THE TELLURIC CONDUCTIVITY ANOMALY AT MAGYARMECSKE: IS IT A BURIED IMPACT CRATER?

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ABSTRACT

In the fifties an approximately round shaped high amplitude telluric conductivity anomaly was found at Magyarmecske, in South-West Hungary (Fig. 1, [1]). Though attempts were made to interpret it as a highly conductive coal bearing Carboniferous sequence (Fig. 2, [2]) some questions have been left open:

- The Carboniferous sequence covered an area much more extended than the anomaly itself, why did the anomaly appear only on a restricted part of it ([3])?
- Old seismic data indicated a low velocity zone in the refracting basement coinciding roughly with the telluric anomaly ([2]), why?
- Deep DC soundings carried out in the area detected an extraordinary deepening of the high resistivity basement on the same location ([2]). What could cause such an approximately round deepening of the basement?

The authors reinvestigated all available geophysical data measured in the area and based on them came to the conclusion, that the conductivity anomaly might indicate a buried impact crater of a big meteorite ([4]).

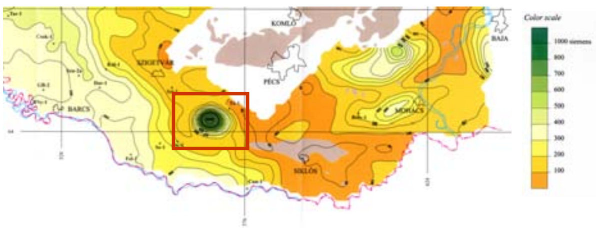

Fig. 1. The telluric conductivity anomaly at Magyarmecske, Hungary, on the Telluric Conductance Map of Transdanubia ([2])

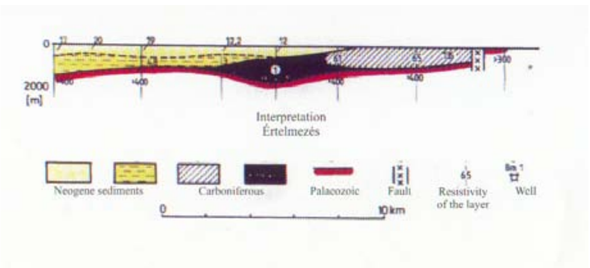

Fig. 2. The Magyarmecske region ([2])

1. GEOPHYSICAL SIGNATURES OF AN IMPACT CRATER

Pilkington and Grieve gave a summary of the geophysical signature of known terrestrial impact craters in 1992 [5]. Following their paper we briefly summarise the expected geophysical signature of an impact crater (Fig. 3).

- **Gravity signature:** The density of crater fills consisting of the breccia lens and covering postimpact sediments is usually much lower than that of the target rocks. The fractured zone around and below craters has decreased density as well. Consequently craters are characterized by a deficiency of mass compared to the preimpact status which means that they are characterized by a *negative gravity anomaly.*
  Maximum values of gravity anomalies due to craters lie between 1 and 10 mgal depending on the diameter of the crater. Horizontally the gravity low extends generally to the crater rim. Since the effect is small it is practical to use residual anomaly maps.
- **Magnetic signature:** Target rocks might have characteristic preimpact magnetic properties indicated by characteristic anomaly trends. Heating up and melting of rocks due to an impact wipe out earlier magnetic properties and postimpact cooling down may result in development of new ones. In this way impacts may confuse preimpact magnetic trends of the target area if there were any. However, the magnetic field is more complex than the gravity field and the magnetic properties of rocks are far more diverse than the gravity ones, thus there is not a one-to-one correlation of the character of the magnetic anomaly and the crater morphology, or by other words impact craters have *no characteristic magnetic signature.*
- **Electrical signature:** The porosity of a breccia lens and a fractured zone is generally higher than that of the unaffected target rocks. Higher porosity results in higher fluid content and that again in higher conductivity. So craters are characterized generally by *high conductivity anomalies*.
- **Seismic signature:** In rocks the velocity of seismic wave propagation depends very much on the

compaction of rocks. Breccia lenses and fractured zones are less compact than corresponding target rocks, consequently *seismic velocities are smaller and the attenuation of seismic energy is higher* in them if compared to the unaffected target rocks.

