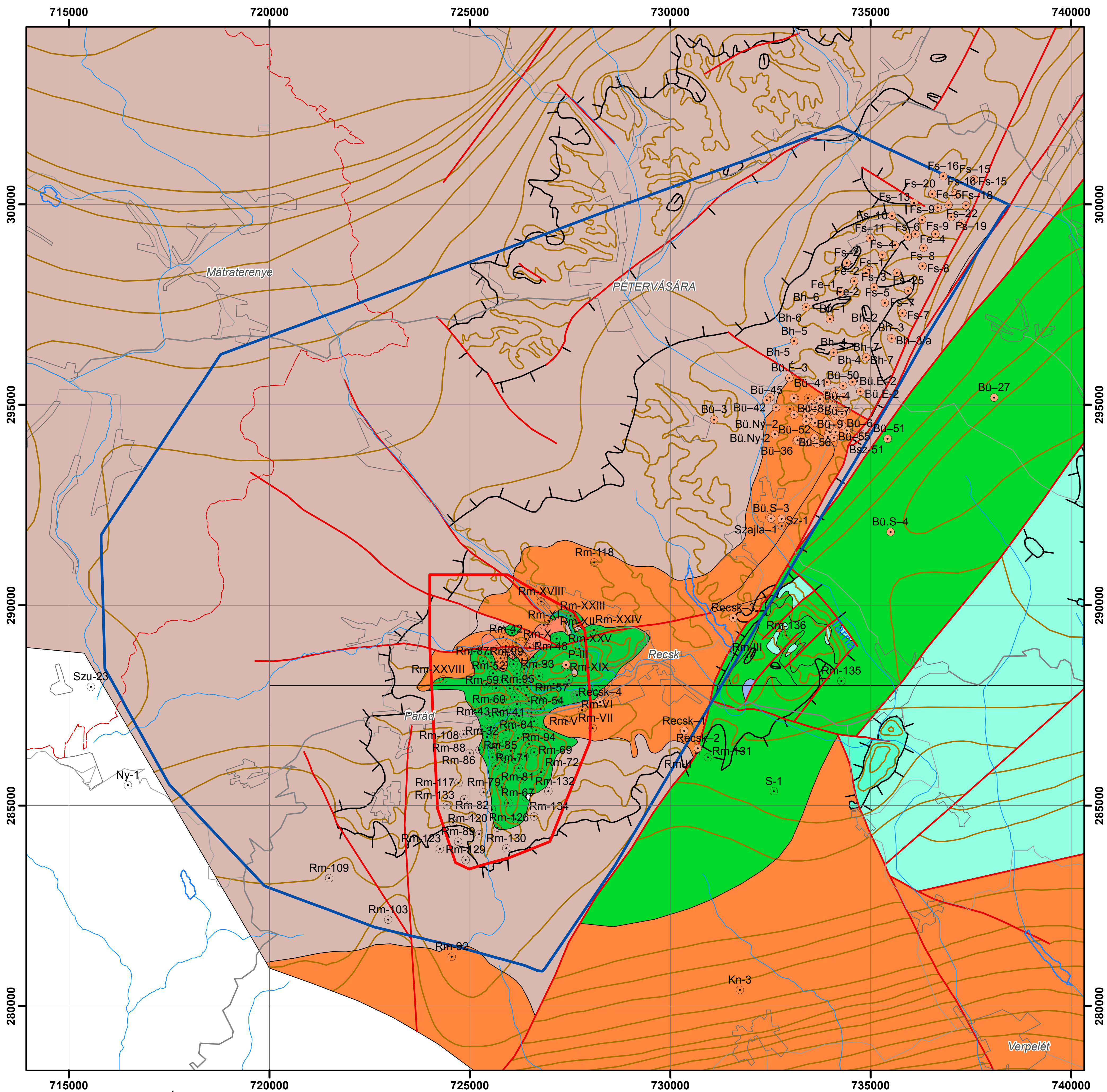
Level of survey in terms of drilling and geophysics (central area): RECSK II.

