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Ground Penetrating Radar Survey in Podil'lya Karst Area (Ternopil Region, Ukraine)

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***Abstract* – The paper describes ground penetrating radar (GPR) survey in karst area of Podil'lya in Ternopil region, Ukraine that was fulfilled during 2005 year. The GPR examination was made in Ulashkovska and Mlynky caves. The GPR was applied in Ozernaya cave for unknown cavities location. Owing to the GPR survey new gallery was discovered. The research demonstrates an efficiency of the GPR application in gypsum caves for search of discontinuities in rock and sediment including cavities and cracked regions. It is shown that the GPR can also be used for human body detection behind a rocky crust. The results are useful for development of GPR operated in underground conditions, destined, for example, for location of coal gas accumulation and other objects in mines.**

***Keywords* – GPR, impulse GPR, karst, cave.**

I. INTRODUCTION

There are lots of tasks in civil engineering, geophysics, and mines exploitation are connected with discontinuities (cavities) detection in monolithic rock. Especially it concerns sediment rocks, were karstic processes are presented. It is known GPR investigation examples of limestone karst areas [1-3]. At the same time information about GPR explorations of gypsum karst are not enough.

A huge gypsum massif that is situated in Ternopil region, Ukraine, has important influence to civil engineering. Usually gypsum massif is covered by thick clay stratum that inconveniences GPR survey. In order to determine possibilities of GPR exploration in gypsum massif for cavities location and wall thickness measurement we used some caves of Ternopil region, Western Ukraine. There are Ulashkovska, Mlynky and Ozernaya caves.

The VIY-2 GPR with central frequency 300 MHz was used [4]. The choice caused by possibilities of this lightweight and compact unit surveying both in field and underground.

II. GPR EXAMINATION IN ULASHKOVSKA CAVE

First of all we investigated possibilities of gypsum massif sounding. For this goal shallow deposed small gypsum cave called Ulashkovska was chosen. A karst bridge near the cave entrance was suitable object for gypsum properties research (Fig. 1).

Figure 1. Karst bridge near Ulashkovska cave entrance.

We found out that basically grass and soil adsorb electromagnetic wave, whereas impulse radiation penetrates into gypsum stratum with low loss. Approximate wave velocity in the gypsum was about 13 cm/ns. Radar profile of the bridge is shown on Fig. 2.

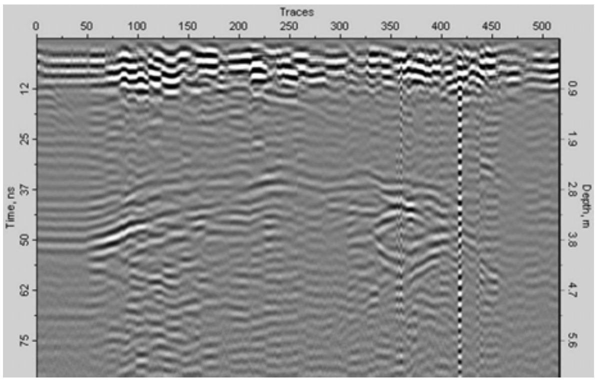

Figure 2. Radar profile of karst bridge near Ulashkovska cave.

It demonstrates the bridge lower boundary and some local discontinuities on about three meters depth.

III. GPR EXAMINATION IN MLYNKY CAVE

The GPR examination was continued in Mlynky cave. We sounded the cave's walls in order to find neighboring passages. The survey method is shown on Fig. 3.

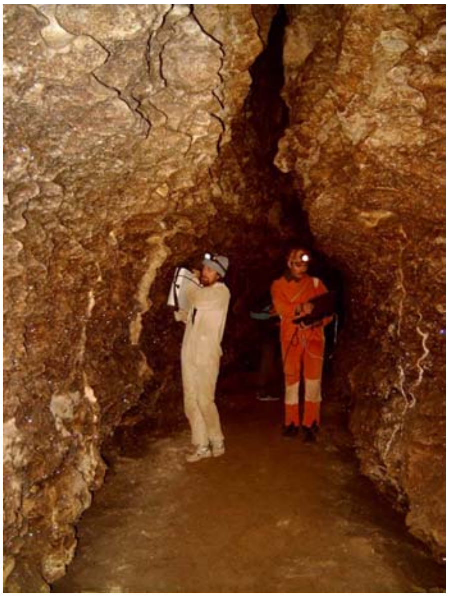

Figure 3. Neighboring passage location in Mlynky cave.