The list of geophysical signatures has to be completed by an important possibility of geophysics, i.e. by the geophysical imaging of subsurface morphology. Impact craters have characteristic morphologic features. As long as they are located on the surface of the Earth those features can be recognised on images of the Earth surface like maps or satellite images. However, if old crater structures are covered by postimpact geologic formations then they are hidden from direct observations. In such cases geophysical methods, electric, electromagnetic and seismic refraction and reflection measurements are to be used to get their morphologic images.

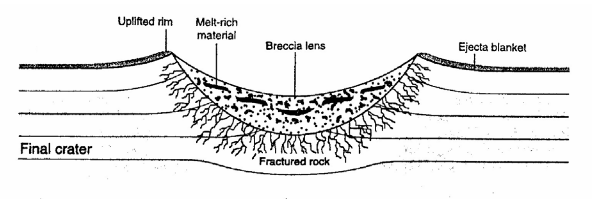

Fig. 3. The final crater (after [6])

2. GEOPHYSICAL RESULTS OF THE MAGYARMECSKE REGION

In the case of the Magyarmecske conductivity anomaly on the surface there are young sediments and the area is entirely flat, no any special morphology can be seen. Old data of magnetotelluric and deep DC soundings indicate that the highly conductive formations are located below the young sediments. Thus if the conductivity anomaly is regarded as the electric signature of an ancient meteorite impact crater then it is buried under younger formations (Fig. 4).

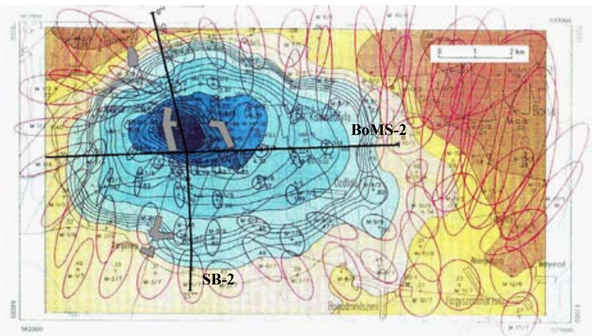

Fig. 4. Detailed map of the conductivity anomaly with the location of seismic reflection lines, and telluric ellipses

In the Bouguer anomaly map a gravity minimum with a peak value of –2 mgal can be found almost on the same location, it is similar in size and extension, however, its centre is slightly shifted westwards from that of the telluric anomaly (Fig. 5).

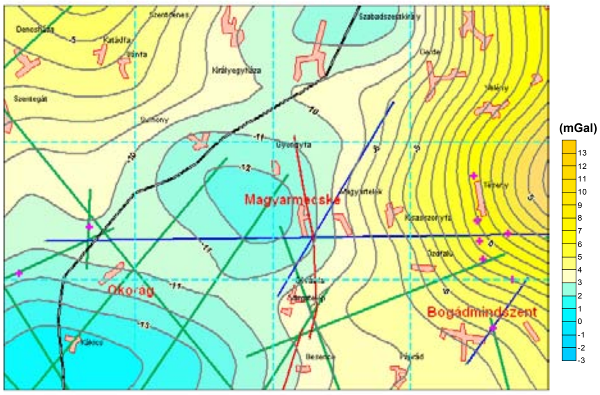

Fig. 5. Gravity Bouguer-anomaly map of the Magyarmecske area

Again on the same location a seismic refraction velocity anomaly of the refracting high velocity basement has been known from the time of the extensive seismic refraction surveys of the fifties. Here the anomaly means a 20 % decrease of the seismic refraction velocities (Fig. 6).

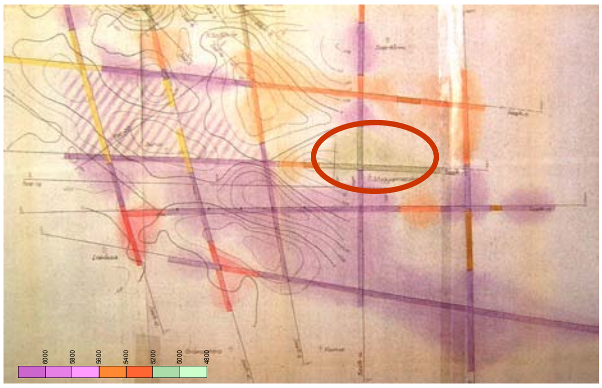

Fig. 6. Seismic refraction basement velocity map in the Magyarmecske area

An old, low coverage, seismic reflection profile crosses the centre of the conductivity anomaly in W-E direction. It was recorded by analogue technique in 1971 and today is available only in paper version (Fig. 7). It shows a structure dipping strongly from East to West. On its deeper western part one side of a crater like structure can be recognised below the young sediments which are at the western rim approximately 900 m thick. On the uplifted eastern part the other side of the structure seems to be rather much eroded and the remnants of the assumed eastern rim underlies sedimentary layers of no more than a 100 m thickness. Maybe, the uplifted and eroded eastern part of the structure is the reason of the asymmetry in the gravity as well as the conductivity images.

