GEOPHYSICAL SETTING OF THE DEEP WELL 6042 DELENI IN CENTRAL TRANSYLVANIA – ROMANIA*

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Le cadre géophysique du puits profond 6042 Deleni dans la partie centrale de la Dépression de Transylvanie – Roumanie. Le puits profond 6042 Deleni a été foré pour l'exploration des hydrocarbures dans la partie centrale de la Dépression de Transylvanie (TD). Il a pénétré à une profondeur d'environ 4700 m et a traversé plus de 350 m, quelques roches mafiques (basaltes, andésites basaltiques, etc.), situées sous la série de carbonate de Tithonique (dolomies). Les roches basiques ont été précédemment considérées comme appartenant à une cicatrice ophiolitique de la branche transylvaine de l'océan Téthys. L'article présente les informations géophysiques aériennes/terrestres liées au secteur, en corrélation avec des données du puits (notations d'étrier, électrique, rayons gamma et notations de neutrone). Il est destiné à ajouter des données géophysiques et tectoniques aux études minéralogiques complètes consacrées aux roches mafiques de nature incertaine croisées par le puits. Des techniques de filtrage ont été intensivement employées pour améliorer le rapport de signal/bruit afin de séparer des effets cumulatifs enduits par des sources diverses en nature et/ou situées à diverses profondeurs. Les données aéroportées ont clairement décrit une grande anomalie géomagnétique régionale couvrant la partie centrale de la TD, pleinement confirmée par les images de la carte géomagnétique composante verticale moulue de la Roumanie. Une certaine interprétation géologique précédente a considéré cette anomalie géomagnétique régionale comme un effet composé principalement dû aux sources situées au moins à trois niveaux: *(i)* Tufs de Dej, situés dans la partie supérieure de la section; *(ii)* roches mafiques aux roches plutoniques intermédiaires, situées au niveau du sous-sol de TD; *(iii)* une composante à longue onde due à l'expression géomagnétique de la couche «basaltique» dans la partie «plus froide» de la TD. Les roches basaltiques révélées dans le puits 6042 Deleni pourraient représenter une des sources principales pour l'anomalie mentionnée ci-dessus. Les analyses faites sur des échantillons à partir du forage ont clairement montré la susceptibilité magnétique élevée pour les basaltes mentionnés ci-dessus, mais les densités restent relativement faibles. Le fait a été attribué à la présence de quelques zones profondes de fracture situées au niveau de sous-sol, cachées sous la couverture mésozoïque et cénozoïque de la TD. La pesanteur et l'information géomagnétique ont indiqué quelques failles régionales profondes avec une orientation nord–nord-est dans

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le secteur de puits. D'autre part, la présence des zones fracturées circulées est bien reflétée dans des associations de hautes rayons γ, de résistivité basse, dans des valeurs plus grandes de porosité neutronique, qui sont peu communes pour les basaltes compacts. En ensemble, il semble que le paquet entier de basalte est fait de plusieurs écoulements de lave de différents âges, séparés par des zones de mobilité, ce qui est en accord avec les données de la géochimie.

Key words: well logging, gravity, magnetics, rock physics, Deleni, Transylvanian Depression

1. INTRODUCTION

The deep well 6042 Deleni (Fig. 1) was drilled for hydrocarbon exploration purposes in the central part of the Transylvanian Depression (TD). It penetrated at a depth of about 4700 m, and went through for more than 350 m, some basic rocks (basalts, basaltic-andesites, etc.), located beneath Upper Jurassic carbonate series (dolomites). The mafic sequence had been considered by several authors as an extension of the similar rocks cropping out in the southern Apuseni Mountains, representing the ophiolitic scare of the Transylvanian branch of the former Tethys Ocean.

The paper was intended to add airborne/surface geophysical information previously obtained into the area in correlation with well-logging data (electric, gamma-ray, and neutron logs) and previous regional geotectonic framework. It aims to add geophysically inferred geotectonic elements to the information provided by recent thorough mineralogical studies on the mafic rocks encountered by this well (Hoeck & Ionescu, 2003).

2. GENERAL SETTING

2.1. BASIC GEOLOGY OF THE TRANSYLVANIAN DEPRESSION

It is widely accepted the idea that the TD geological history starts with the opening of the Tethys Ocean. TD comprises large developments of Jurassic and Cretaceous formations, spatially isolated Eocene and Oligocene formations, followed by Burdigalian, and considerable thick Badenian, Sarmatian and Pannonian deposits covering almost all the area. The largely developed mid-late Miocene deposits correspond to an important subsidence period, to which some authors use to restrict the whole evolution of TD.

The TD basement, as intercepted by boreholes especially along the TD borders, was generally attributed to Median Dacides (eastern half) and to Internal Dacides (western half).

Triassic deposits are assumed to be present within TD by similitude with deposits of the same age in the adjacent areas. Ophiolitic suite + cherts, red marls, clays, white limestones (similar to those in the sub-bucovinic nappe - Săndulescu, 1984) were met in deep wells at Isa, Mercheaşa, Jibert. The presence of dolomites, marls, and reddish limestones similar to those in the Codru nappe system (NW Apuseni Mts. – Ciupagea, 1970), is uncertain.

Jurassic deposits (limestones and dolomites met in the Band and Deleni boreholes) are attributed to Malm, while others (central-south TD) seem to belong to a Dogger in a similar facies to the eastern Apuseni Mts. or Măgura Codlei (eastern end of Southern Carpathians).

Lower Cretaceous formations (black marls, red clays, sandstones, Barremian micro-conglomerates, Aptian limestones) have been intercepted by wells at Grânari (overlaying the crystalline basement), Band, Deleni (lying on Dogger), and Agnita (overlaying Triassic?). Extending the whole Lower Cretaceous area (from boreholes at Mercheaşa, Jibert, Alămor, as well as from east Apuseni Mts. outcrops) a development of the whole Valanginian-Albian interval is presumed.

Upper Cretaceous formations were intercepted by wells on a large area central and west TD. They may exceed 1350 m and comprise sandstones, conglomerates and marls in Gossau facies in the western TD, and Cenomanian flish deposits in its eastern part.

Paleogene formations exhibit large facial and thickness variations, in north, west, central and south TD. Paleogene suites may reach thicknesses of up to 3000 m.

Eocene deposits (sometimes including possible undifferentiated Paleocene series) evolve from basal continental facies (sandstones, conglomerates, sands, red and green clays, massive limestones: lower striped series), to Mid-Upper Eocene marine facies (lower marine series, upper striped clays + upper marine series) and a thickness of about 100–750 m in north-west (Pogăceaua, Miheş, Lujerdiu, Bădeşti, Darja, Vima boreholes) and of about 100–870 m in the south part (Copşa Mică, Cenade, Şeica, Ruşi, Salcău, Daia Sibiului, Nucet, Mercheaşa wells).

Oligocene deposits, exclusively developed in the northern and western part of TD, are made of sandstones, sands, clays, slightly bituminous marls. The upper part of Paleogene (Chattian) gradually passes to the Lower Miocene.

