THE SOLOTVYNO FILES

Based on results of the DG ECHO UCPT Missions

Dr László PERGER

Chief Advisor for Water
Former EUSDR PA 4 Coordinator
Expert of the EUCPT Missions in UA

Pictures, figures, maps by curtesy of the EUCPT Team, Salt Mine Enterprise-Solotvyno, NAS UA and the Upper-Tisza Regional Directorate of Water, HU

OUTLINE

1. Cause of the problem
2. The Missions
3. The Mine history
4. The Salt-Mine file
5. The Geology/hydrogeology file
6. The Hydrology/water quality file
7. The Ground movement file
8. The Risk assessment file
9. Next steps
10. Conclusions

1. Cause of the problem (...the first significant indication)

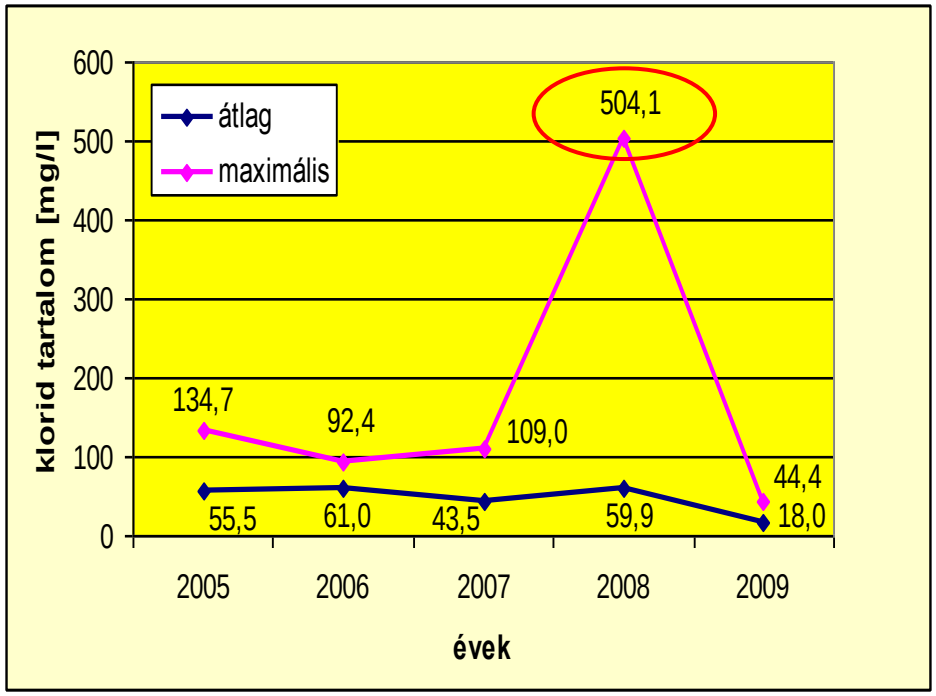


Figure 1: Maximum and average chloride content at the section of the Tisza River (Tjachiv, 35 river km downstream from Solotvyno)

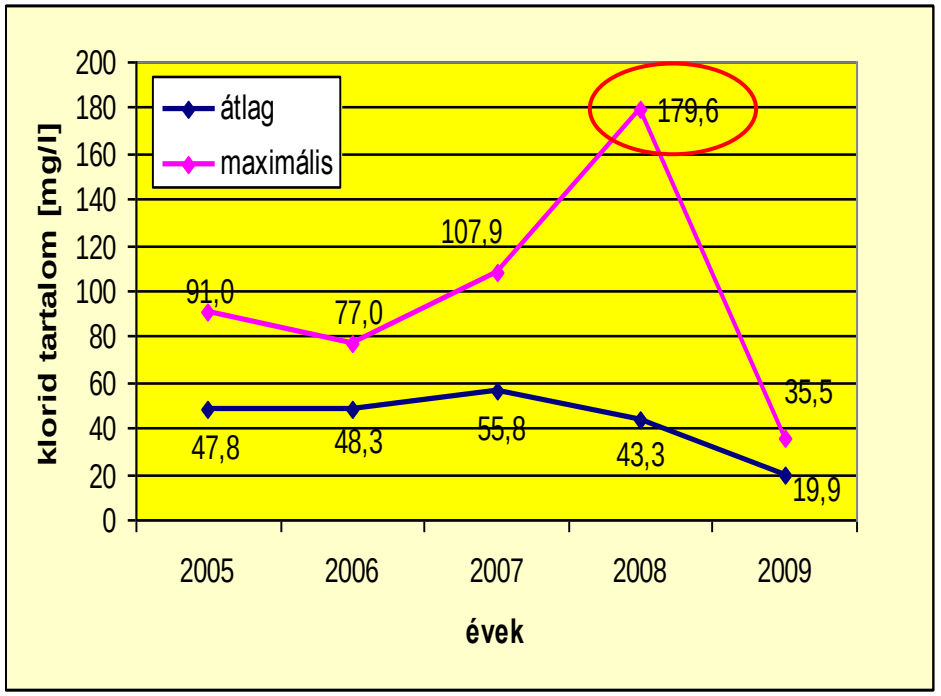
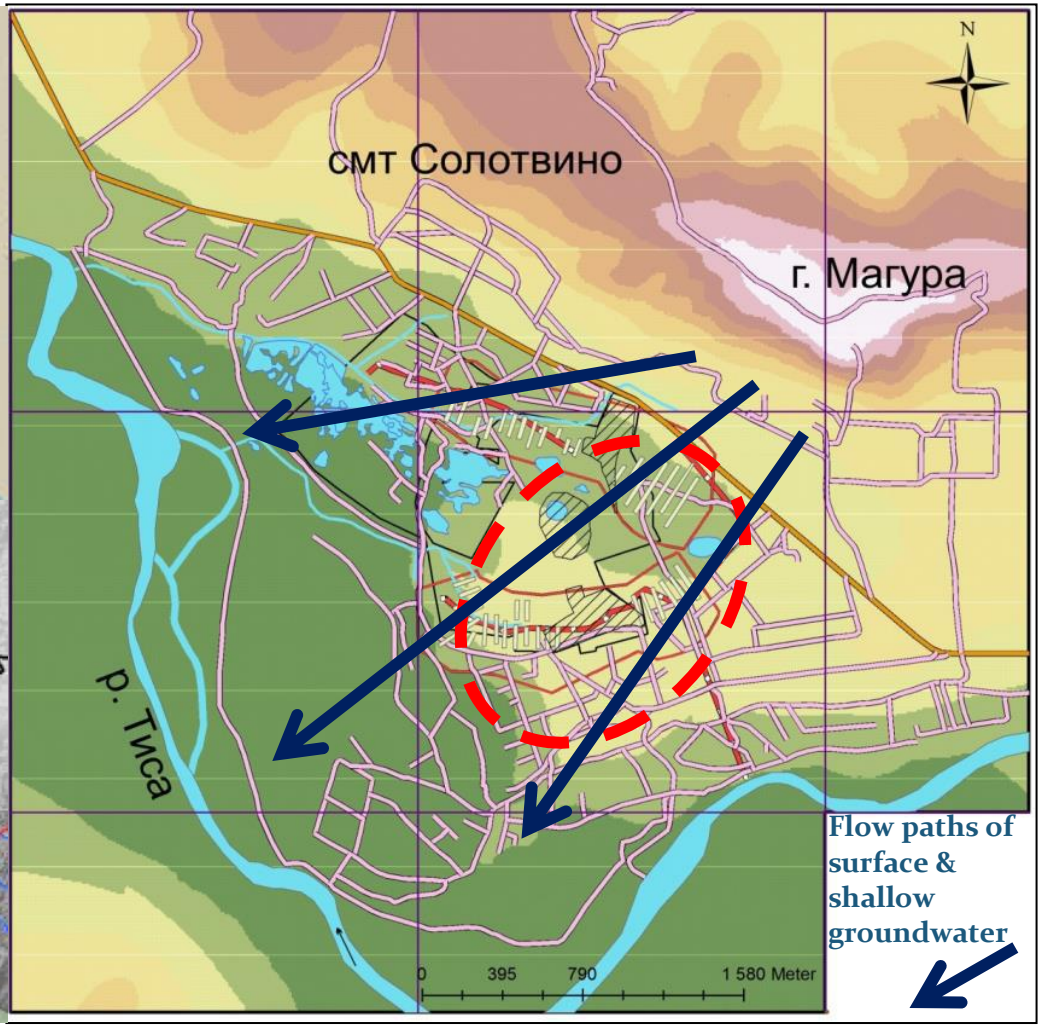


Figure 2: Maximum and average chloride content at the section of the Tisza River (Vilok-Tiszabecs, 104 river km from Solotvyno)

The ‚spot' of the Solotvyno Salt Mine disaster



Story of the EU assistance in solving the Solotvyno Salt Mine problem

- On 12 January 2016, **the Hungarian and Ukrainian civil protection authorities** (due to the strong initiatives of the HU EUSDR NC) **addressed a letter** to Commissioner Stylianides and the Director General of **DG ECHO**, Ms. Monique Pariat, concerning a cross-border environmental pollution originated from the Solotvyno salt mine complex
- The EU Civil Protection Mechanism **(EUCPM) was activated** on 17 June 2016 and they decided **to deploy a scoping mission** between the 3 to 8 July to support the national authorities. **The expectable results were**:
  - **Technical Report** on the **(1st) Scoping Mission with findings**
  - **ToR to design the work for the next Advisory Mission (2nd)**
  - **Activation of the (2nd) EUCPT Advisory Mission in autumn 2016** (14 September – 7 October)

The EUCPT Advisory Mission consisted of

- **16 independent experts from EU** and 1 Liaison Officer (LO). They were deployed for a 24-day mission (the longest and largest one has ever been before under EUCPM)

The EUCPT Advisory Mission's objective was

- **"Risk Assessment of the Solotvyno mine area" report**

2. The Missions (from the beginning)

1) High level bilateral (HU-UA) On-Site Mission on **15 July 2015**

- Aim: to get first impression and meet relevant responsible persons
- Output: - decision on continuation by scientific way
  - request from EU Commission (finance and team)

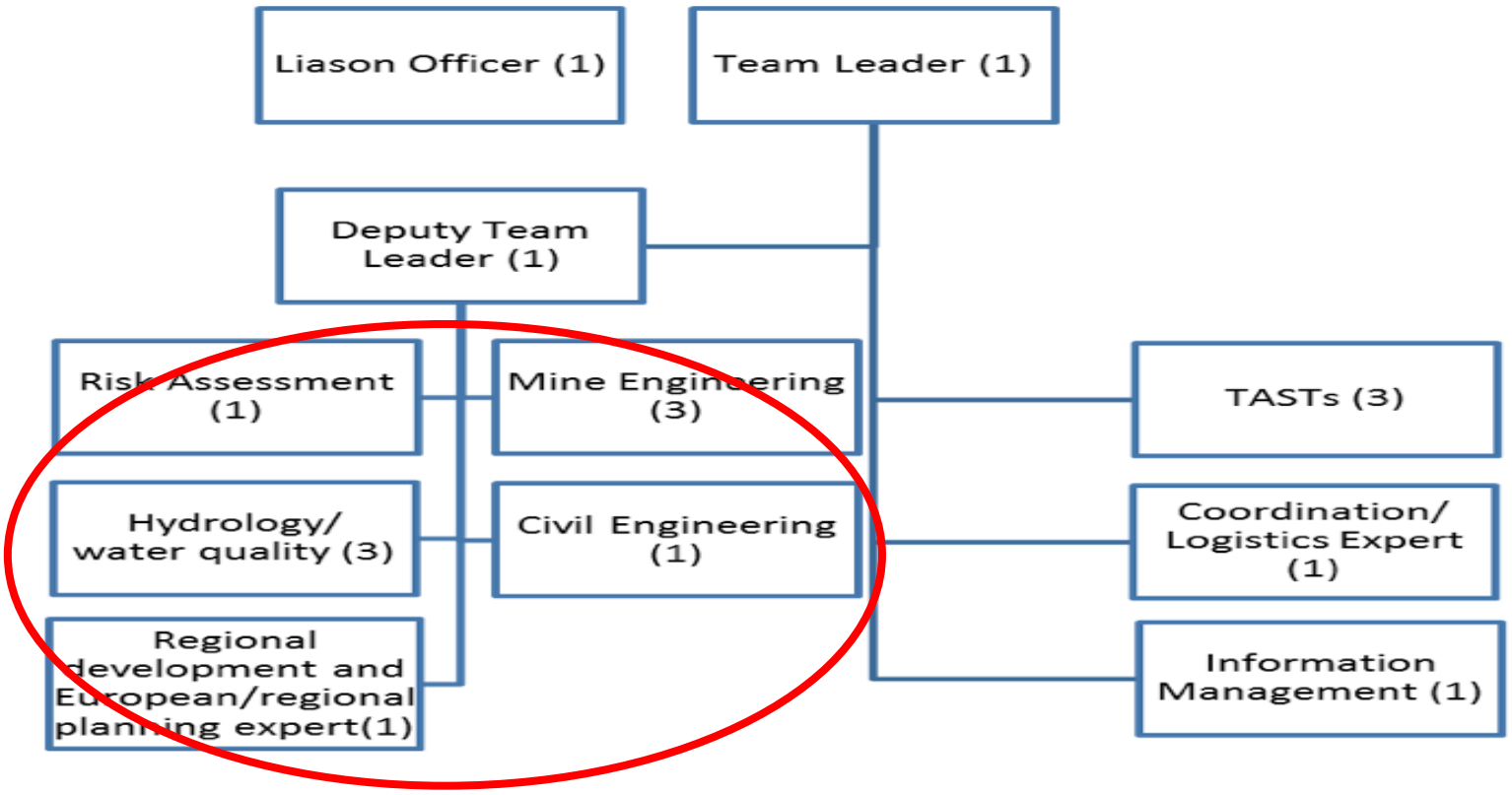
2) EUCPT Scoping Mission on **2 -9 July 2016**