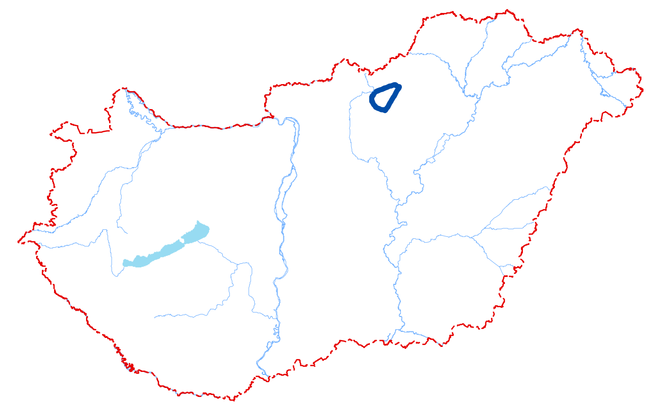
Complex sensibility and loadability assessment report to Recsk II. area

MBFH-MFGI cooperation, 2015.

MFGI MAGYAR FÖLDTANI ÉS GEOFIZIKAI INTÉZET

Scale: -	Principal:	MBFH	
Projection: EOV	Digital editing :	György Paszera	
Date: 15.07.2015.	Supervised by:	György Gyuricza	
	Endorsed by:	Tamás Fancsik	Annex 5.





- Study area
- Recsk – Bükkszék thermal karst
- Hydrocarbon exploration borehole registered by MBFH
- Borehole reaching 500 m in depth (MFGI, GeoBank)
- Buda Marl Formation
- Csipkéstető Radiolarite Formation
- Dallapuszta Radiolarite Formation
- Hosszúvölgy Basalt Formation
- Hosszúvölgy Formation and Mónosbél facies together
- Kiscell Clay Formation
- transition between Kiscell and Szécsény Formations, or combined
- Mónosbél Formation
- Nagyvisnyó Limestone Formation
- Oldalvölgy Formation
- Recsk Andesite Formation
- Szépvölgy Limestone Formation
- Szécsény Schlier Formation
- transition between Szécsény and Pétervására Formations, or combined
- Tard Clay Formation

Look for the key to tectonic elements in Appendix 2.

0 1,5 3 6 km

Pre-Neogene geologic map of the Recsk – Bükkszék area (Budinszkyné et al. 1999.)