Lower Miocene (Aquitanian-Burdigalian), which may reach 1500 m in thickness, overlaps approximately the Oligocene area. It was intercepted by boreholes at Buneşti-Gherla, Puini, Sic, Sucutard, Miheş, Filitelnic, etc. and consists of molasse deposits (marls, sandstones, clays).

Middle-Upper Miocene formations (Badenian-Sarmatian-Pannonian-Pontian) are marked by a major subsidence, which determined accumulation of more than 3000 m of molasse deposits. The stratigraphical succession is marked by the salt and tuffs (Dej, Hădăreni and Bazna) sequences. They often provide traps for important natural gas accumulations.

On the mafic rocks presence

Although the previously considered ophiolites in the TD basement intercepted by deep wells at Deleni, Beudiu and Zoreni proved to represent **island arc volcanics** (Hoeck & Ionescu, 2003), the assumption on the presence of an ophiolitic layer central TD (Târnave Basin), under the Jurassic and Cretaceous deposits, has been still valid.

Mafic/ultramafic rocks crop out within the major Tethyan suture area (Southern Apuseni Mts), and were supposed to extend eastward, within the TB basement. Several authors considered them as remnants of an oceanic floor:

– fragments of Jurassic arc-type oceanic crust (Cioflică *et al.*, 1980; Cioflică & Nicolae, 1981; Nicolae, 1995)

– Jurassic MORB-type oceanic crust (Savu *et al.*, 1981; Savu *et al.*, 1994).

2.2. BRIEF CONSIDERATIONS ON THE TD GENESIS

Generally, most theories trying to decode the TD genesis associate a common origin and evolution for both Pannonian Depression (PD) and TD. But mention should be made to several distinct peculiarities for TD as compared to PD:

– an average higher altitude, of about 600 m (as compared to 100 m for PD);

– the presence of an unexpected low surface heat-flow (three times less than within PD);

– the salt presence (which is absent within PD);

– gas deposits (which are almost absent within PD area);

– the absence of oil deposits (well represented within PD area);

– a strong geomagnetic regional high within central TD.

Accordingly, several distinct hypotheses concerning the TD genesis have been postulated:

– **collapse of a non-regenerated massif** (Dumitrescu *et al.*, 1962);

– **back-arc extension** as a consequence of the westward subduction beneath Eastern Carpathians (Bleahu *et al.*, 1973);

– the occurrence of a **Tertiary extensional phase** (Crînganu, 1987) (it is worth mentioning that the last model conflict with low heat flow and high altitude observed within TD);

– a main control of the subsidence by **temporary dynamic loading from below during subduction**; further amplified by sedimentary loading and subsequent uplift due to the unloading of the subducted plate (Royden *et al.*, 1982; Burchfiel & Royden, 1982; Royden, 1988);

– retro-foreland basin (Sanders, 1998).

One of the major open questions is about the extensional/compressional events experienced by TD during its genesis and evolution. Visarion and Veliciu (1981) considered that a continuous compression occurred within the basin due to the Alpine subduction in the Eastern Carpathians. Later on, Polonic (1996) took into consideration two main extensional phases within TD evolution, during *Late Cretaceous,* and in *Early Badenian*. By thoroughly analyzing several seismic reflection lines, Ciulavu (1998) showed that there is no evidence for any Tertiary extension. The only extensional phase took place during *Late Cretaceous*, when the basin occurred. The author found also geophysical evidence for the *post-Badenian* NE compression.

2.3. GEOPHYSICAL SETTING OF THE TD

Regional geophysics carried out during the time revealed several peculiarities in the geophysical behavior of the TD, as follows:

1) an unusual low heat flow (about 40 mW/m^2), except for its northern part (about 60 mW/m^2), which is bellow the continental average, and three time less than in the Pannonian Depression;

2) almost zero recent crustal vertical movements (Popescu & Drăgoescu, 1986);

3) a large aeromagnetic high dominates the TD central part. It is fully supported by images provided by the ground vertical component geomagnetic map of Romania (Airinei *et al.*, 1983; 1985). During the time, it has been attributed to various sources:

– the elevated position of the lithospheric mantle (Airinei, 1957);

– the large presence of ophiolitic masses within the TD basement (Săndulescu & Visarion, 1976);

– the cumulative effect of at least three major sources, located at various depths: the Dej tuff in the upper segment, well known for its magnetic properties, the presence of largely developed basic to intermediate igneous rocks at the basement level, and the geomagnetic expression of the lower crust ("basaltic layer") located above the Curie isotherm, due to low vertical gradient of the temperature in the central part of TD (Beşuţiu, 1984);

4) former refraction and reflection seismics from the seventies (Rădulescu *et al.,* 1976; Rădulescu, 1988) revealed a normal thickness of the crust within the inner part (29 km), and increasing values (up to 34 km) towards its borders, while new reflection seismics data pointed out a thicker crust (42–47 km) within central TD, with a large transient zone starting at the 27 km depth (Răileanu & Diaconescu, 1998);

5) lithosphere thickness has been evaluated by interpreting seismic and MTS data (Enescu, 1987; Stănică *et al.*, 1986), which provided an estimate of about 80 km. Rheological models indicate a weak lithosphere and thinning of the upper crust (Lankreijer *et al.*, 1997).

6) The ROMPLUS catalogue (Oncescu *et al.*, 1998) shows numerous normal earthquakes within TD. The strongest earthquakes foci are located along NW trending structures, while weaker events were recorded along NE trending structures. It seems that the most active faults are located in the north-western part of TD, but numerous earthquakes were also recorded in the southern part of TD.

3. NEAR TO SURFACE GEOPHYSICS WITHIN THE 6042 DELENI WELL AREA

To study the geophysical and tectonic environment of the Deleni well, gravity, magnetics (both ground and airborne), geothermics (vertical gradient and heat flow), as well as seismics were taken into account. Various filtering techniques (matrix smoothing, polynomial regression, etc.) were extensively used in order to improve the signal/noise ratio in separating effects made by sources of different extent and/or located at various depths.

Regional Bouguer anomaly outlined the location of the 6042 Deleni well on the northern flank of one of the two major basins of the TD: the Târnave Depression (Fig. 2). Further processing of the gravity data, by removing a 5th order polynomial trend from the observations, locates the deep well in an area of an increased horizontal gradient of the gravity, advocating for the presence of a tectonic discontinuity striking northeastward (Fig. 3).

As previously mentioned, airborne data (Cristescu & Ştefănciuc, 1968) outlined a large regional geomagnetic anomaly over the central part of the TD (Fig. 4).

Ground vertical component geomagnetic anomaly in the area is rather similar to the aeromagnetic image, advocating for the deep nature of the main source. However, it brings additional details related to tectonics of the basement. Low magnetic corridors splitting the regional high have been interpreted as regional active faults, where crust looses its magnetic behavior by tectonic fragmentation. Among them, mentioned should be made to the Târnava Fault, striking ENE on the northern flank of the Târnave Depression crossover the area of the 6042 Deleni well (Fig. 5). It is worth mentioning that analyses made on core samples from the 6042 Deleni borehole showed high magnetic susceptibility for the basalts assumed to be one of the main sources of the geomagnetic anomaly, but unusual low densities. The fact was attributed to the presence in the Deleni area of some deep fracture circulated zones located at the basement level, hidden beneath the TD Mesozoic and Cenozoic cover. While gravity expression of these deep seated discontinuities is masked by the shallower effect of the thick sedimentary cover, geomagnetic data processing sharply pointed out the presence of a regional fault belonging to the NNE striking system of TD, parallel to the flanks of the Puini basin (Ciulavu, 1998).