- Aim: to deploy EUCPT & HU experts to know and survey the situation
- Output: - immediate recommendation to the Ukrainian Authorities for protecting human life
  - decision on deployment of the Advisory Team to reveal the details
  - ToR preparation for the Advisory Mission

3) EUCPT Advisory Mission on **14 September – 07 October 2016**

- Aim: to prepare an independent risk assessment report made by the Advisory Mission

The EUCPT Advisory Mission organization (17 experts)



Scientific Team (9 experts)

The Advisory Mission

EUCPT at Solotvyno Mine, backdrop the sinkhole No8

The Advisory Mission

Working together with the Ukrainian experts

The Advisory Mission

Meeting mining staff and full accessing all mine information

3. The Mine history

1. The first historical records on salt-mine activity from the Roman Empire times – strip-mining
2. The ‚Christina' Mine (№ 1) opened in 1778 under Hungarian Kingdom, as strip-mine (to 1781) – **was not really productive**
3. **The first deep-mine** – ‚Albert' Mine (№ 2) – opened in 1781 (to 1789) – **water intrusion**
4. ‚Kunigunda' Mine (№ 3) – opened in 1789 (to 1905) - **water intrusion**
5. ‚Nikolai' Mine (№ 4) – opened in 1799 (to 1905) - **water intrusion**
6. ‚Joseph' Mine (№ 5) – opened in 1804 (to 1850) – **overexploited**
7. ‚Old Ludwig' Mine (№ 6) – opened in 1804 (to 1810) - **overexploited**

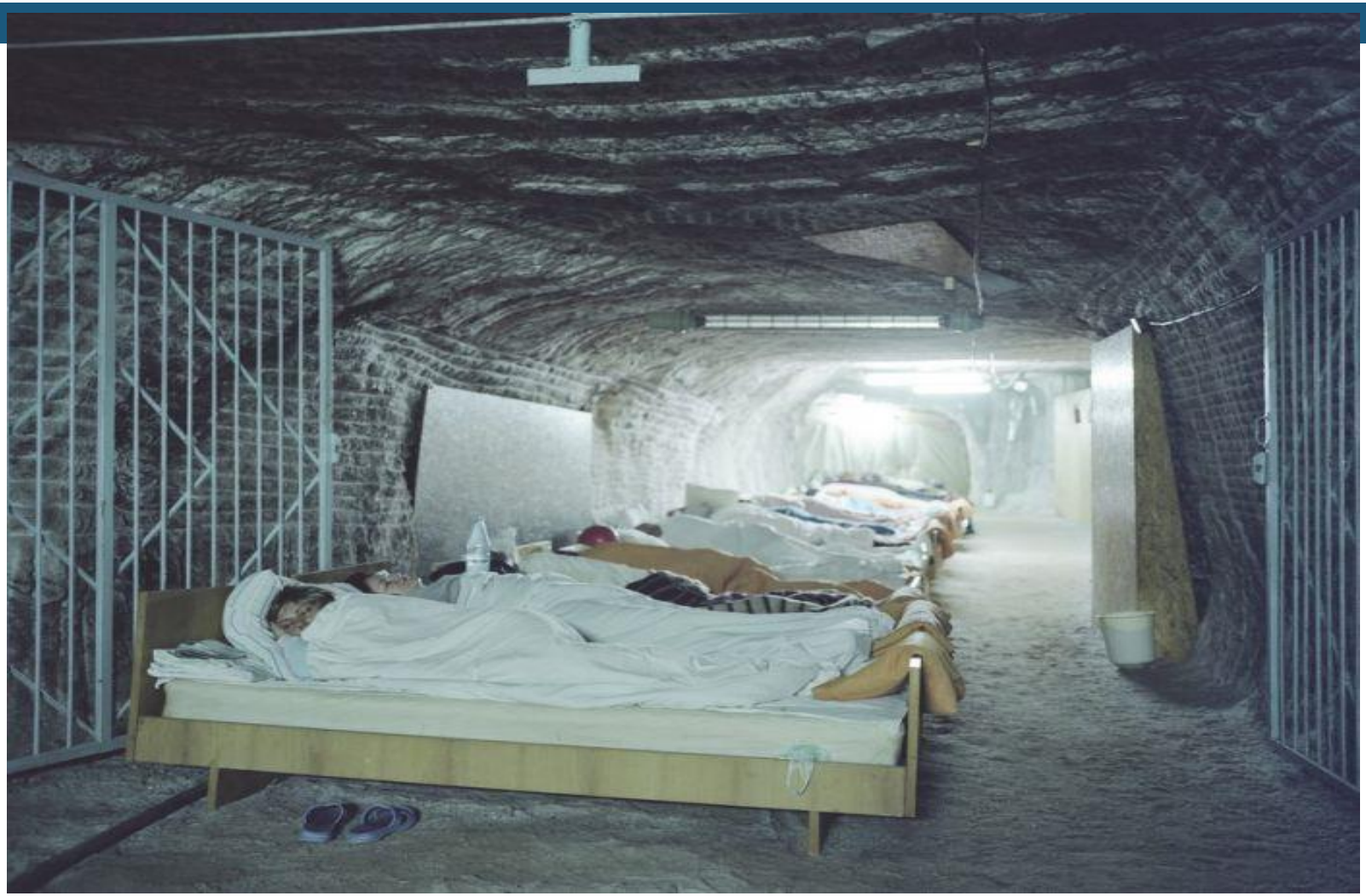
3. The Mine history (continuation)

8. ‚Frantisek' Mine (№ 7) – opened in 1809 (to 1953) - **water intrusion**
9. Mine ‚№ 8' – opened in 1886 (to 2010) - **water intrusion**
10. Mine ‚№ 9' – opened in 1975 (to 2008) - **water intrusion**

Summary/conclusion

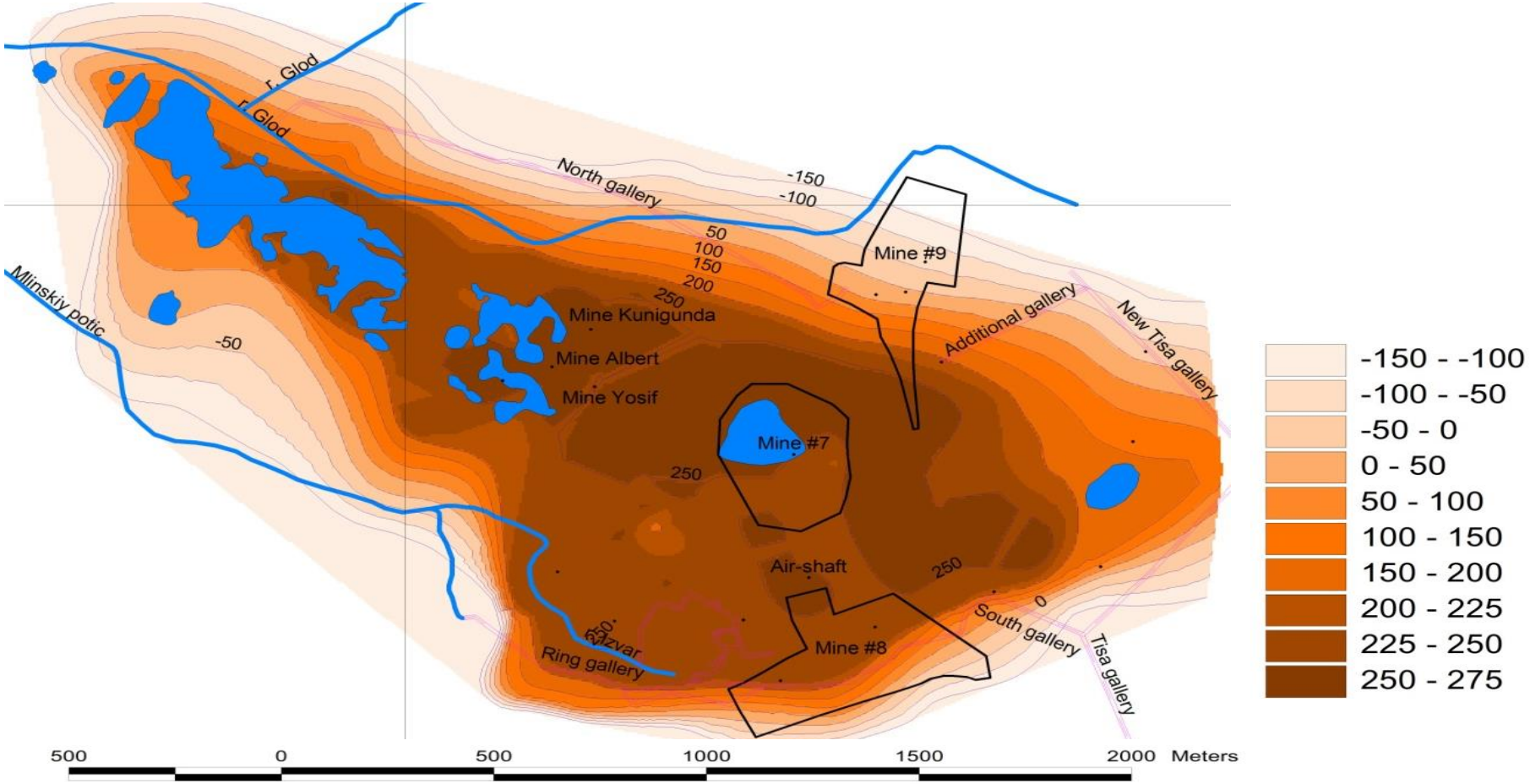
- ✓ *6 deep-mines from 8 ones had to be abandonned by water intrusion (it means 75% rate !!!)*
- ✓ *BUT, in case of well mine-management the lifetime of deep salt-mines is more than one hundred years , in average*
- ✓ *The last time opened deep-mine lived only a bit more than 30 years*
- ✓ *AND NOWadays , as consequence of it, cracks and new sinkholes come out and can observe continuously!*

Inside the Mine № 7 (named Frantisek) at the end of 19th century
(The height of the hall is more than 100 meters)