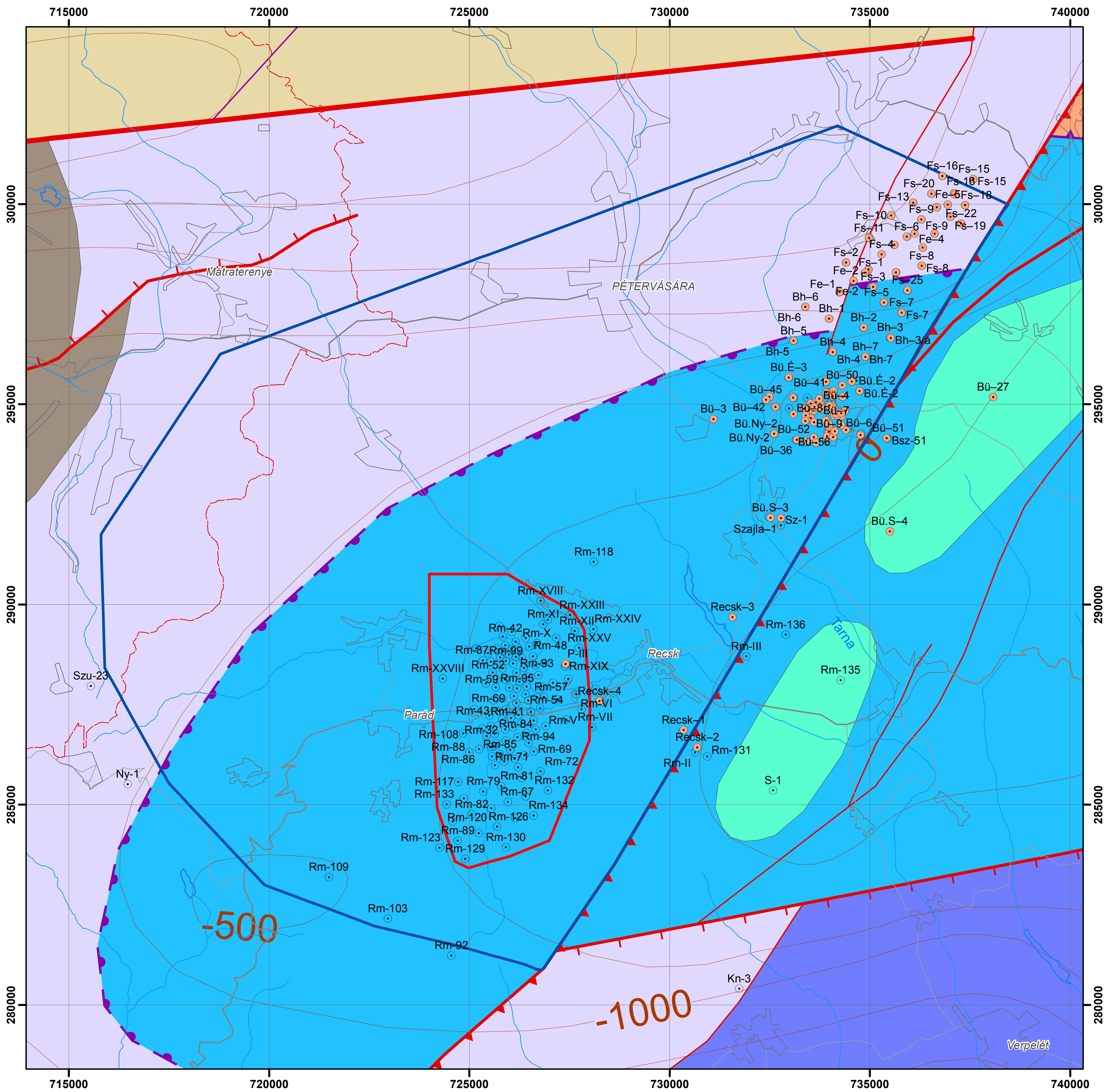
Complex sensibility and loadability assessment report to Recsk II. area

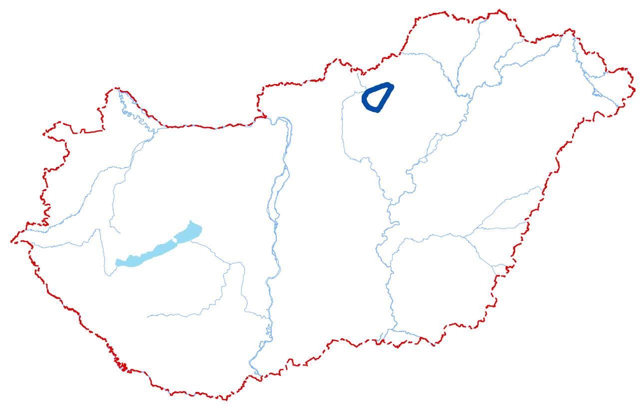
MBFH-MFGI cooperation, 2015.

Scale:	-	Principal:	MBFH
Projection:	EOV	Digital editing:	György Paszera
Date:	05.06.2015.	Supervised by:	György Gyuricza
		Endorsed by:	Tamás Fancsik

Annex 6.

Budinszkyné et al. 1999: Az Északi-Középhegységi terület preneogén földtani térképe, (neogén és negyedidőszaki képződményektől mentés földtani térkép) 1:100000. – Földtani Intézet kiadványa





Recsk – Bükkszék thermal karst
Hydrocarbon exploration borehole registered by MBFH
Borehole reaching 500 m in depth (MFGI, GeoBank)
Jurassic basic magmatic rocks
Middle Jurassic olistostrome mélange
low grade metamorphic Middle-Upper Triassic platform carbonates
very low grade metamorphic Upper Permian – Lower Triassic shallow-marine limestone, sandstone, marl
very low grade metamorphic New Paleozoic and Mesozoic formations, undivided
very low grade metamorphic New Paleozoic formations
Paleozoic and Mesozoic formations, undivided

Look for the key to tectonic elements in Appendix 2.