Fig. 6 presents a residual of the airborne total intensity anomaly obtained after removing a 1st order polynomial trend from data. The filter has been chosen according to Kautzleben criterion: an appropriate reference field, should provide a geomagnetic anomaly with zero mathematical expectation. The thus revealed blue shadow corridor striking NNE, across the 6042 Deleni well zone, seems to define the track of one of the above mentioned regional faults, hidden by the TD cover.

4. WELL LOGGING ANALYSIS AND CORRELATION WITH CORE SAMPLES GEOCHEMISTRY

4.1. GENERAL CONSIDERATIONS

Drilling core samples collected from the deep well 6042-Deleni were used to construct a relatively comprehensive lithostratigraphic column. However, various circumstances encountered during the drilling did not allow a permanent recovering of the cores, thus leaving several “gaps” in this column. Therefore, the well was also continuously investigated by ATLAS GIP S.A. using several well logging tools. A gamma log, which allows good correlations between geological formations, was performed from the bottom to the top of the well. It was combined with a neutron log, usually used in oil well exploration in determining the reservoir porosity. Down from the depth of 4490 m a Laterolog 3 investigation was added in order to determine the electrical resistivity of the geological formations crossed by the drill.

4.2. INTERPRETING THE WELL LOGGING DATA

Basically, while investigating homogeneous basalts, well log records of radioactivity, electrical conductivity, and porosity should be almost constant at the lowest level. In the case of the deep well 6042-Deleni, the large presence of alteration zones in basalts (Ionescu *et al.*, 2003), visibly marked by numerous veins, nests, and pseudomorphoses with calcite ± iron oxides, chlorite and serpentine minerals, etc., are well expressed in the unusual low bulk density (ranging from 2.5 to 2.7 g/cm^3, while density of normal basalts is above 2.80 g/cm^3). Consequently, they find a large reflection in the variations of the above mentioned parameters within the well logging records.

Following the re-interpretation of well logging data in connection with geochemistry analyses results (Hoeck and Ionescu, 2003), at least two main aspects should be stressed:

– the presence of some higher porosity zones, marking rock discontinuities;

– peculiar logs features and geochemistry within each of thus discriminated segments, advocating for the existence of several basalt sequences.

4.2.1. Presence of discontinuities within the basalt lavas package

Several zones of **increased porosity** within basalt rocks were mainly revealed by the neutron log (Fig. 7). They might be related to **highly fissured/fractured regions** that mark **major** limits between **various basalt sequences**, along which some displacements could take place under the action of tectonic forces.

Basically, the neutron log data in such zones should be associated to lower values of the electrical resistivity in the Laterolog-3 records (due to electrolytes conductivity that occurs in porous media) and, either low values of the gamma log records as a result of U and K removal by intense water circulation, or, on the opposite, increased values generated by the higher content in radiometric elements, mainly K^{40} from alteration processes and/or deposition of shale films along the fissures.

First discontinuity (I) was revealed by well logging at the top of the basalt lavas package, pointing out the major limit between basalts and Jurassic sedimentary (at about **4700 m** depth). Actually, there is a first narrow gamma log peak in the area associated with low porosity on the neutron log that seems to be related to the presence of a narrow marl strip between Jurassic limestone and basalt top, but the following gamma log high is well developed in the area of increased neutron log porosity associated with low resistivity. Deeper, a large area of high neutron porosity appears in correlation with low electrical resistivity, and low gamma response. Unfortunately, starting with the depth of 4698 m till 4742 m strong underground eruptions of salt water and gases prevented the recovery of drill cores. Fragments of dolomites mixed with fragments of basaltic rocks were collected in the well screens for the first two meters of the above mentioned interval, but beneath the 4700 m only basaltic rocks appeared. Under these circumstances, the discontinuity revealed by the well logging seems to be related to the presence of a highly circulated fissured/fractured zone, very likely indicating a mobile (shearing?) plane.

It should be mentioned that a quite similar gamma-log high could be generated by the presence of radiolarites, well known for their U affinity, and often met as the ophiolites cover within Alpine catenae (Foucault, Raoult, 1980). However, the radiolarites presence within Deleni area is unlikely. Basalt rocks in the area of the Apuseni Mts (AM) and TD belong to two series (Nicolae *et al.*, 1992; Sacani *et al.*, 2001; Bortolloti *et al.*, 2004): tholeitic sequence (ophiolites), and calc-alkaline series (island-arc basalts). In all known outcrops, the cherts always lie on the top of ophiolitic series only, which is not the case of Deleni basalts. Geochemistry analyses clearly attributed them to the island-arc calc-alkaline rocks (Ionescu and Hoeck, 2004). Besides, the presence of radiolarites within AM area is very scarce, with thicknesses of no more than 1-2 meters (Nicolae *et al.*, 1992).

Finally, it should be stressed that no cherts were noticed on the well screens, and, if present, they should be associated with high resistivity zones on electrical logging, which the Laterolog-3 did not reveal within Deleni well.

The next major increased neutron porosity zone (II) is located at about **4770** m depth, just beneath a strange association of low neutron porosity and high resistivity (which appears quiet normal for a basalt), with higher values of gamma log (that are unusual for compact basic igneous rocks). The revealed discontinuity associates high neutron porosity with higher electrical conductivity values, and low gamma log records.

The third major zone of increased porosity (III) was outlined at about **4840 m** depth by a typical combination of high neutron porosity – low electrical resistivity and increased gamma log records. Besides, the area marks a change in the trend of gamma log (from small increasing to small decreasing relative to the general increasing trend).

The fourth major fractured zone (IV) appears at a depth of about **4940 m**, tightly preceded by the above mentioned unusual logs association of low porosity – low electric conductivity and high gamma log values. In this case, higher porosity environment is associated with low gamma log and weak increasing of electrical conductivity records, which is expected within highly circulated fractured zone circumstances followed by U and K removal. The presence of this discontinuity is well supported by the radical change of gamma log behavior.

The fifth major fractured zone (V) was revealed at about **4980 m** depth. It is characterized by higher neutron log porosity, weak decreasing in resistivity, and lower values gamma log records. Besides, the discontinuity is well expressed by an obvious pattern change of logs, marking the top of a highly inhomogeneous zone with fast and large changes in all records.

4.2.2. Geophysical behavior of various basalt lava sequences

As previously stated out, well logging has allowed the revealing of several major discontinuities which advocate for an inhomogeneous basalt lavas package, made of several sequences. Looking for the geophysical behavior of these possible sequences, the most valuable information seems to be provided by gamma log, which is more sensitive to the crossed lithology (Telford *et al.,* 1978).