We choose area where wide gallery and narrow passage are situated side by side. A map of examined part of cave labyrinth is shown on Fig. 4.

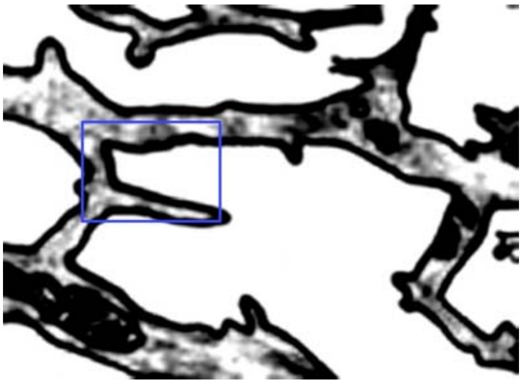

Figure 4. Fragment of Mlynky cave's map (blue rectangle indicates examined wall of labyrinth).

The result of neighboring passage location is shown on Fig. 5. It demonstrates that wavy surface didn't influence on the cavity location. Electromagnetic wave propagates along the gypsum stratum with low attenuation. It allowed searching cavities and another discontinuities up to 8 meters distance.

We defined that the VIY-2 GPR is suitable for caves exploration owing to compact and lightweight design, and short deployment time. The GPR demonstrated reliability and durability during eight-hours cave trip.

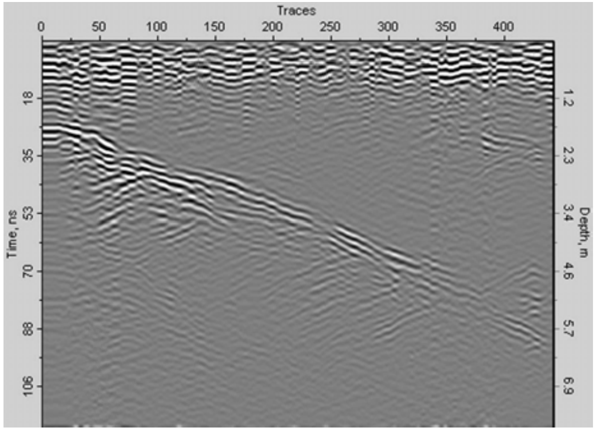

Figure 5. Radar profile of neighboring passage location.

IV. GPR APPLICATION IN OZERNAYA CAVE

Obtained experience of GPR applications in cave environments we used for cave exploration. For this goal suitable test area were chosen. Two longest gypsum caves over the World – Ozernaya and Optimisticheskaya – are situated in a common gypsum stratum. The shortest distance between known labyrinths are only some hundreds meters. There were lots of attempts to find connection between these caves and this problem is very topical up to now.

We decided to apply the GPR in Ozernaya cave for connection passage location. The survey method consisted in search of any discontinuities behind known cave labyrinth. Based on the cave map we defined the most promising direction and explored it (Fig. 6).

Figure 6. Search of unknown cavities in Ozernaya cave.

During the survey we located in gypsum massif an object similar to cavity. Radar profile of this place is shown on Fig. 7.