0 1,5 3 6 km

Pre-Cenozoic basement (Haas et al. 2010.): Recsk–Bükkszék

MFGI Magyar Földtani és Geofizikai Intézet

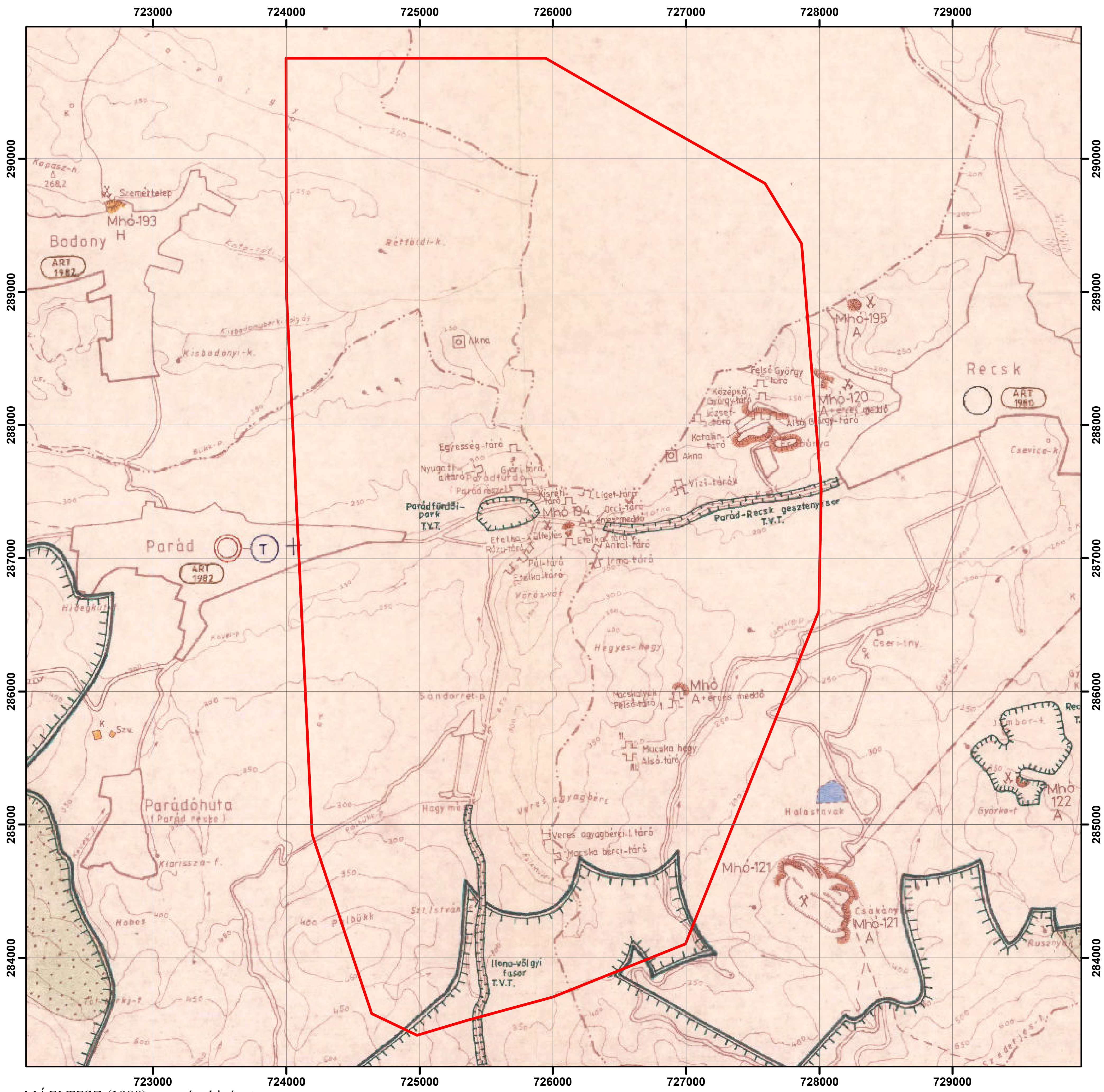
Complex sensibility and loadability assessment report to Recsk II. area

MBFH-MFGI cooperation, 2015.