As a general trend within the studied sequence, the gamma log records (Fig. 8) seem to reveal a permanent increasing with the depth (dashed dot curve). The trend is interrupted at the previously discussed discontinuities, and has a peculiar aspect for each of the revealed segments, which is overprinted on the general increasing trend from top to bottom. After each break the gamma log seems to re-start from the initial level of the previous segment, but the increasing slope preserves along the whole basalts package.

Interesting results were obtained when comparing the gamma log behavior with geochemistry of the core samples (Ionescu & Hoeck, 2003). Thus, in the upper part, along the two segments (B' and B") the gamma log records seem to be fully controlled by the concentration in K^{40} present within shale films on the basalt fissures. Both increasing (segment B') and decreasing (segment B") in K content are well expressed in the trend of the gamma log records (blue solid line) although overprinted on the general increasing trend with the depth (blue dashed curve). To emphasize the correlation between K content on core samples and gamma log intensity, the relatively increasing/decreasing trends on the gamma record were discriminated (red dashed line) from the general trend.

In turn, concentration in U and Th do not seem to influence the log aspect for the upper sequence. However, a sharply decrease in their content can be noticed at the limit between sequences B' and B". Besides, for the following basalt sequences (C', C"), the rise of concentration in U and Th with the depth (as revealed by analyses) seems to play a major role in the morphology of the gamma log record, by determining its general increasing trend. However, it should be stressed that spectral gamma log (which the authors did not have at their disposal) also indicate an increased contribution of K^{40} (Prof. Dr. Neguţ, personal communication). According to the respective records, gamma log highs within 4995-5050 m interval seem to be provoked mainly by an increased content in Th and K^{40}.

On the other hand, several associations of high neutron porosity with low resistivity and low gamma logs (see fig. 7) seem to indicate fractured zones of the above mentioned interval.

Therefore, higher degree fractured/fissured zones seem to be located especially at the top (segment A) and the bottom (segment C") of the crossed basalts by large and fast changes in their physical properties.

5. CONCLUDING REMARKS AND SPECULATIONS

To conclude, the following remarks should be stressed:

– well logging pointed out at least four major sequences within the sampled basalts intercepted by the drilling;

– the basalt sequences are separated by highly fractured/altered zones well reflected in higher neutron porosity and electrical conductivity values, rather unusual for compact basic rocks: sometimes high values of gamma log seem to indicate the presence of radiometric elements (especially K^{40}), as a result of biotitization and/or shale deposition on the circulated fissures;

– as shown by the core samples geochemistry, between depths of 4765 m and 4910 m the gamma log is highly controlled by K_2O content, which is supposed to be associated to the presence of shale films along the fissures;

– distinct log pattern along different basalt sequences advocate for their distinct age: at least four generations were geophysically revealed;

– each basalt sequence is characterized by a specific gamma log behavior: increasing values from top to bottom, and variable pattern from one sequence to another;

– high porosity intervals between them could be developed under the action of tectonic forces (related to thrusting?), which accented the initial discontinuities by creating some milonitic circulated zones between different basalt lava flows.

Data provided by some sonic log records in the same well (Dr. Aurică Damian, personal communication) are in full agreement with the above conclusions.

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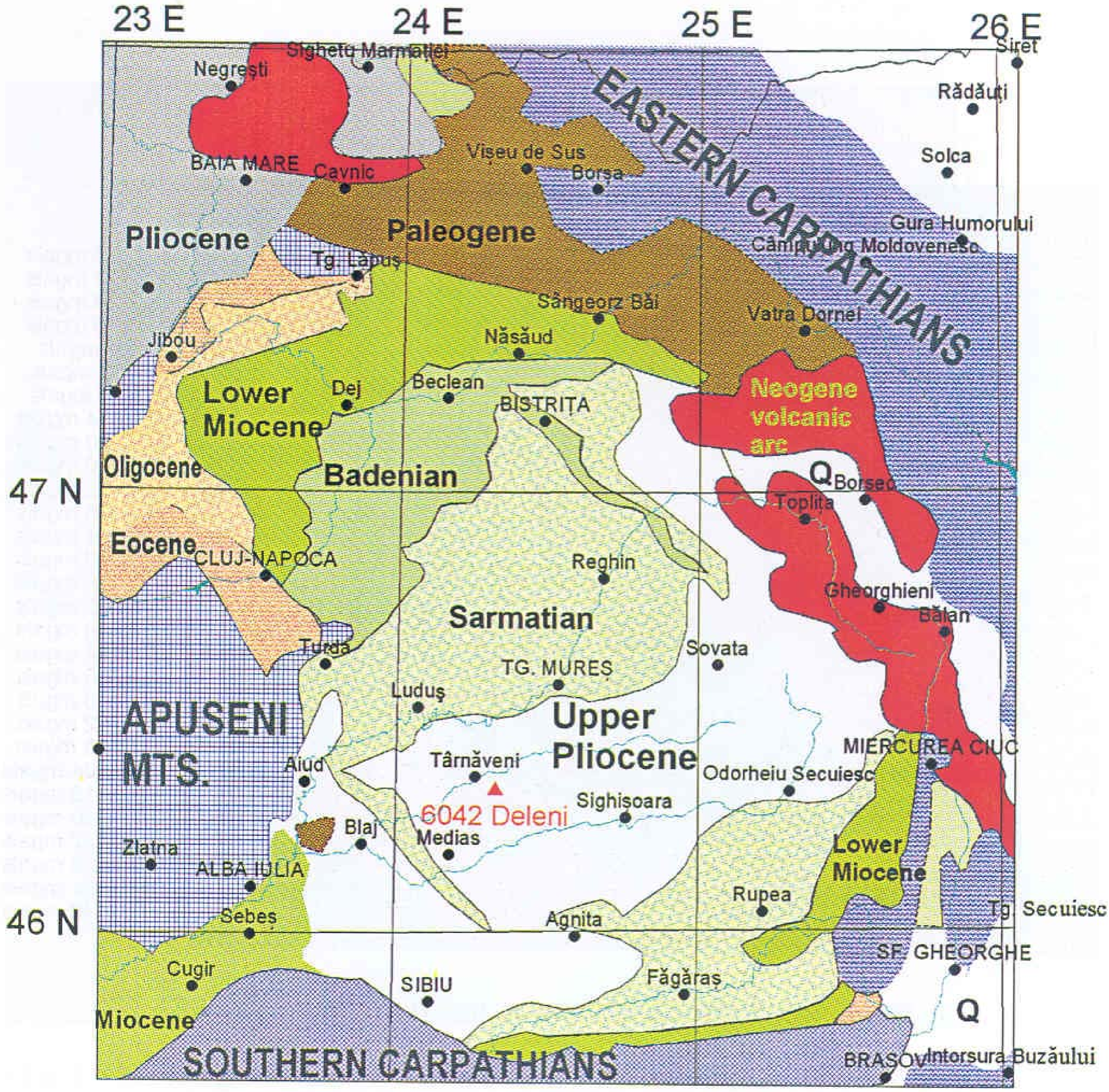

Fig. 1 – TD geological sketch and the location of the 6042 Deleni deep well (modified after Ciulavu, 1998).