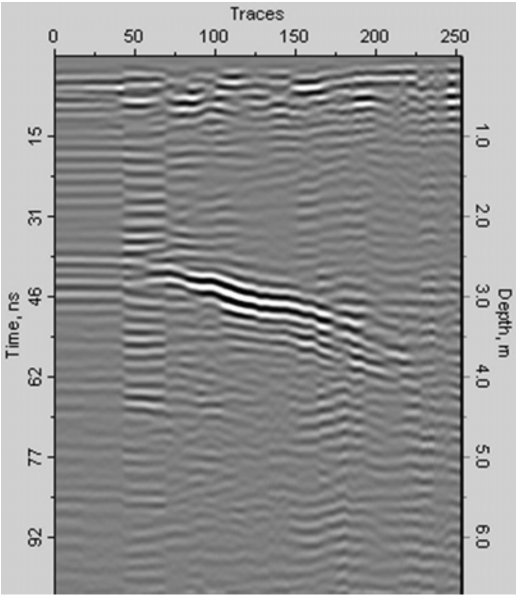

Figure 7. A radar profile of monolithic wall of the cave. Unknown cavity is located on about 3 meters distance.

Taking into account the acquired data, digging works was scheduled and executed (Fig. 8).

Figure 8. Start of the digging works.

Later a new 15-meters passage was discovered in according with the radar data (Fig. 9). After topographic survey the passage was added to the cave map (Fig. 10).

Unfortunately the founded passage was not the caves connection one. Therefore the search is still continued. We hope to provide cavers of all possible kinds of assistance in order to find connection of two longest gypsum caves over the World.

Figure 9. Just discovered passage.

Figure 10. Topographic survey of the passage.

Simultaneously with search of connection passage we used underground environment for one more examination – human body detection behind the rocky crust (Fig. 11).

Figure 11. Human body detection behind the rocky crust.

The GPR was leaned against the 3-meters thickness wall. Six-meters width passage was after the wall. Two people went across the passage approaching and withdrawing from the GPR position.

Initial (left) and processed (right) radar profiles are shown on Fig. 12. Zebra stripes caused be multiple reflections between GPR antenna and the cave walls. The track of people movement is appeared even on initial radar profile.

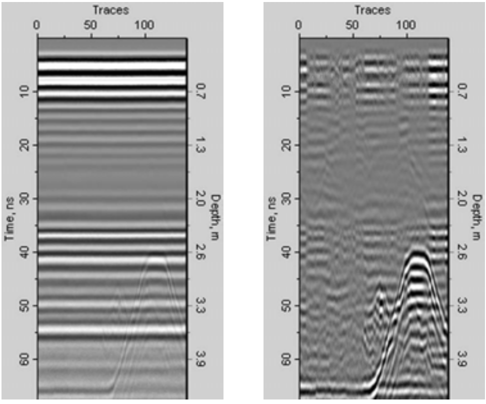

Figure 12. Initial (left) and processed (right) radar profiles.

Figure 13. The VIY-2 GPR, used for the caves exploration.

V. CONCLUSIONS

In this work we demonstrated efficiency of the GPR application in gypsum caves for search of discontinuities in rock and sediment including cavities and cracked regions. It is shown that the GPR is very attractive equipment not only for natural caves exploration but also for location of coal gas accumulation and other objects in mines. The GPR application for human body detection behind rocky wall is perspective as well.

VI. ACKNOLEDGMENT

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REFERENCES

[1] S.Geraads and G.Omnes, "Imaging Karstic Structures with GPR along a Motorway Under Construction", Proceedings of 9th International Conference on Ground Penetrating Radar, April 29-May 2, 2002, Santa Barbara, California, USA, p. 141-146.

[2] M.Tallini, D.Ranalli, M.Scozzafa and G.Manacorda, "Testing a New Low-Frequency GPR Antenna on Karst Environments of Central Italy", Proceedings of 10th International Conference on Ground Penetrating Radar, June 21-24, 2004, Delft, The Netherlands, pp. 133-136.

[3] L.Nuzzo, G.Leucci and S.Negri, "GPR Survey in the Karstic Area "Vore di Spedicaturo" near Nociglia (Lecce, Italy)", Proceedings of 10th International Conference on Ground Penetrating Radar, June 21-24, 2004, Delft, The Netherlands, pp. 609-612.

[4] V.P.Prokhorenko, V.E.Ivashchuk and S.V.Korsun, "Ground Penetrating Radar VIY-2", IEEE A&E Systems Magazine, vol. 20, No. 7, July 2005, pp. 16-18.