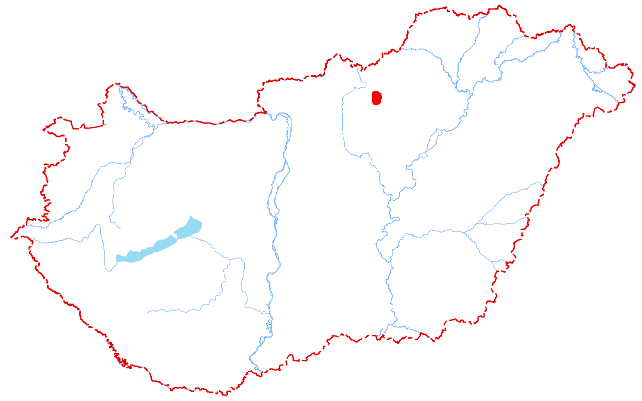
Scale:	-	Principal:	MBFH
Projection:	EOV	Digital editing:	György Paszera
Dátum:	05.06.2015.	Supervised by:	György Gyuricza
		Endorsed by:	Tamás Fancsik

Annex 7.

Haas J., Budai T., Csontos L., Fodor L., Konrád Gy. 2010: Magyarország pre-kainozoos földtani térképe, 1:500000. – Földtani Intézet kiadványa



MÁFI TFSZ (1988) nyomán, kivágat



LEGEND

1

Environmental protection

Particularly protected area

Nature conservation area of national importance (Mátra Landscape Protection Area)

Nature conservation area of regional importance

Te — Nature conservation object

Moderately air polluting settlement

Recreation, tourism

Settlement with certified health and holiday resorts

T — Thermal bath and spa

Settlement with thermal bath

ART 1980 — Settlement with general development plan

Waste heaps, mining

Mhó-154 — Cadaster number of waste heap

D — Waste material

Open-pit mine

Mhó — Waste heaps not included in the cadaster

Drive for ore exploration

Shaft

Operating mine

Closed mine

A — Andesite

D — Diabase

H — Sand

Ü — Slag from glass factory

Study area

0 0,5 1 km

Anthropogenic factors, protected areas, waste heaps: RECSK II.

Complex sensibility and loadability assessment report to Recsk II. area

MBFH-MFGI cooperation, 2015.