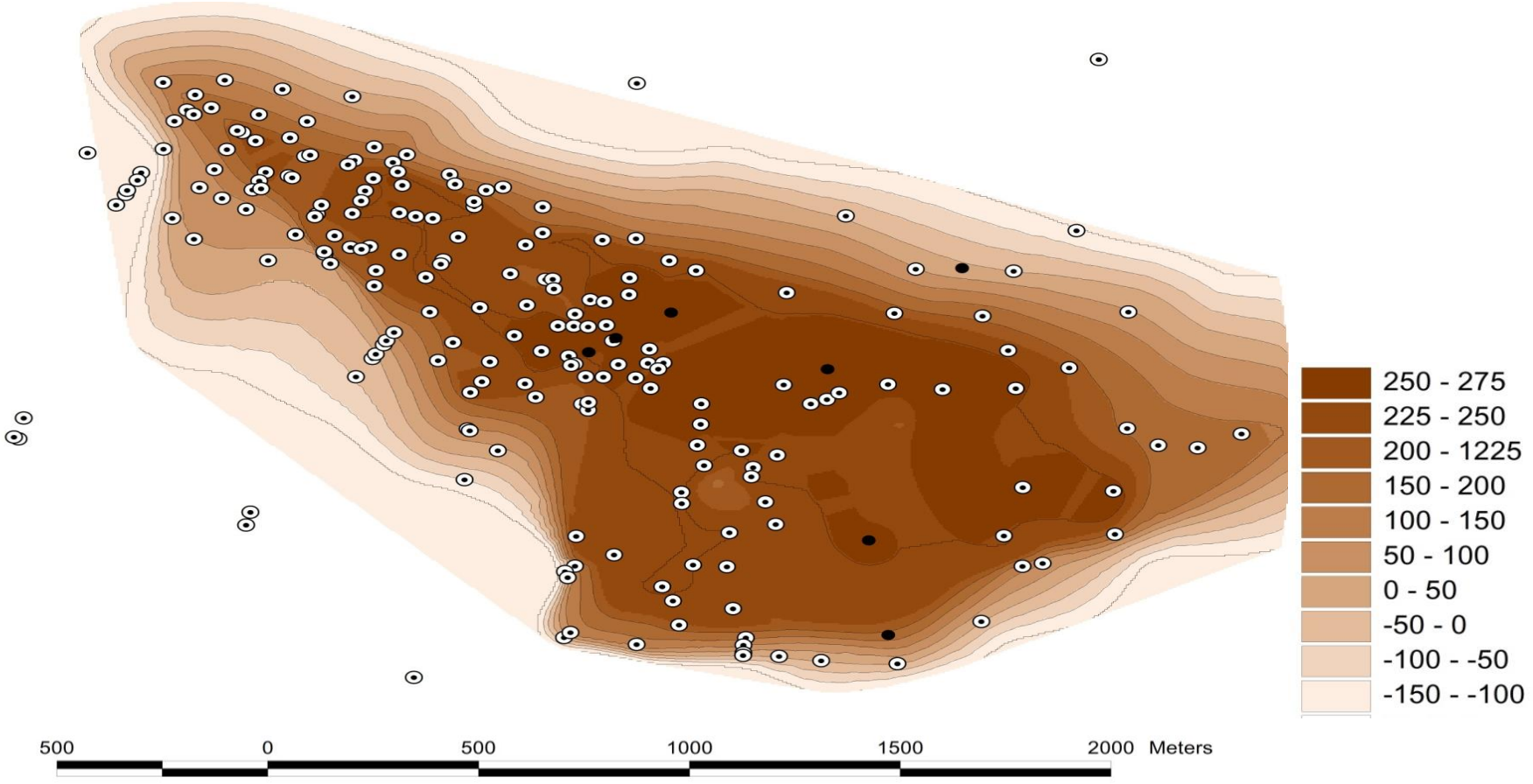
Speleotheraphy in the Mine № 9 about 300 meters below ground, sometime in the 2000's, before water incrushing

4. The Salt-Mine file (Map of the salt dome)



Map of the salt dome ABSL with lakes, sinkholes and mines (by curtesy of the INSTITUTE of GEOLOGICAL SCIENCES, NAS of UKRAINE 2016)

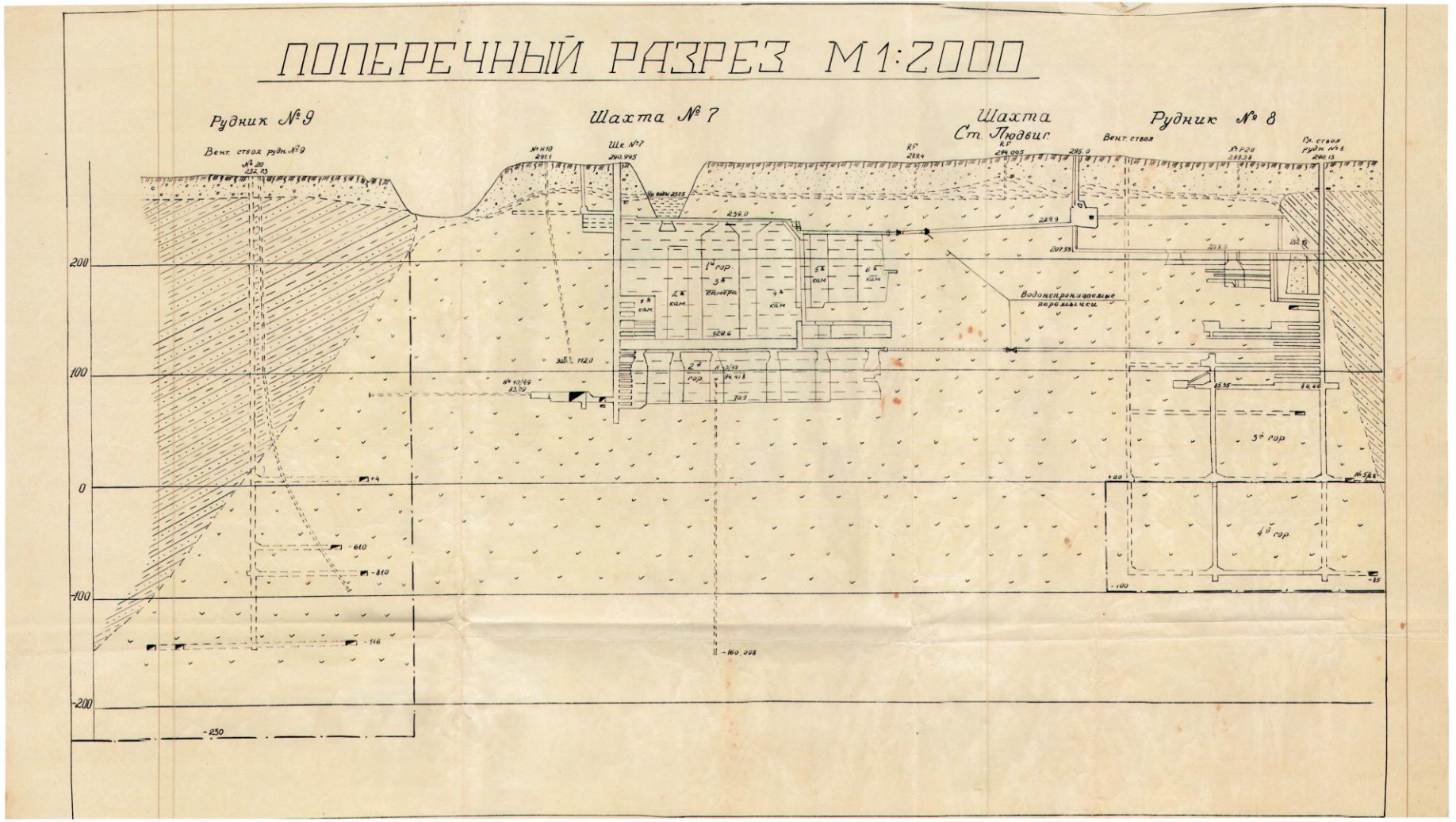
4. The Salt-Mine file (Map of the boreholes)



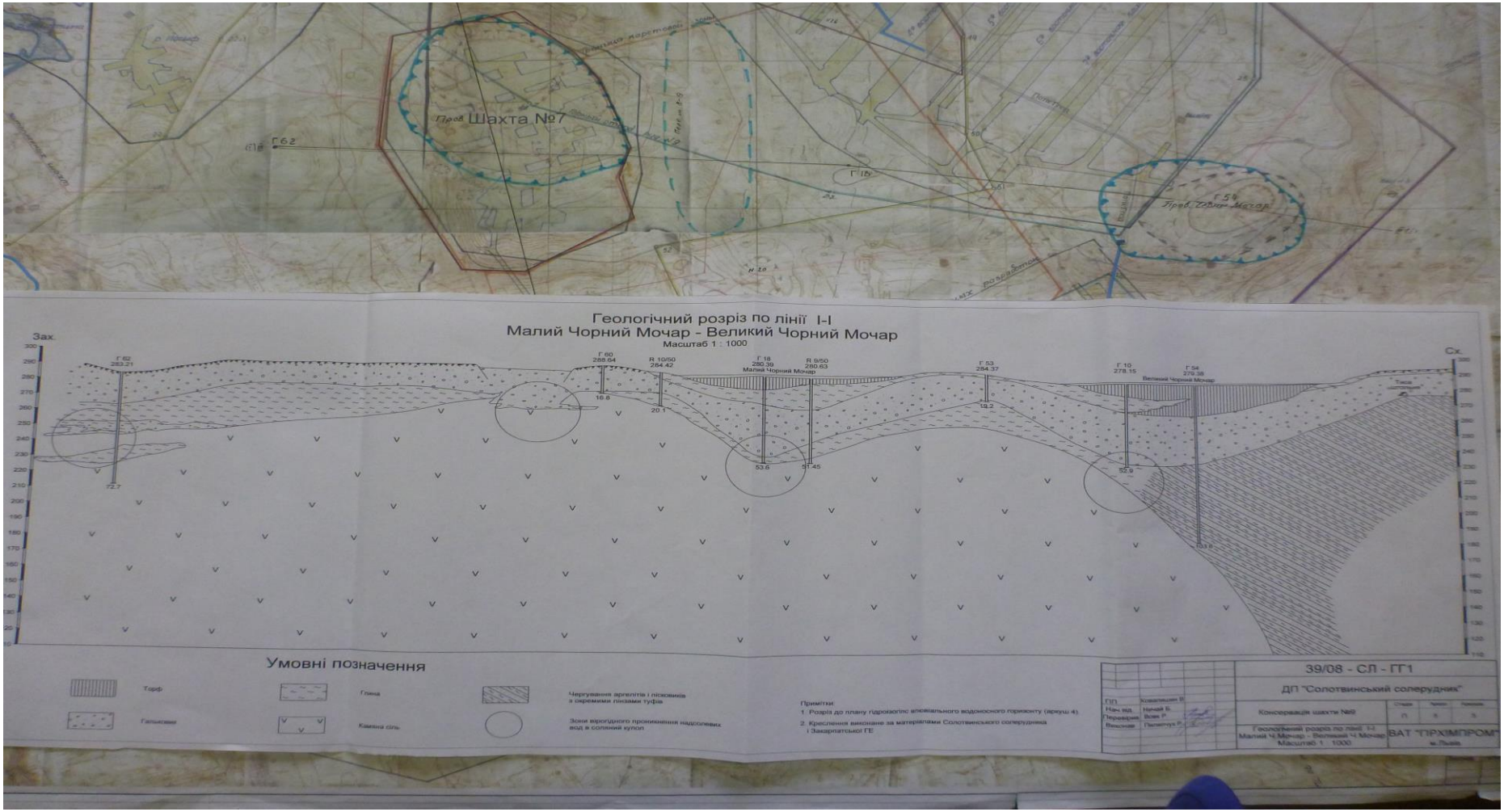
Map on the boreholes (for salt & water) between 1946-1973 with the salt-dome surface (by curtesy of the INSTITUTE of GEOLOGICAL SCIENCES NAS of UKRAINE 2016)

4. The Salt-Mine file (Map on the sinkholes)

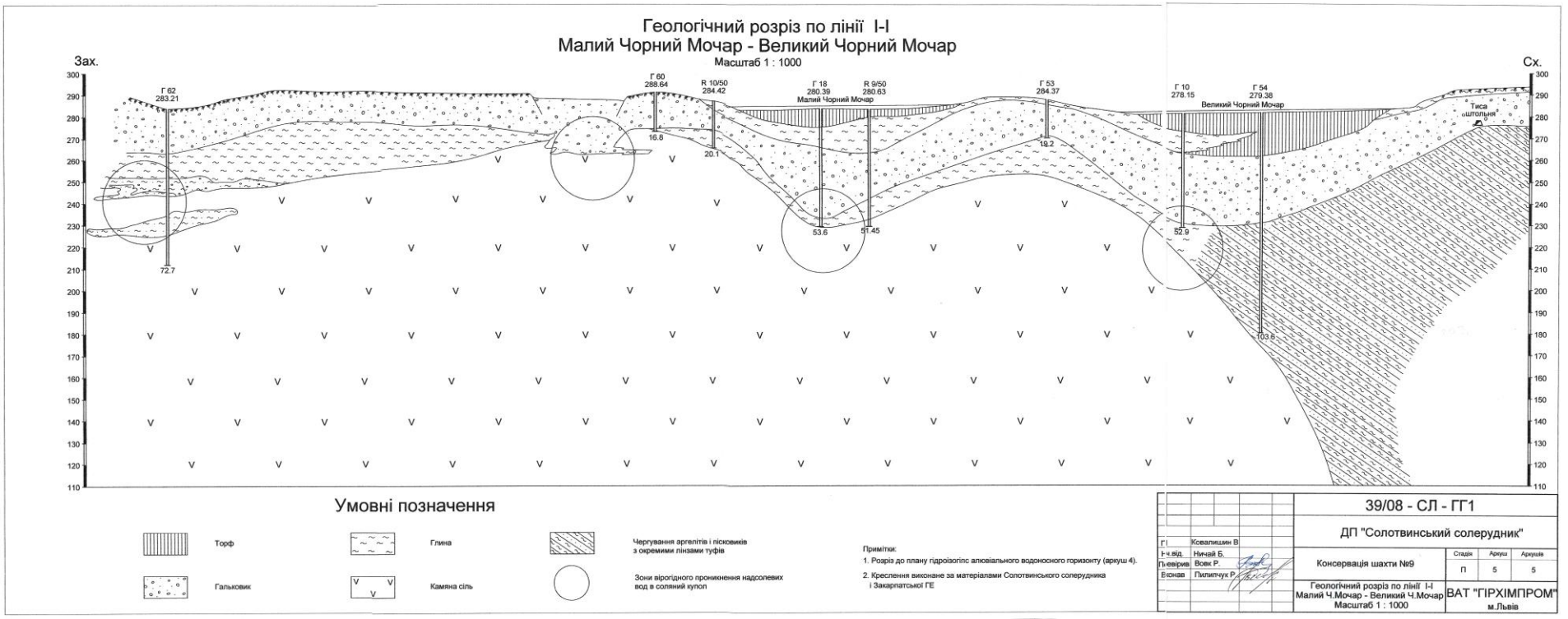
4. The Salt-Mine file (Cross-section on the mines)