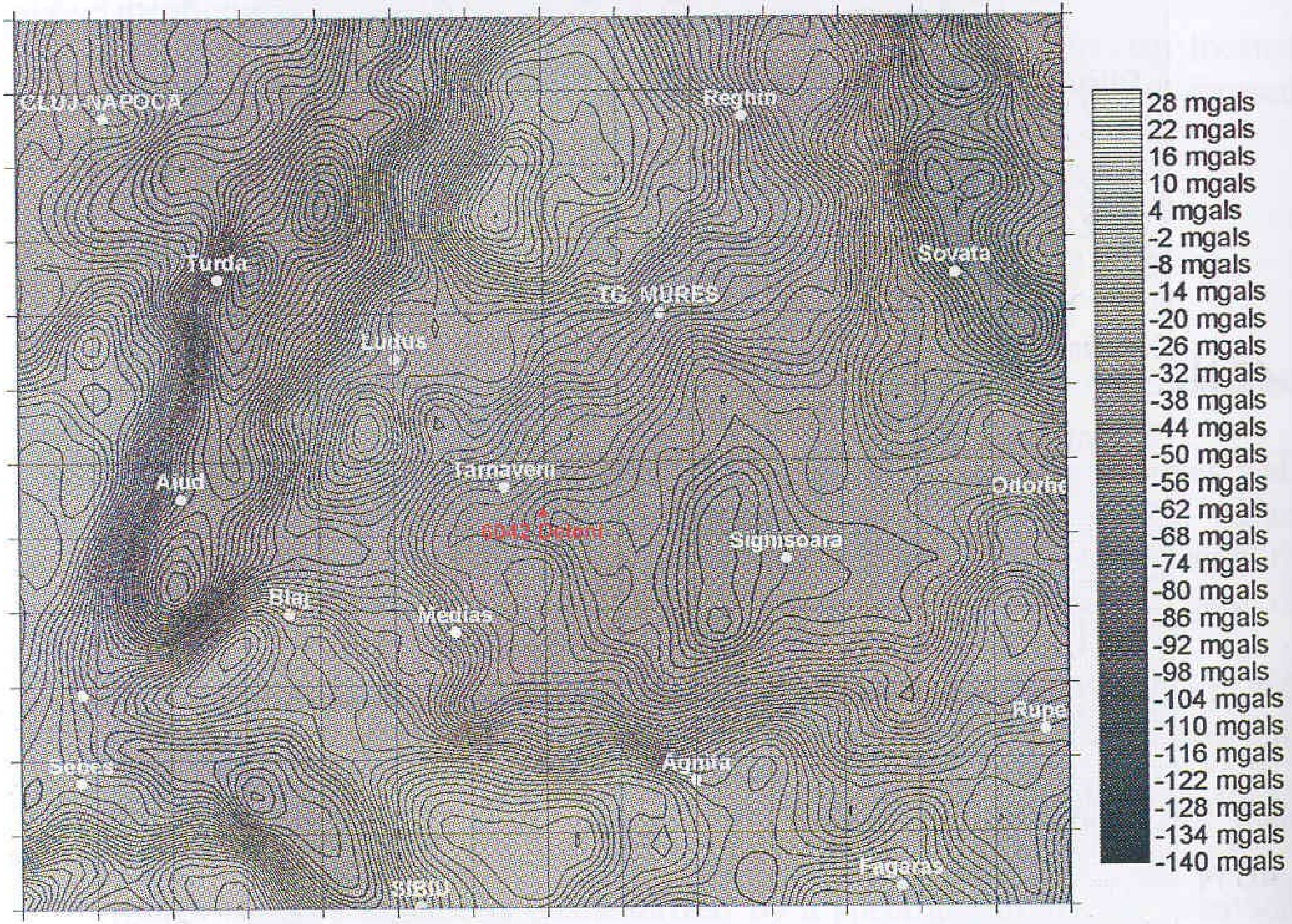

Fig. 2 – Bouguer anomaly trend within the TD area (2670 kgs/m^3).

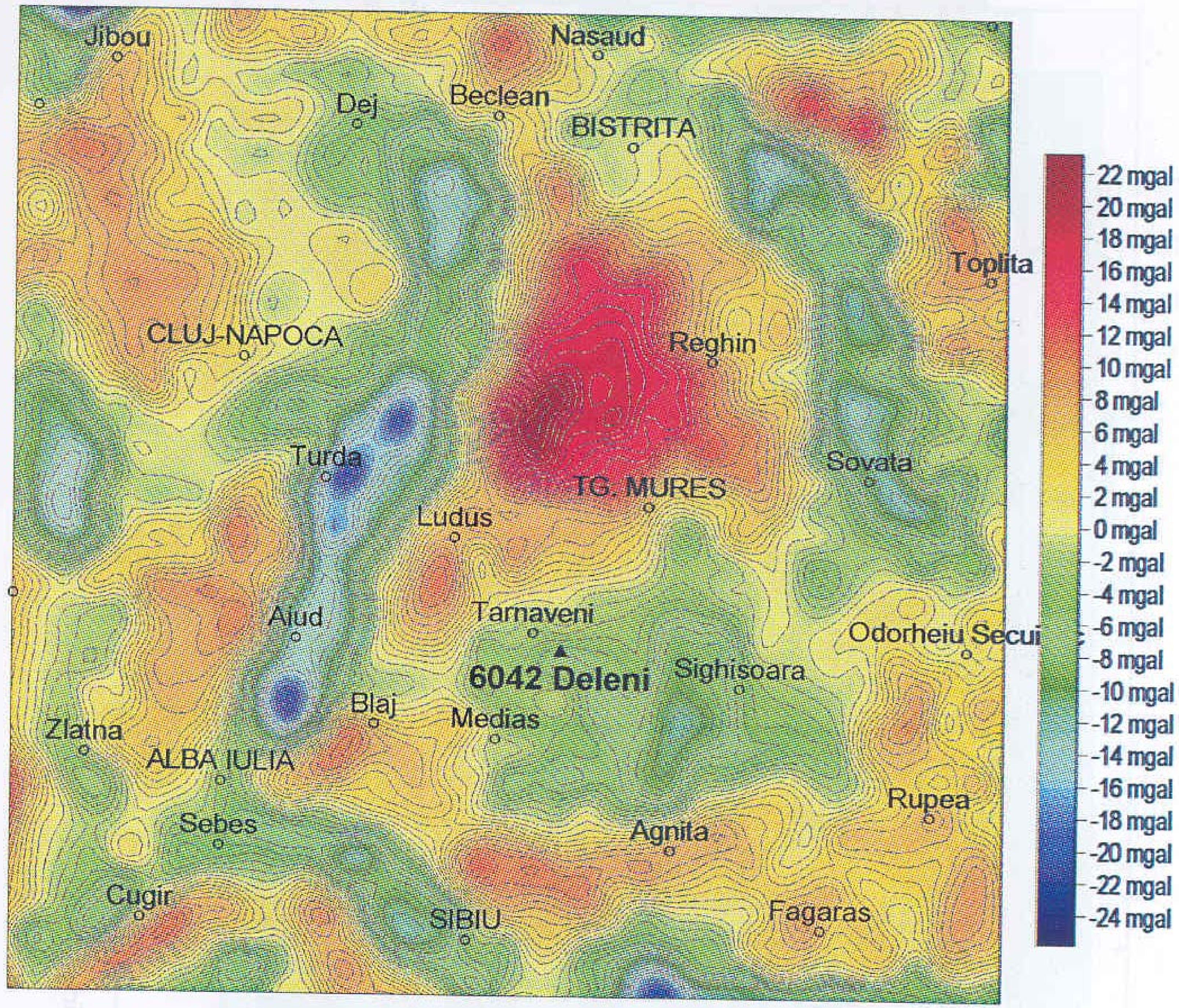

Fig. 3 – Residual gravity anomaly within the 6042 Deleni well region. A 5th order polynomial trend has been removed from data.