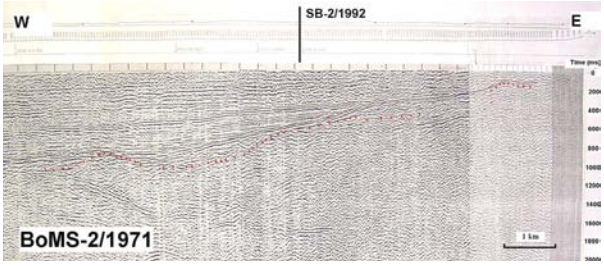

Fig. 7. The BoMS-2/1971 seismic reflection profile

Another seismic reflection profile recorded by up-to-date digital technique in the early nineties crosses the area in N-S direction also just in the centre of the telluric anomaly. It shows remarkable features similar to the cross-section of a one-ring impact crater just below the Neogene sediments (Fig. 8). The northern rim can be found in a depth of approximately 450 m, the southern rim at 550 m whereas the peak of the central uplift at 650 m, respectively. The southern side of the structure shows the traces of postimpact tectonic events, the profile crosses a fault line here with a throw of about 100 m.

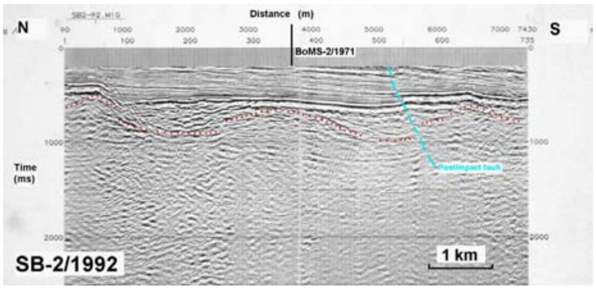

Fig. 8. The SB-2 migrated seismic reflection profile

3. CONCLUSIONS

Based on the geophysical signatures of the area described above, the authors came to the conclusion, that the Magyarmecske conductivity anomaly might indicate a buried impact crater of a big meteorite.

The impact happened probably sometimes after the Carboniferous on an area where the Carboniferous sedimentary rocks were on the surface that time, and it created a complex crater with central uplift in them. The structure had a crater diameter of approximately 6-8 km. The surface of the target rocks was either oblique by the time of the impact or became tilted soon after that. The western part of the structure had been or got under sea- level and was covered by sediments meanwhile the eastern part fell on mainland and suffered erosion for a while. Later the whole structure has been buried and underwent tectonic effects. We think, that the above described process resulted in the complex structure which is known today as the "Magyarmecske telluric anomaly".

4. REFERENCES

1. Ádám A., Verő J., Results of the regional telluric measurements in Hungary (in German), *Acta Technica,* Vol. 47, 63-77, 1964.

2. Nemesi L. et al., Telluric map of Transdanubia, *Geophysical Transactions*, Vol. 43, 169-204, 2000.

3. Majoros Gy., A few reflections on the telluric conductance map of Transdanubia, *Geophysical Transactions*, Vol. 43, 291-296, 2000.

4. Bodoky, T. et al., A magyarmecskei tellurikus vezetőképesség anomália: eltemetett meteoritkráter? (in Hungarian with English abstract), *Magyar Geofizika,* Vol. 45, 96-101, 2004.

5. Pilkington, M., Grieve, R.A.F., The Geophysical Signature of Terrestrial Impact Craters, *Reviews of Geophysics*, Vol. 30, 161-168, 1992.

6. French, B. M., *Traces of Catastrophe: a Handbook of Shock-Metamorphic Effects in Terrestrial Meteorite Impact Structures.* LPI Contribution No. 945*,* Lunar and Planetary Institute, Houston, 1998.