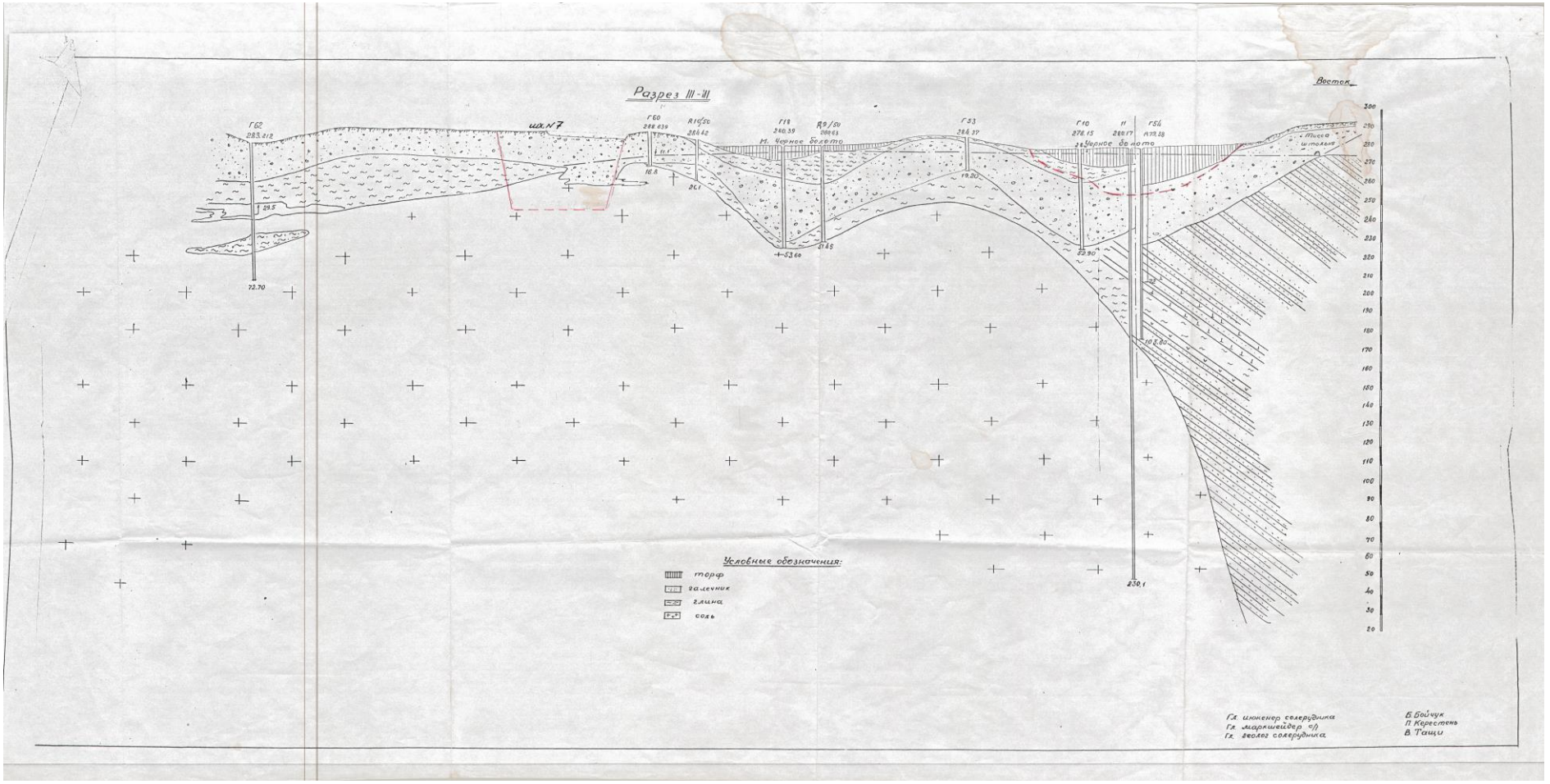
4. The Salt-Mine file (Map & Cross-section synthesis)



4. The Salt-Mine file (geological layers covering the salt-dome)



4. The Salt-Mine file (water short-cuts)



4. The Salt-Mine file

So begins the story .... with just an immomentous dip

4. The Salt-Mine file

But a bit time later....

4. The Salt-Mine file

... and finally a ‚newly – born' huge crater

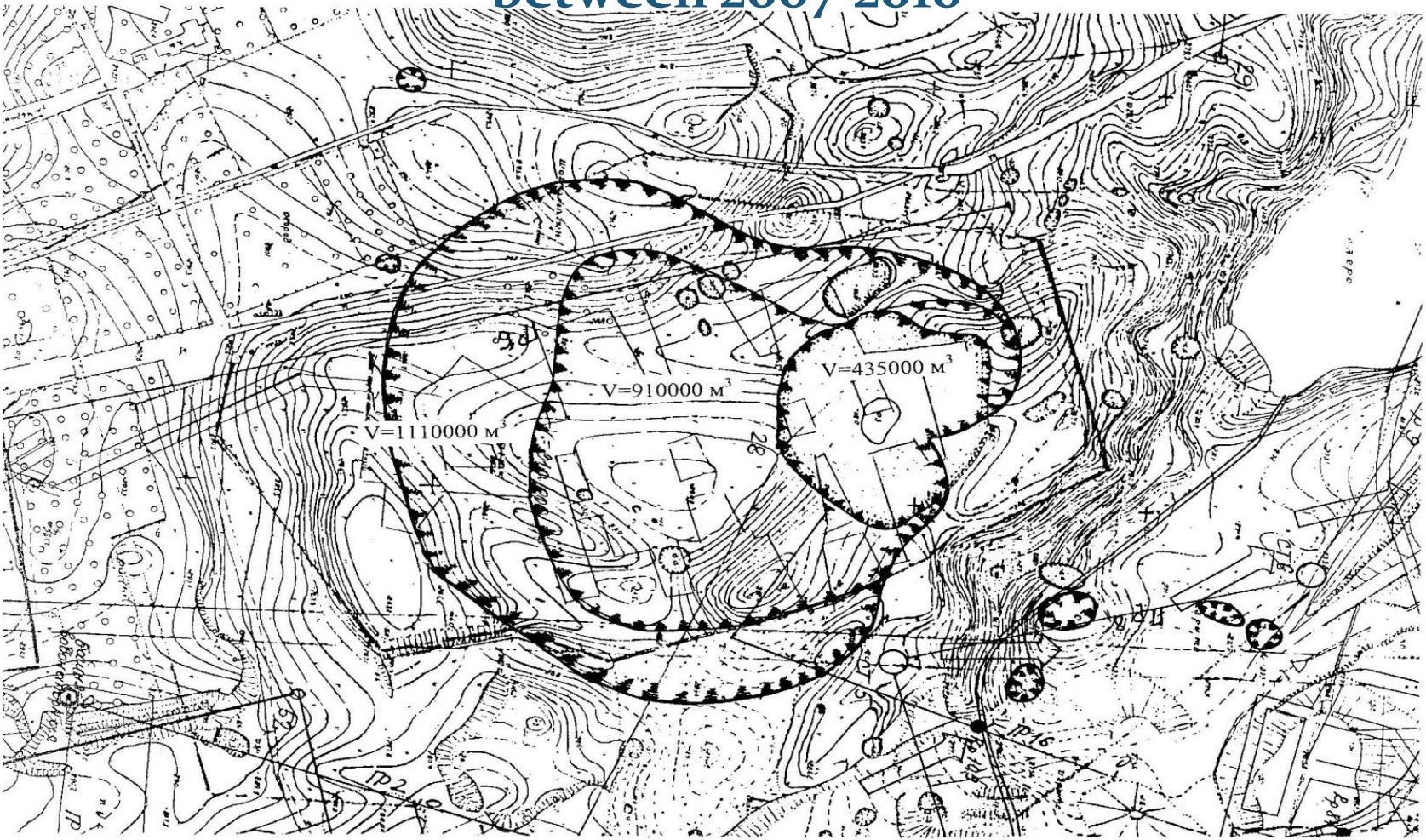
4. The Salt-Mine file

One of the craters filled in water at the place of the former Mine shaft 8 backdrop the Mine shaft 9 is flooding as well

4. The Salt-Mine file

One of the craters is approaching to the Mine Office building

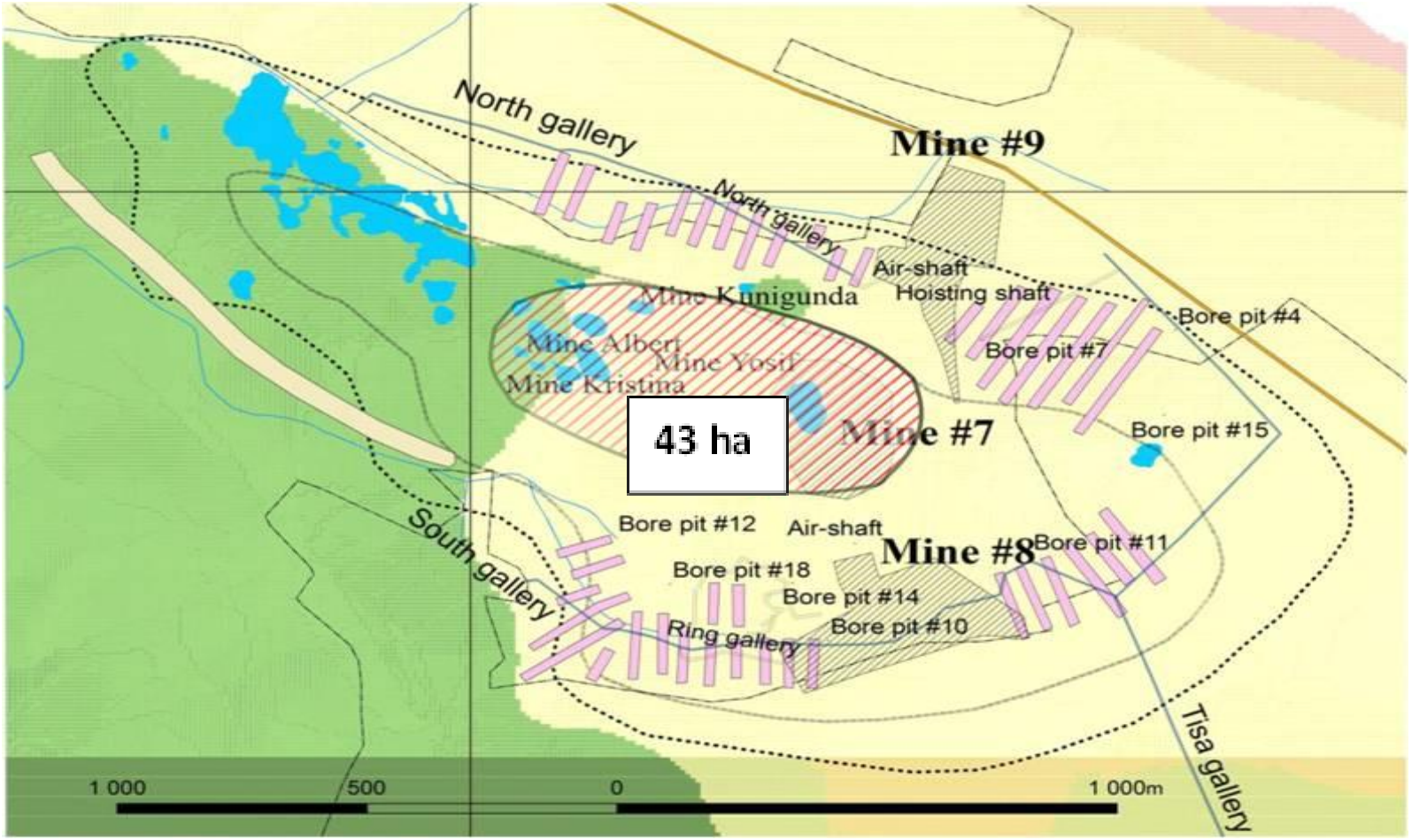
Sinkhole development (in m3) at the place of the Mine 7 between 2007-2010