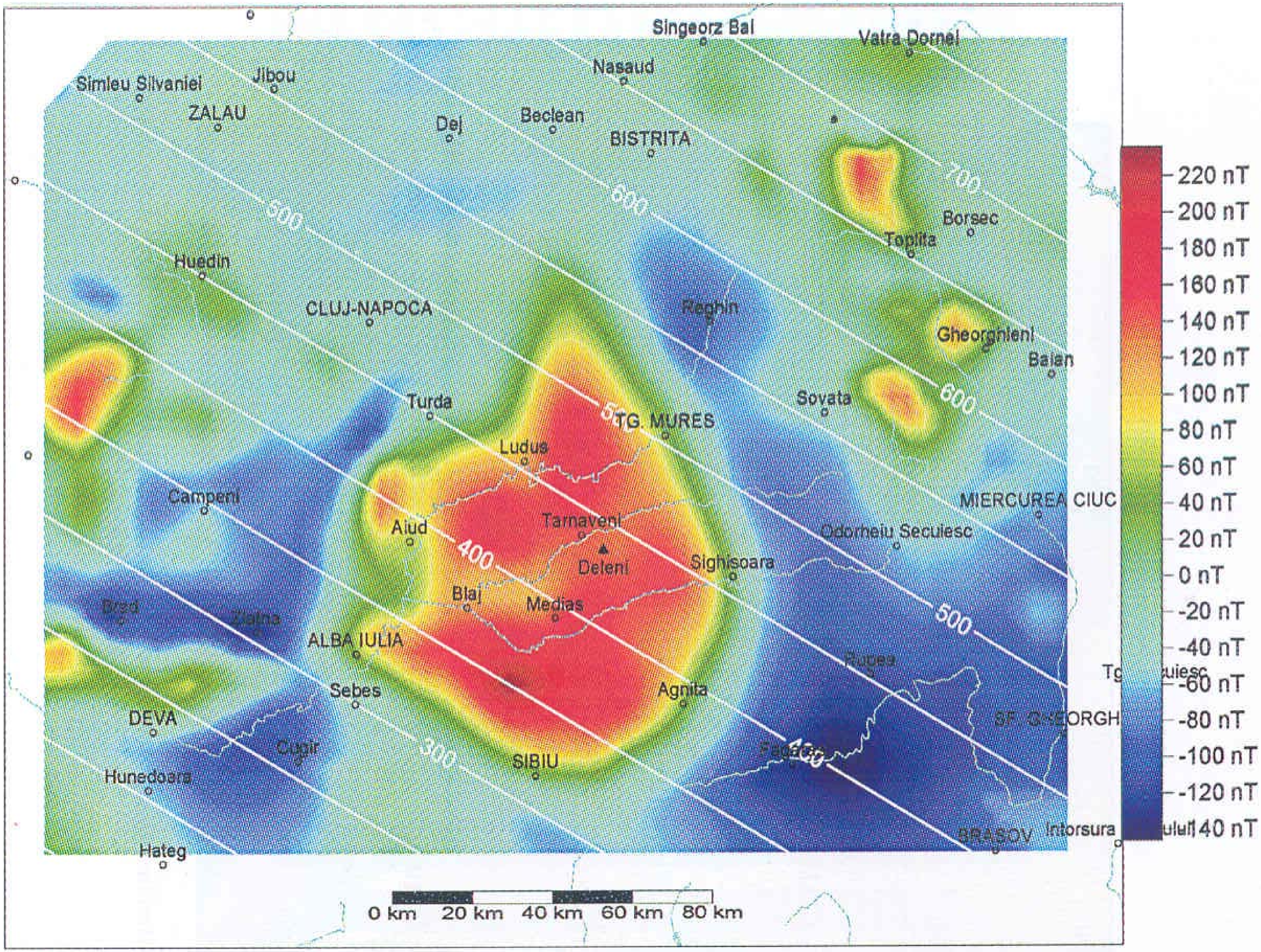

Fig. 4 – Airborne total intensity geomagnetic anomaly over the TD area at a flight altitude of 3,500 meters. White lines show the reference field trend.