Scale:	-	Principal:	MBFH
Projection:	EOV	Digital editing:	György Paszera
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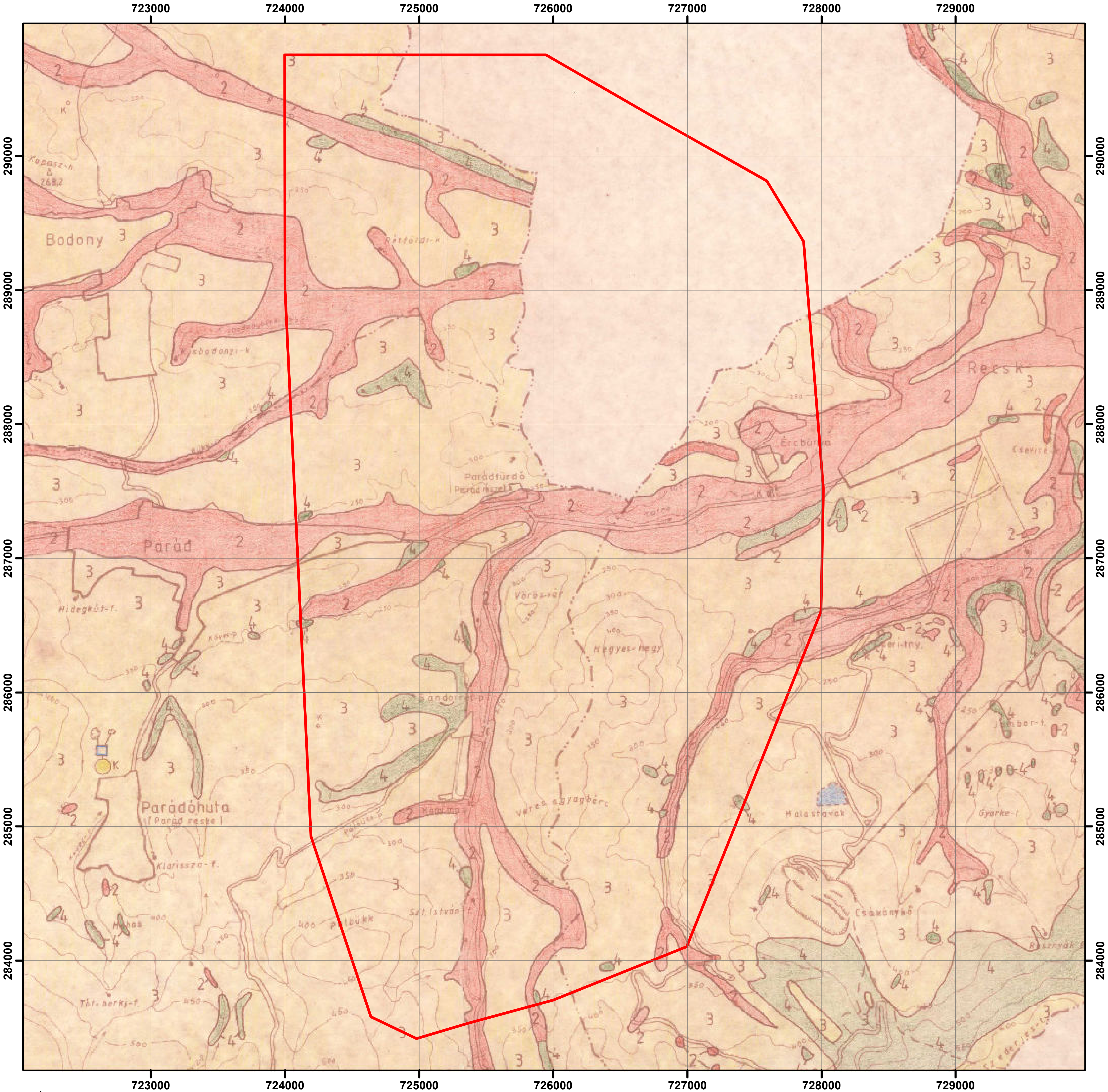
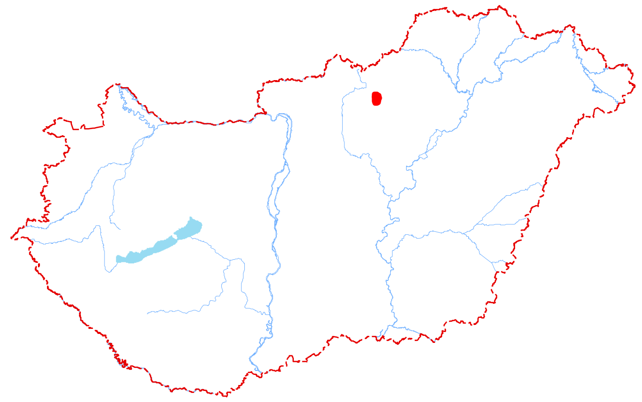
MFGI Magyar Földtani és Geofizikai Intézet

Annex 8.



MÁFI TFSZ (1988) nyomán, kivágat



LEGEND

2

1	Karst formations hipersensitive to contaminations of surface origin (not present in the area)
2	Porous formations hipersensitive to contaminations of surface origin
3	Formations moderately sensitive to contaminations of surface origin
4	Formations non-sensitive to contaminations of surface origin

Study area

0 0,5 1 km

Sensitivity to contamination on the surface: RECSK II.

Complex sensibility and loadability assessment report to Recsk II. area

MBFH-MFGI cooperation, 2015.

MFGI Magyar Földtani és Geofizikai Intézet

Scale:	-	Principal:	MBFH
Projection:	EOV	Digital editing:	György Paszera
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		Endorsed by:	Tamás Fancsik

Annex 9.