4. The Salt-Mine file (No comment)

4. The Salt-Mine file (Salt karstification in 2008)

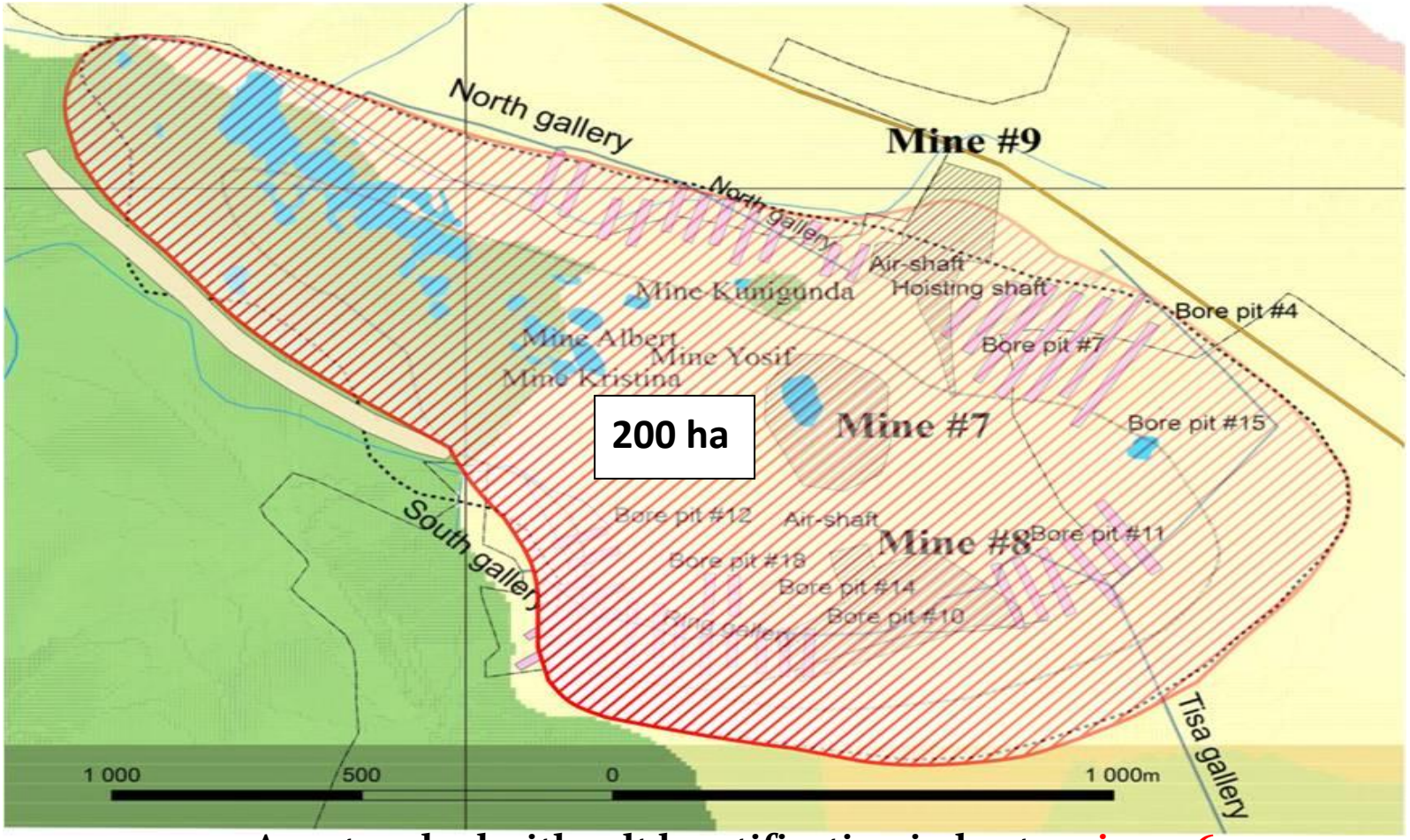
4. The Salt-Mine file (Development of the salt karstificated area)



Area touched with salt karstification in hectare in 1960

(by curtesy of the INSTITUTE of GEOLOGICAL SCIENCES NAS of UKRAINE 2016)

4. The Salt-Mine file (Development of the salt karstificated area)



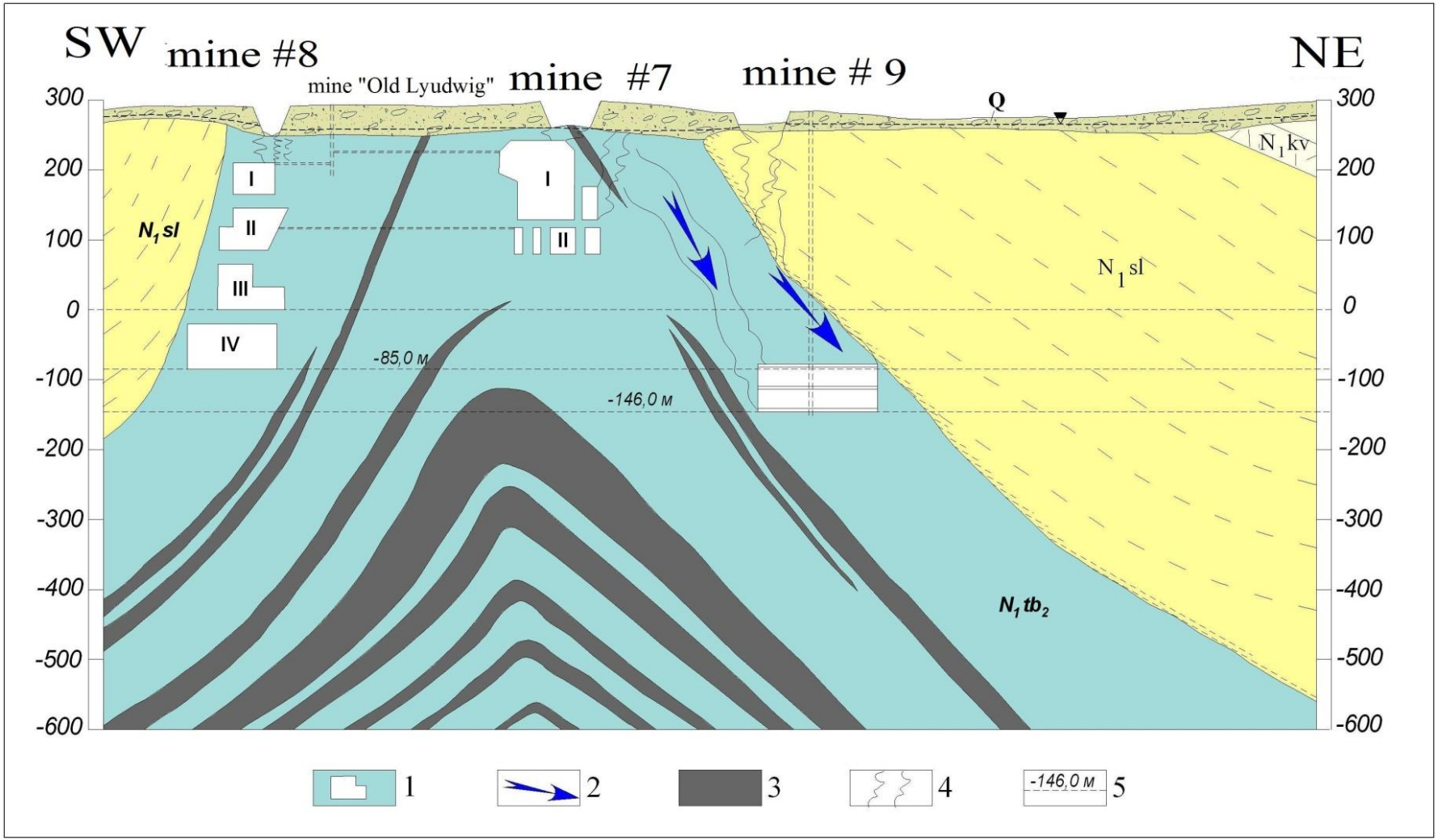
Area touched with salt karstification in hectare in 2016

(by curtesy of the INSTITUTE of GEOLOGICAL SCIENCES NAS of UKRAINE 2016)

Crater condition at the On-Site Mission on 15 July 2015

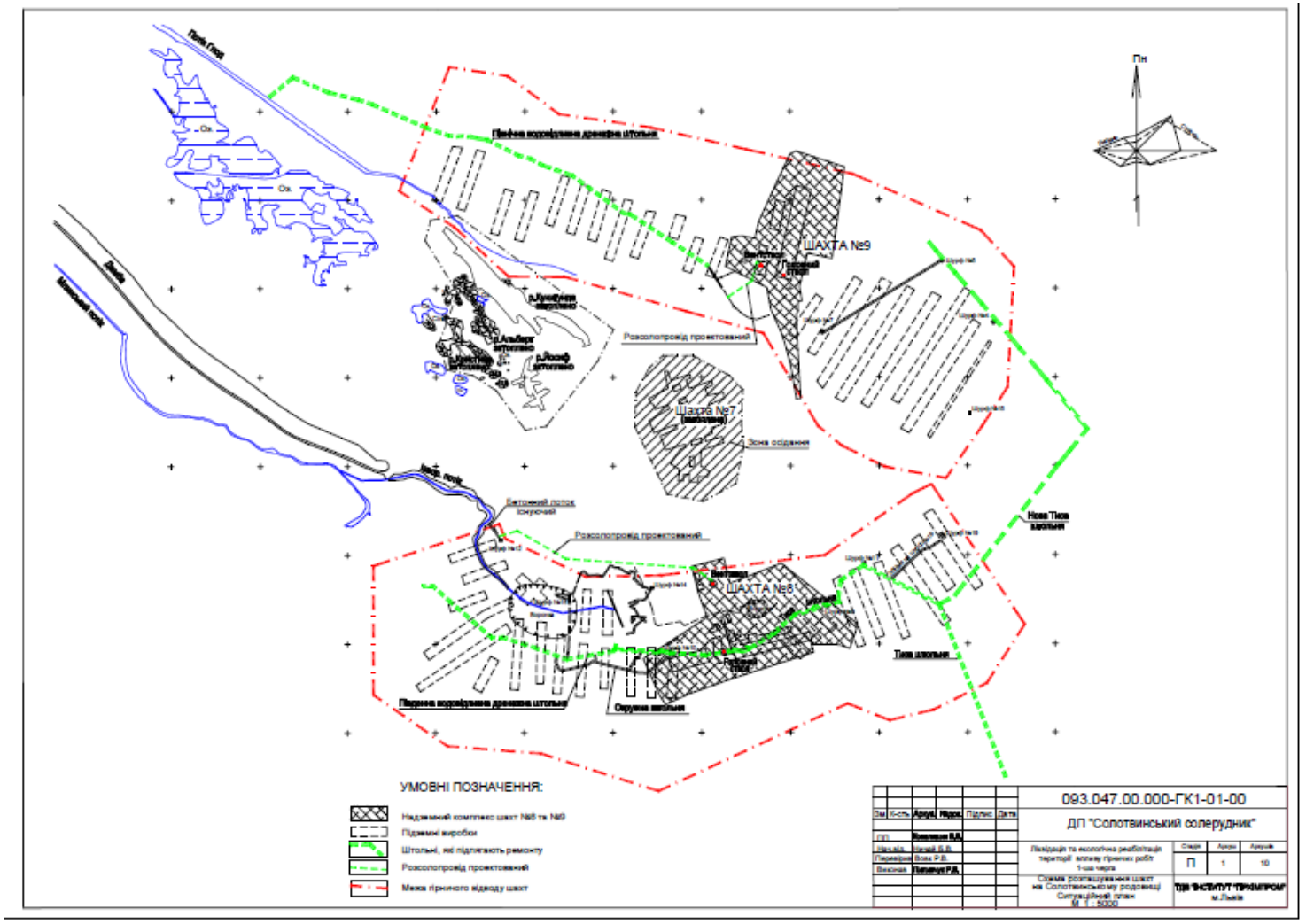
… and the same place at the Advisory Mission in September 2016