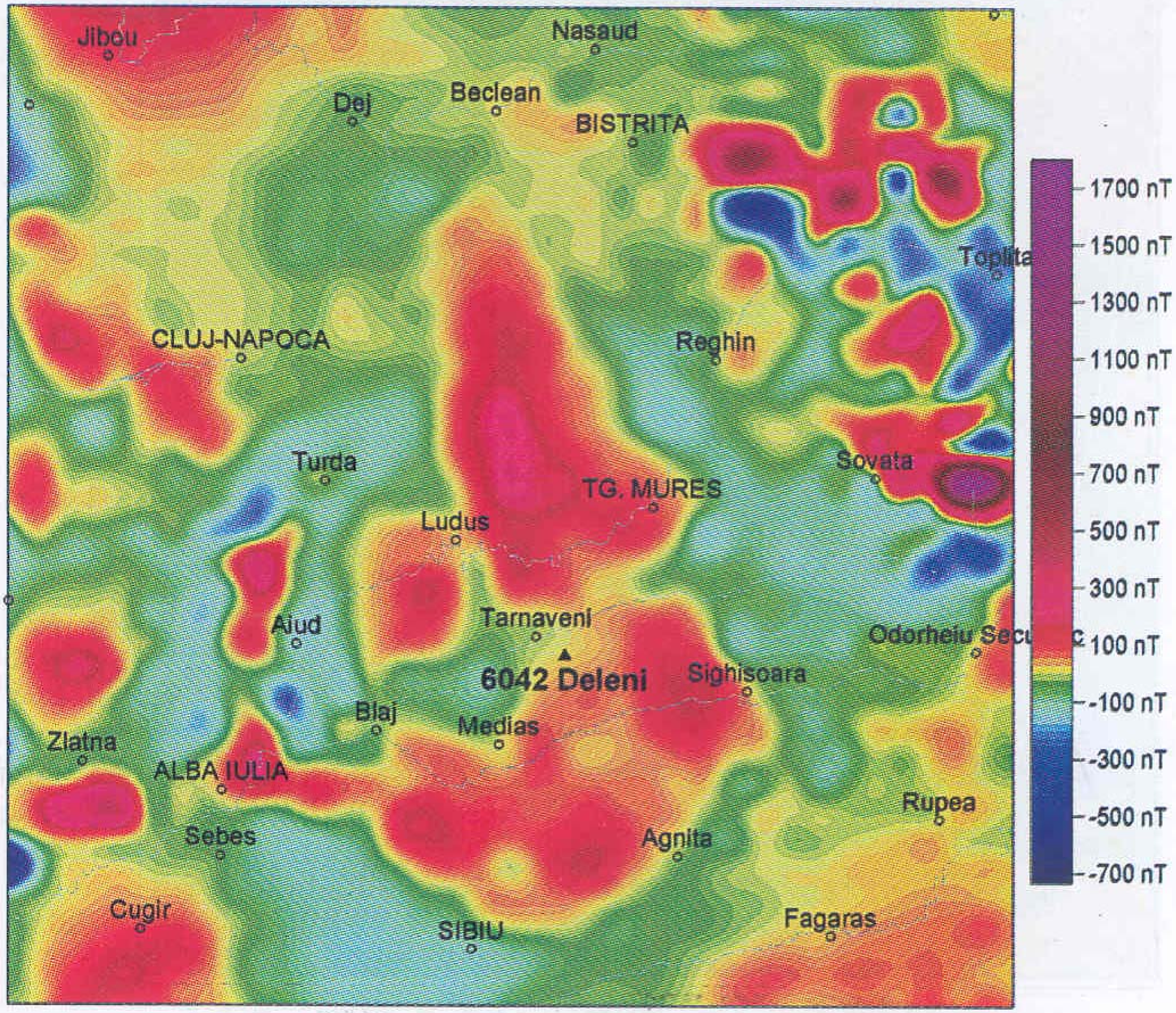

Fig. 5 – Residual ground vertical component geomagnetic anomaly within the 6042 Deleni well region. A5th order polynomial trend has been subtracted from data (raw data according to Airinei *et al.*, 1983).

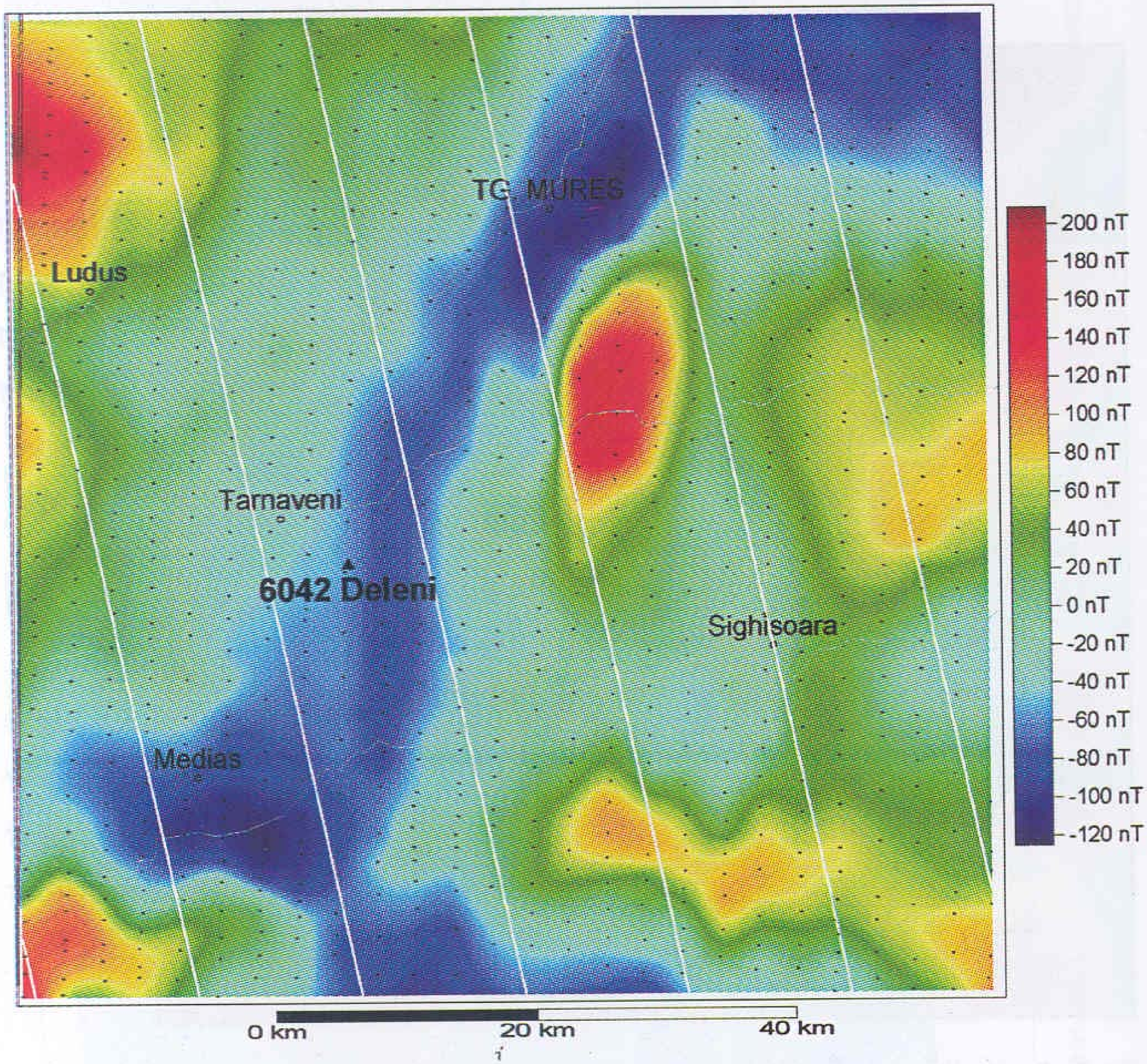

Fig. 6 – Reflection of the deep located geomagnetic zones in the total intensity residual geomagnetic anomaly as obtained after removing a first order polynomial trend from the aeromagnetic anomaly in the study area. White lines mark the geomagnetic reference field trend.