5. The Geology/hydrogeology file(simplifed cross section of the salt dome)

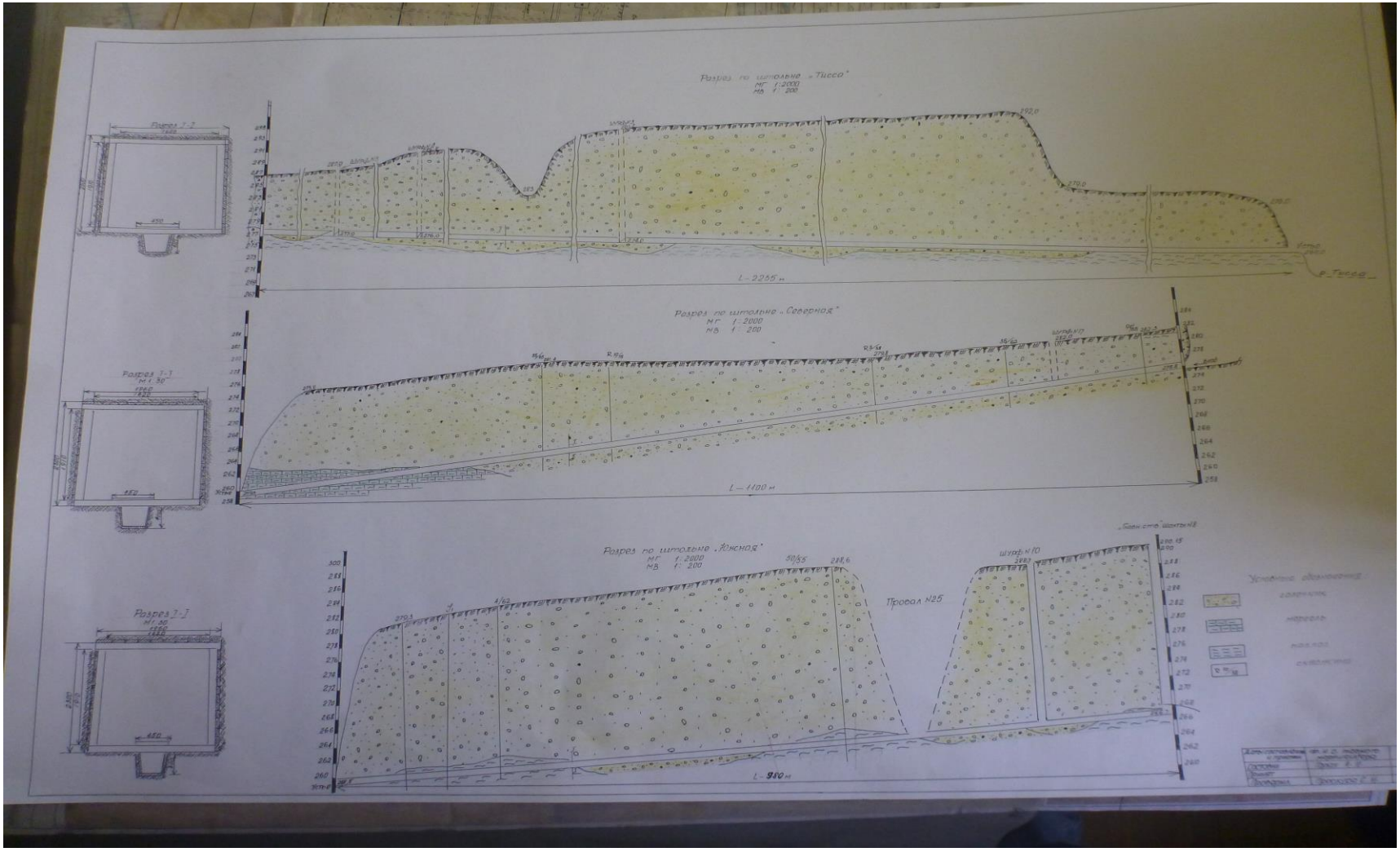


5. The Geology/hydrogeology file (Lythogenezis of salt)

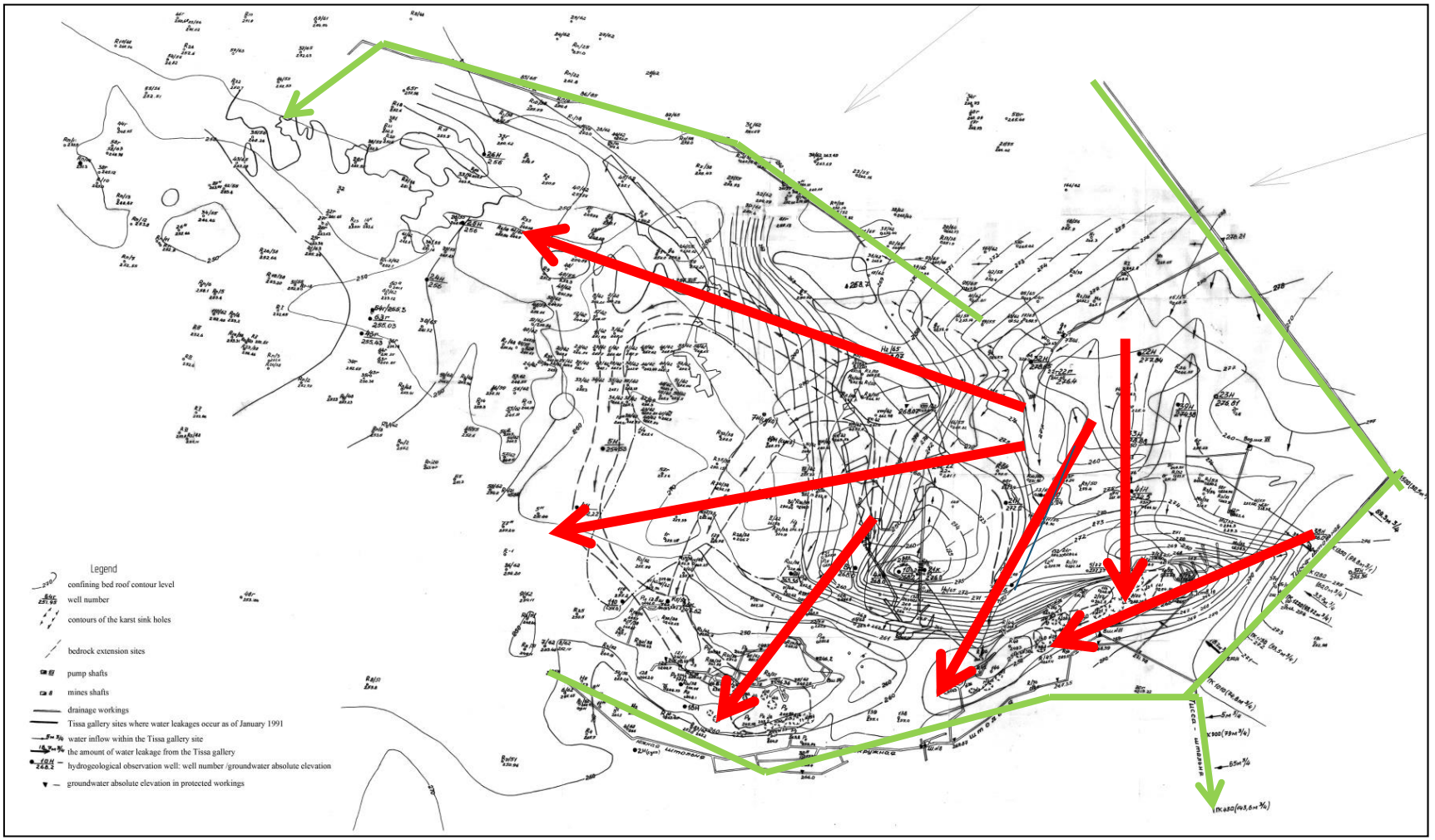
5. The Geology/hydrogeology file (tracing of the water-drainage system)



5. The Geology/hydrogeology file (cross-section of water tunnel/stolna)



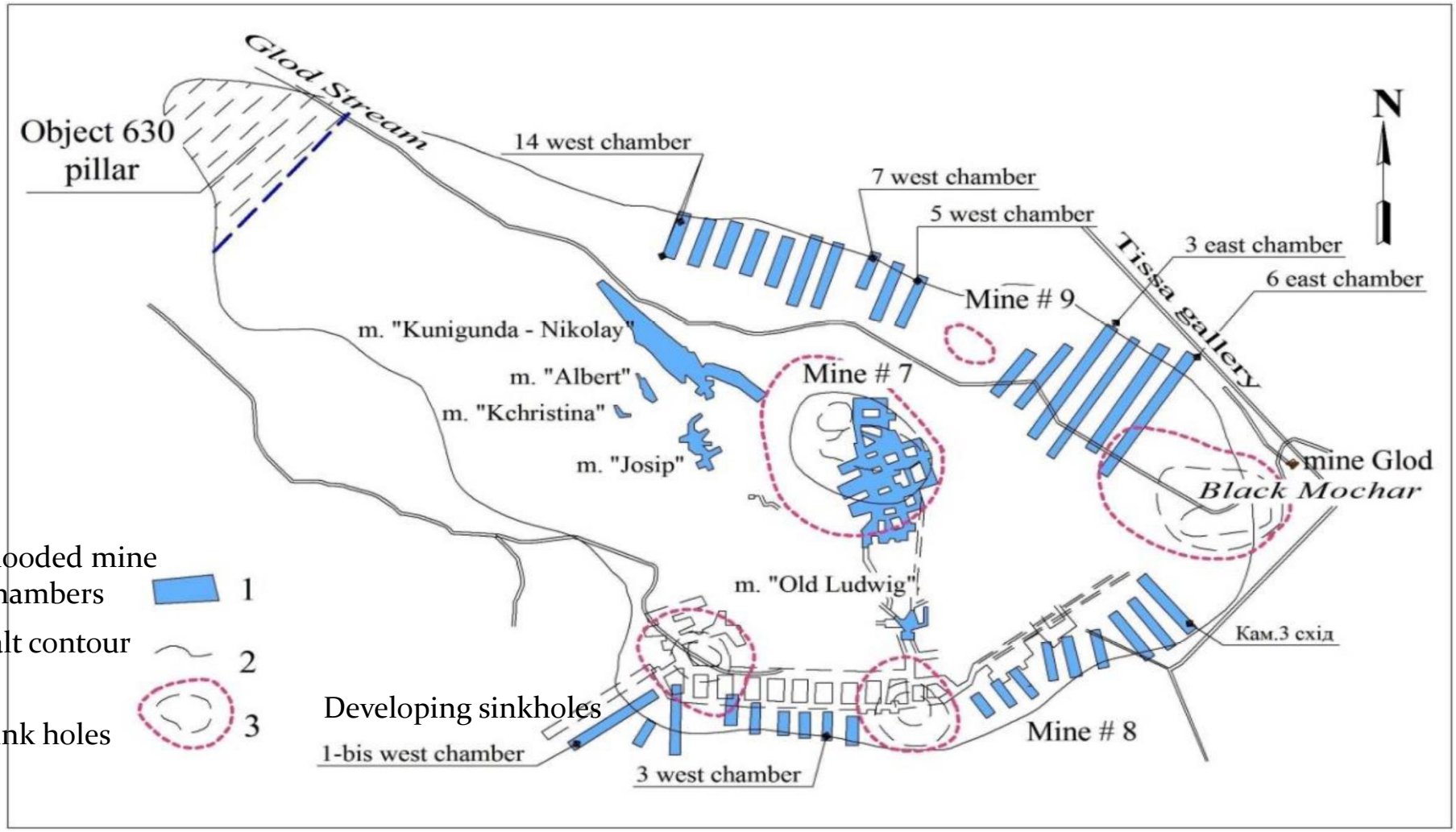
Hydrogeological map made in 1991 on the Solotvyno territory



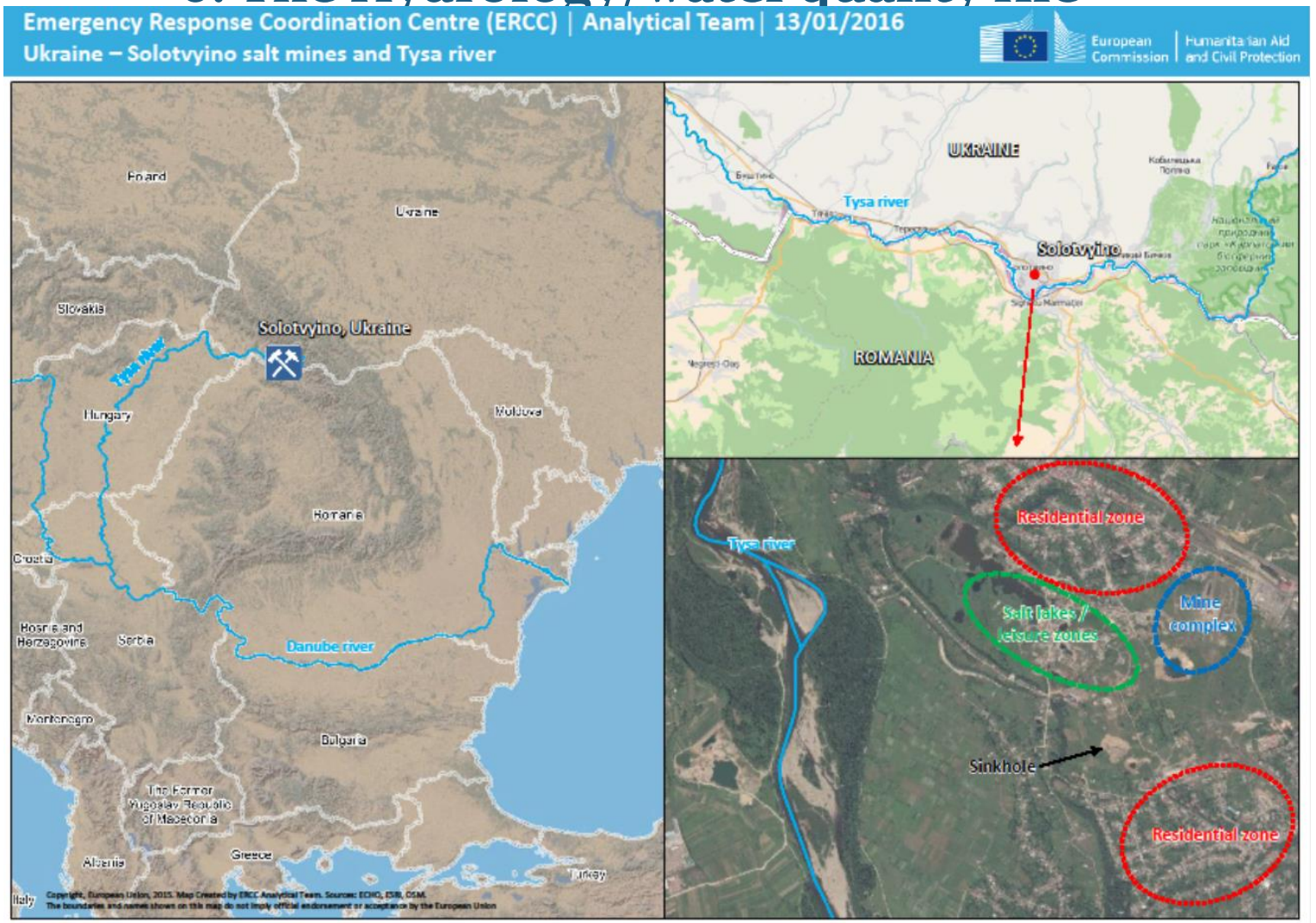
Pictures on the destroyed /not-functioning water drainage (stolna) system

Only one section of the drainage (stolna) system is working, partly (Q= 200m3/h; Conductivity= 670microS)

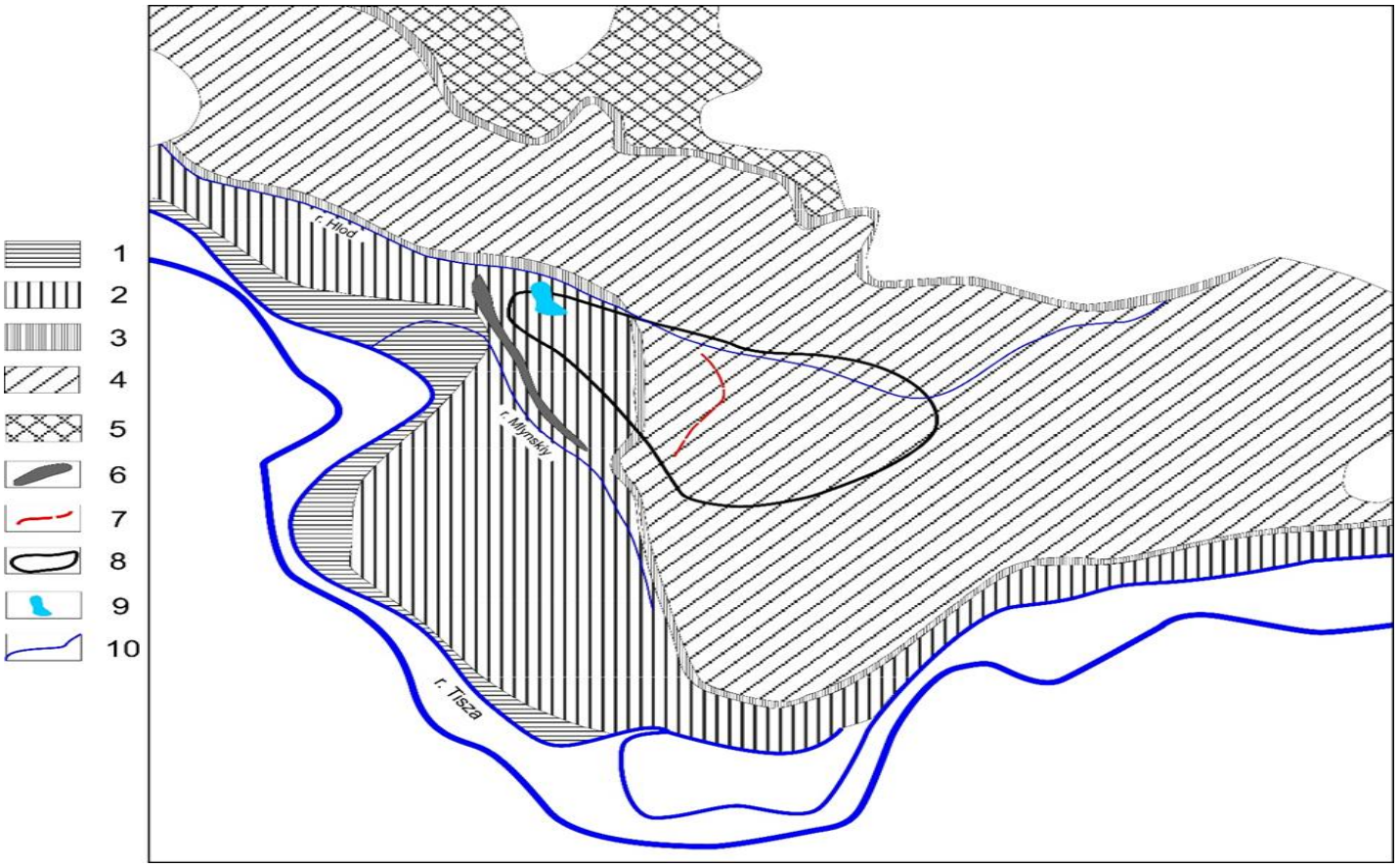
Complex status assessment of the mine area



6. The Hydrology/water quality file



Geomorphological map of Solotvyno with sediment layers (recent floodplain with former ones – 3 river terraces)



Legend: 1 – Floodplain of Tisza river; 2 – 1-st river terrace; 3 – edge of terraces; 4 - 2-nd river terrace; 5 – 3 river terrace; 6 – dam; 7 – old quarry wall; 8 – salt dome; 9 – salt lakes; 10 – rivers, streams. (Elizarov A.F.)

6. The Hydrology/water quality file

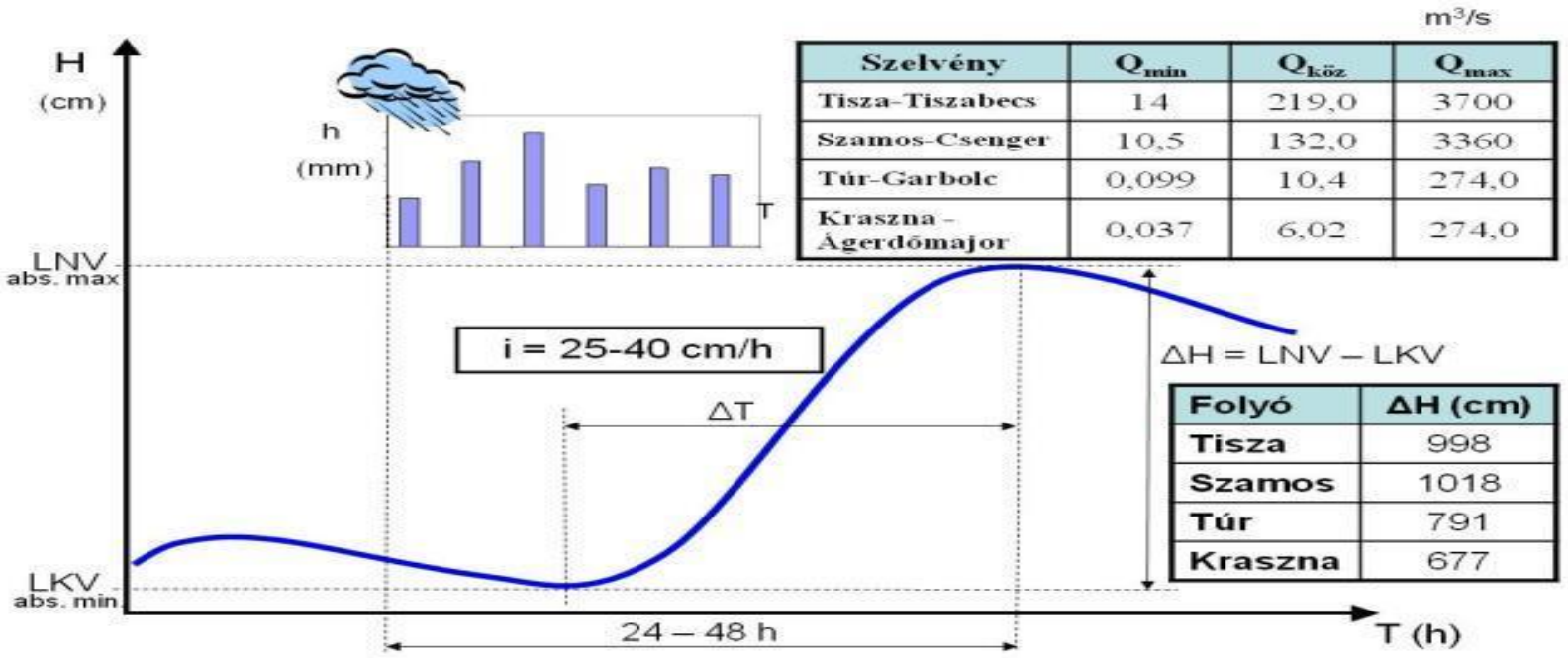
Flood inundation in 2001

Постраждалі райони	Підтоплено (кількіст
Берегівський	13
Виноградівський	20
Іршавський	24
Міжгірський	23
Рахівський	21
Тячівський	59
Хустський	26
м. Хуст	1
Ужгородський	10
Воловецький	4
Мукачівський	10
Перечинський	5
Свалявський	28
м. Мукачево	1
Всього	245

Об'єм води, отрим

6. The Hydrology/water quality file

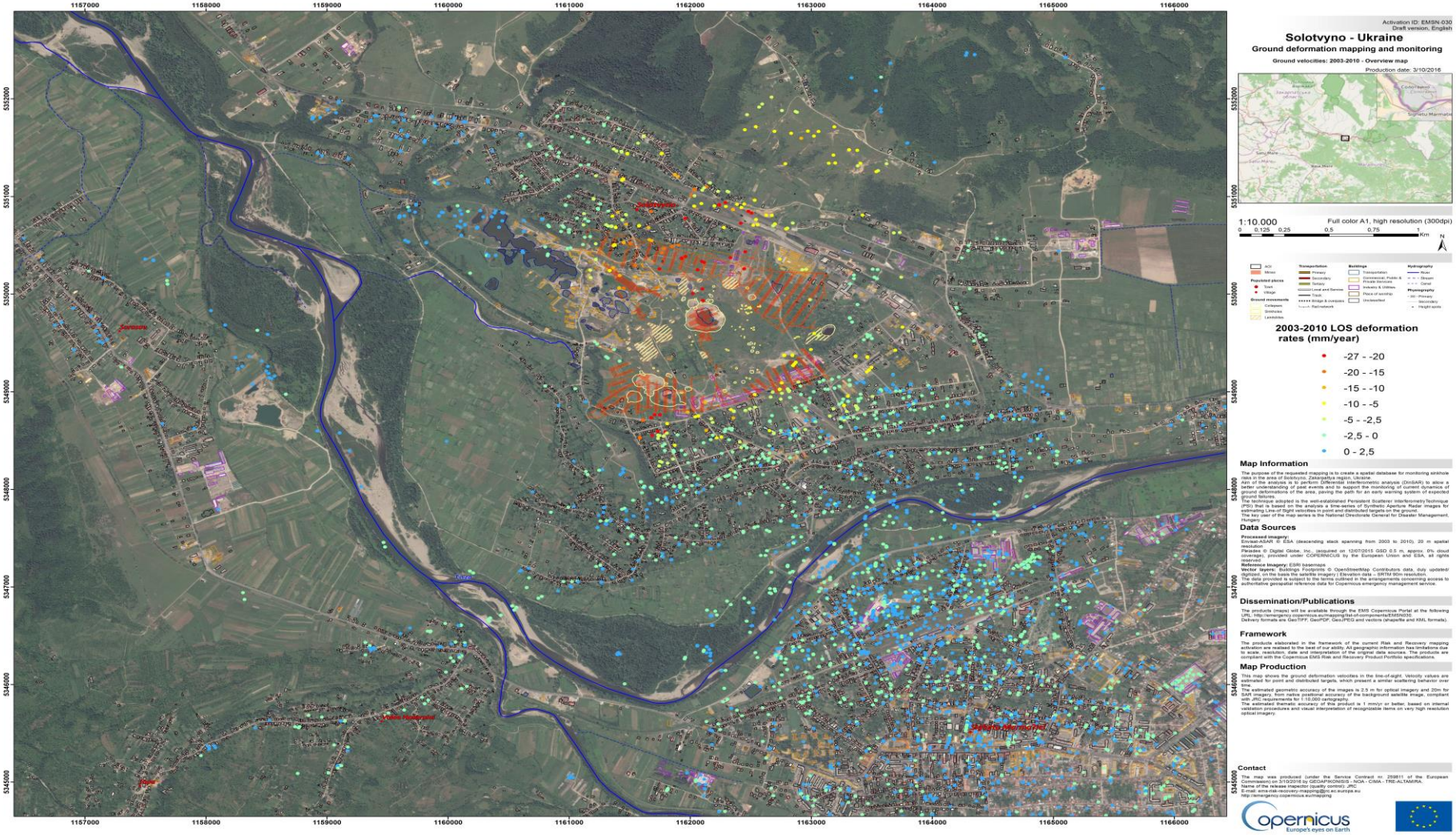
- ‚Flash-flood' type floodings (very frequently in 1998, 2001, 2006, 2008, 2010)
- Difference between lowest and highest water volume is more than 100 times
- Elevation's rate of water level is 25-40 cm/hour (7-10 m/day)
- Floating and dissolved contamination