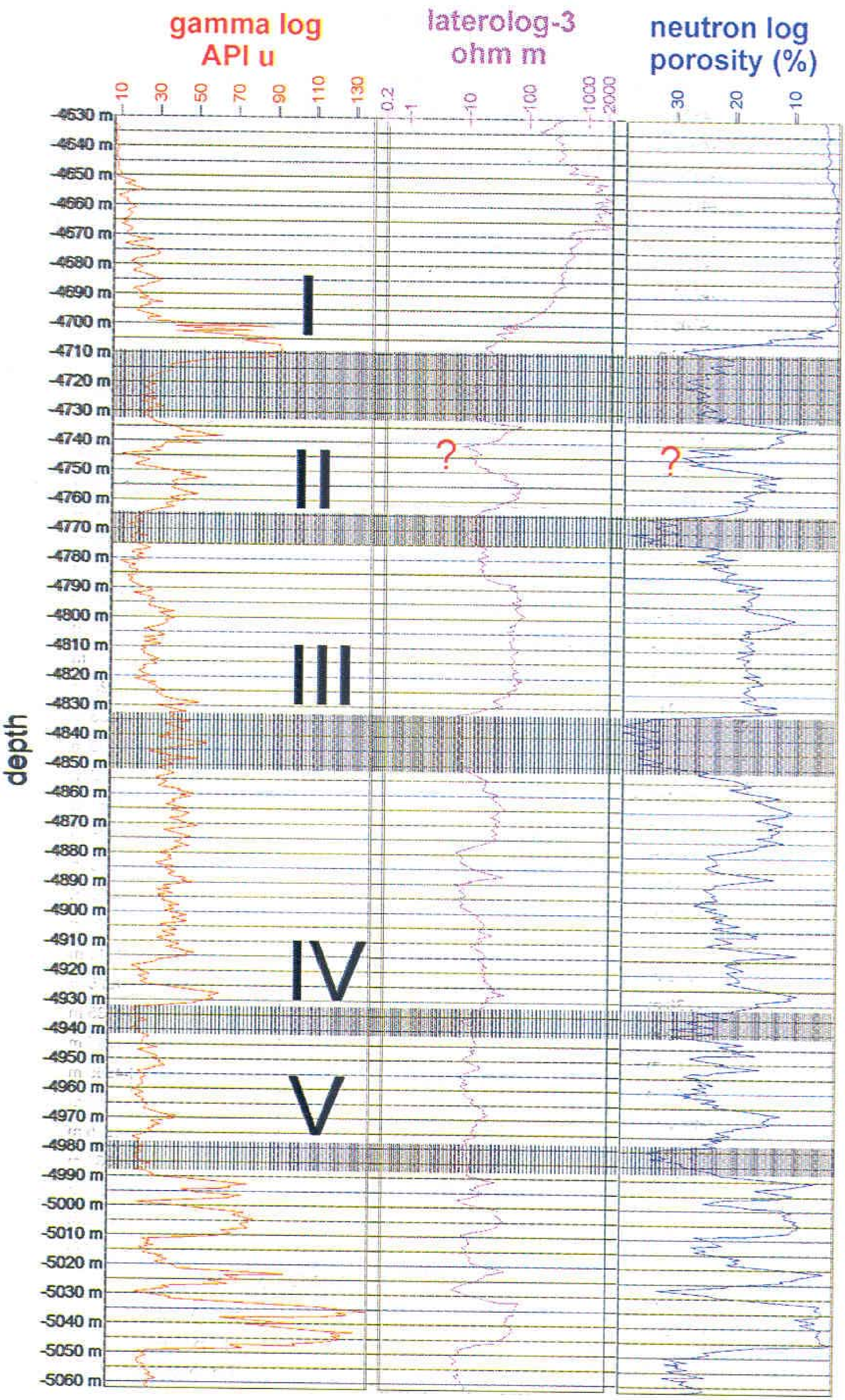

Fig. 7 – Well logs performed within the deep well 6042 Deleni (courtesy of ROMGAZ S.A.). Stripes mark major discontinuities.

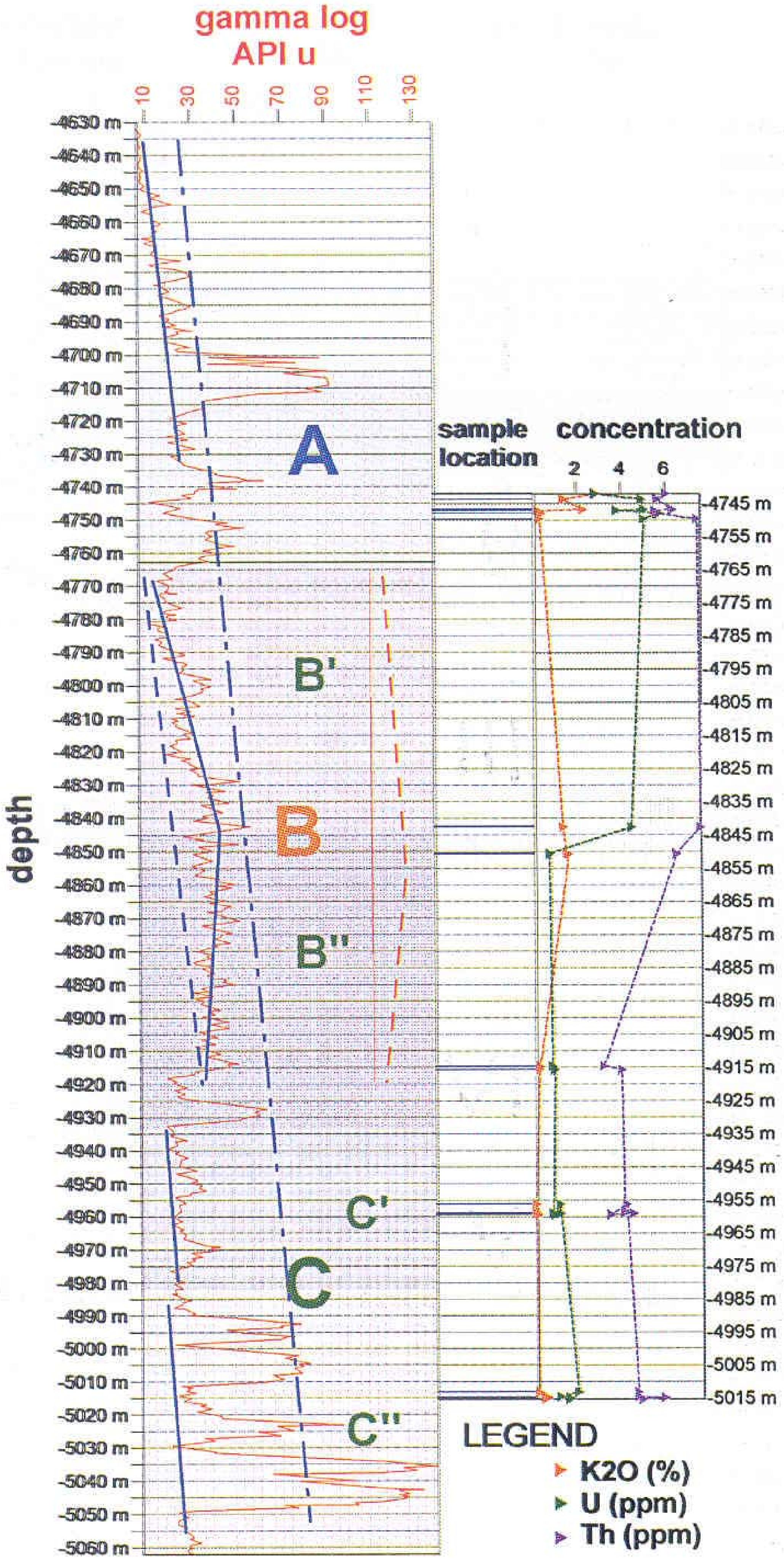

Fig. 8 – Gamma log interpretation and geochemistry of the core samples (geochemistry data according to Hoeck & Ionescu, 2003).