Szelvény	Q_{min}	$Q_{köz}$	Q_{max}
Tisza-Tiszabecs	14	219,0	3700
Szamos-Csenger	10,5	132,0	3360
Túr-Garbolc	0,099	10,4	274,0
Kraszna - Ágerdőmajor	0,037	6,02	274,0

Folyó	ΔH (cm)
Tisza	998
Szamos	1018
Túr	791
Kraszna	677

7. The Ground movement file (sinkholes & craters indications)



7. The Ground movement file

Home buildings destroyed by ground movements, which are causing life hazards and social challenges

7. The Ground movement file

Home buildings destroyed by ground movements, which are causing life hazards and social challenges

7. The Ground movement file

Home buildings destroyed by ground movements, which are causing life hazards and social challenges

8. The Risk assessment file

Objectives

- ✓ Conduct a comprehensive risk assessment at the Solotvyno salt mines area.
- ✓ Advise the development of a monitoring system, involving the local, state and international stakeholders, in order to determine milestones for next steps.
- ✓ Make short, medium and long term recommendations, including potential mitigation and engineering solutions.
- ✓ Make follow-up observations on immediate measures to be taken by the Ukrainian authorities on recommendations provided by the EUCPT during the Scoping Mission.
- ✓ Identify next steps to be taken by the competent authorities and appropriate stakeholders for hand-over of the findings, recommendations and suggestions for further work.

8. The Risk assessment file

Activities

- Review of the Scoping Mission Report and information.
- Field assessments, (mine)office work with archive collections and investigations.
- Interviews with stakeholders at State, Regional, District and Local level, including members of the public from Solotvyno and surrounding areas.
- Water sampling and on-site measurements.
- Chemical analyses carried out on- and off- site. Isotope determinations were carried out in a laboratory in Germany.
- Development and use of a risk assessment model
- Development of a dedicated GIS data base to support the mission and inform future actions and programmes.
- Detailed review and research of mining records, mapping, plans, and other historical data products.
- Detailed data and information analysis.
- Daily technical workshops and de-briefings in close cooperation with Ukrainian technical experts.

8. The Risk assessment file

Overall conclusions

- The requirement for a suitable and viable monitoring system was acknowledged and the recommendations of the Risk Assessment Report are totally fit into the *Pillar B* "Protecting the environment" of the EU Strategy for the Danube Region (EUSDR).
- The vulnerability of the population in the hazardous area is high.
- There are significant uncertainties in the mining area, referring to development of the ground-collapses (craters), sinkholes and potential landslides, which could, either, have a direct impact on human life or an impact on buildings, houses and other constructions (infrastructure), as well as consequential effects on society and the economy.
- An additional finding is, that the domestic and industrial waste on the spot has huge potential hazards to health and the environment.

9. Next steps (Recommendations of the RAR)

1. Implement a long-term monitoring system
2. Undertake proactive, coordinated, short and medium term mitigation planning in conjunction with the monitoring and vulnerability programmes
3. Work in proactive collaboration with the EUSDR
4. Conduct a detailed geological, hydrogeological, lithological and geomechanical model
5. Revise the land use plan, as a land use management plan
6. Consider to prepare an environmentally sustainable Economic Development Plan
7. Improve public awareness campaigns on the hazards and risks
8. Develop, implement and maintain a robust Waste Management Plan

What's next?

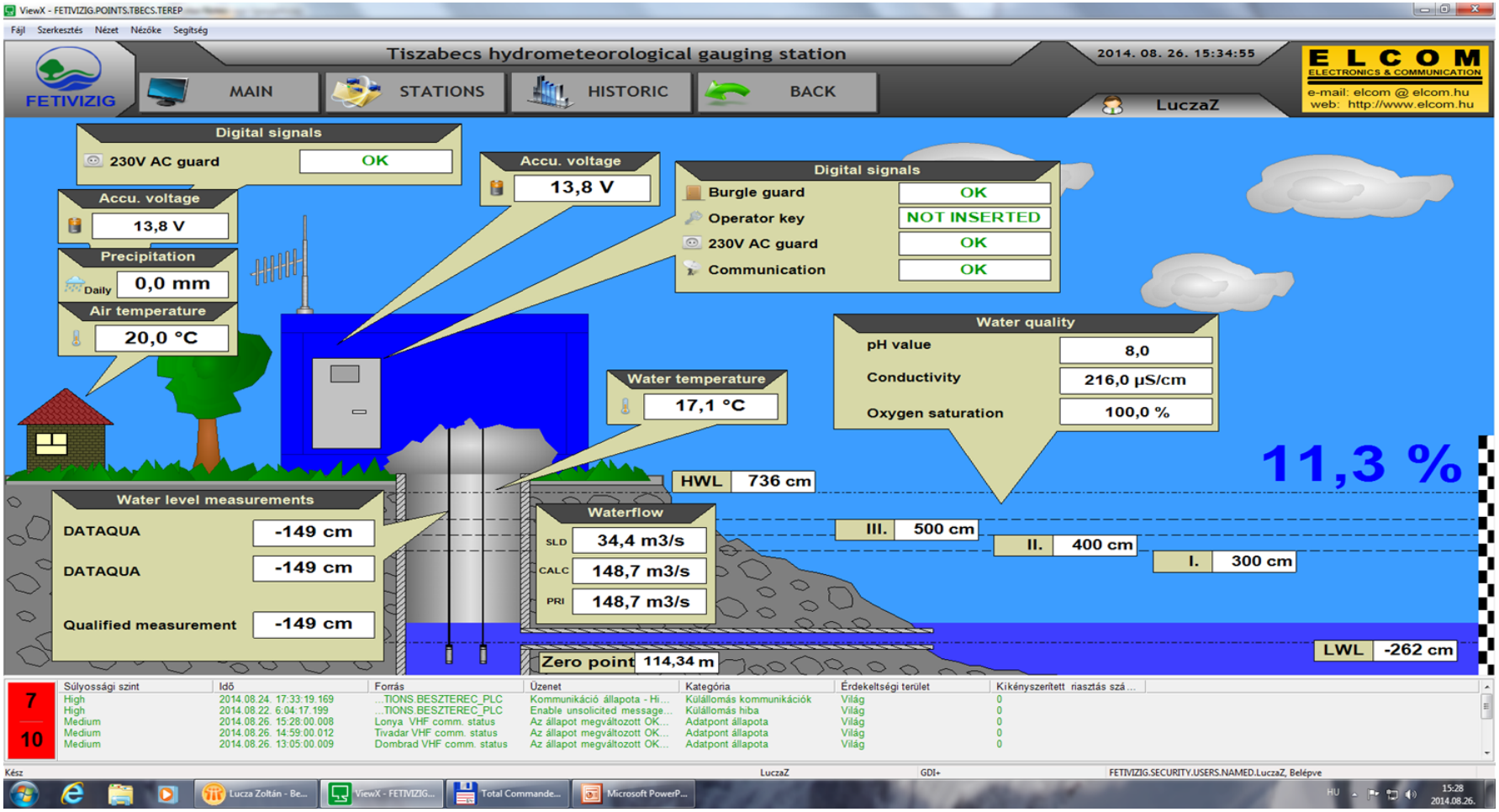
The first steps, as following...

- Complex local monitoring system in Solotvyno
- Transboundary water quality monitoring system on the River Tisza

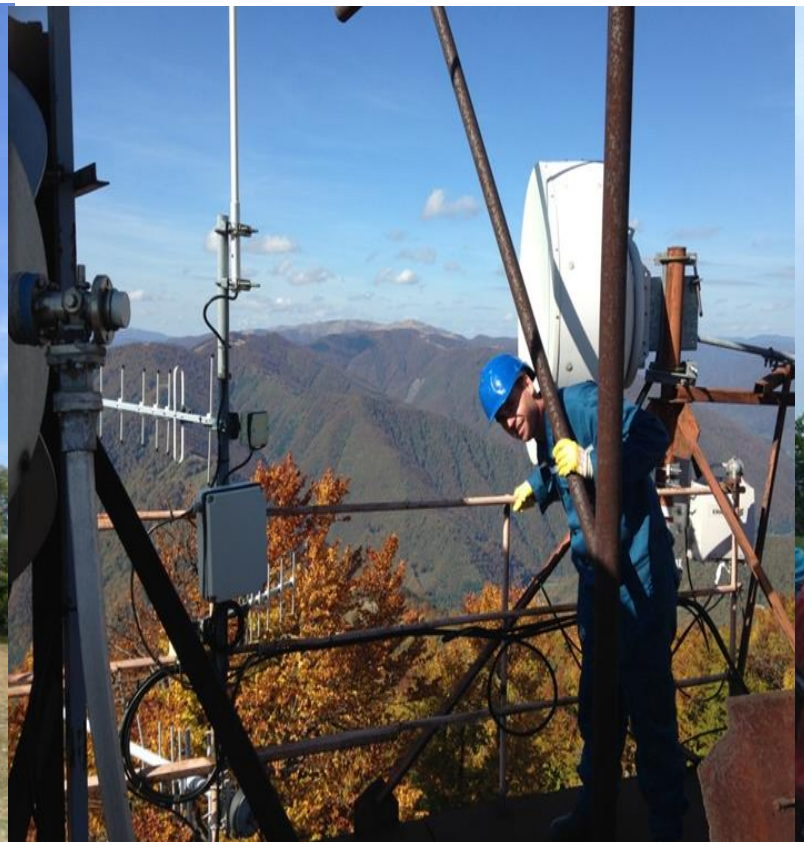
The currently operating Upper-Tisza (HU-UA) telemetric monitoring system (HU-UA Hydro-meteorological network since 2003)

Measured parameters at monitoring station Vilok (Tiszabecs)

Water level, discharge, temperature air-water, precipitation, pH, conductivity, dissolved Ox



Data transfer by the telemetric monitoring stations (already working)



Solution of the Solotvyno Salt Mine problems

Aim

- To protect water quality of the Tisza River since the salt mine catastrophe site is very close to the Tisza River and the progress not finished yet

Findings

- Salt water discharge is continuing despite the limited salt concentration currently
- Urgent and utmost act is needed to
  - design and operate a complex monitoring system for protecting Solotvyno and the Tisza River
  - manage the harmful progress (sinkholes, ground moving, building damages, etc.,)
  - start the spatial planning and rethink the mining activity

Achievements

- EU DG ECHO (Humanitarian Aid and Civil Protection) accepted the request of the PA 4 to disclose the situation (with help Commissioner Johannes Hahn)
- DG ECHO organized two missions onto the spot (a Scoping Mission on 3-8 July and an Advisory Mission on 14 September -7 October)
- The Advisory Mission prepared a Risk Assessment Report (containing short-, middle- and long term measurements) which was formally submitted to the Ukrainian Government and handed over to the DG REGIO
- Works following the missions are continuing in frame of the EUSDR (projects!!!)

10. Conclusions (of the Missions)

1) Neglecting of the maintenance of the water drainage system against ground- and surface water was one of the most crucial things in the series of the other technical shortcomings. The high likelihood of the intrusion of waters into the mine openings was totally underestimated.
2) Due to lack of the effective water drainage the salt karstification processes were/are growing in space and speeding-up in time.
3) The situation was further deteriorated by the forced salt production using blasting operation technology. Using of not optimized volume of the explosives, the risk of water intrusion, through the man-made fissured geological strata, radically increased.
4) Mine flooding, sinkhole and crater genetic processes are still ongoing and so, finalization of the ground movement is not finished and known yet.

THANK YOU FOR ATTENTION