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# Rock densities in the Pannonian basin — Hungary

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In that density is a fundamental parameter of gravity exploration, and that Bouguer- and terrain corrections and interpretation of gravity measurements require reliable density data, the authors carried out a detailed investigation to determine the densities of all possible important geological formations in the Pannonian basin. The study was based on the laboratory measurement of 12 000 rock samples and on 145 000 linear metres of density logs. The results themselves are presented in this paper in histograms, figures and tables.

**Keywords: gravity surveys, density, Pannonian basin, density logging, Hungary**

## 1. Introduction

Up till now only sporadic density information has been published for the Hungarian part of the Pannonian basin [PINTÉR–SZABÓ 1964, SZÉNÁS 1965, KILÉNYI 1968, KOVÁCSVÖLGYI 1996]. More density information is available for the Slovakian part of the basin [ŠEFARA 1987]. Despite its incompleteness, this data set was acceptable for regional studies but nowadays — in the post-regional era — when detailed large-scale investigations are on the agenda, more accurate density data are needed for geophysical interpretations.

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Rock densities can be determined directly by laboratory measurements or from gamma-gamma density logs. They can also be determined indirectly from the gravity measurements themselves (Nettleton method).

Here, we present density data obtained from laboratory measurements and gamma-gamma density logs.

## 2. Laboratory measurements

Density measurements on core samples can give good results especially in consolidated rocks, but they are normally available for very limited segments of the total geological column — especially in young sediments. Since the cores tend to be from the harder and more resistive part of the column, results obtained from core samples are generally higher than the actual density of the measured rock material, this is particularly true for shallow depths.

Between 1967 and 70, in ELGI's Tihany Observatory laboratory density measurements were carried out on more than 12 000 rock samples — mainly on drill cores. The samples originated from 305 localities (*Fig. 1*). The project was abruptly terminated, so the results were not evaluated and published.

The laboratory measurements were carried out by means of the buoyancy method. The samples were dried and weighed in air, then coated with paraffin and weighed again. In the next step the paraffin covered samples were immersed in water and weighed again. In water there is a loss of weight which is equal to the weight of the water displaced by the sample. The first measurements give the weight of the sample, but the second ones give a correction factor for the paraffin coating; the third ones give the volume of the sample. Knowing the density of the water and the paraffin, one can calculate the density of the sample. The average standard error of the density determination was ±20 kg/m$^3$.

The laboratory measurements have a high precision but because of the lower pressure prevailing in the laboratory and the dry condition of the samples (loss of pore water) the density values obtained from the cores are lower than the original 'in situ' values. To compensate for the pressure dif-

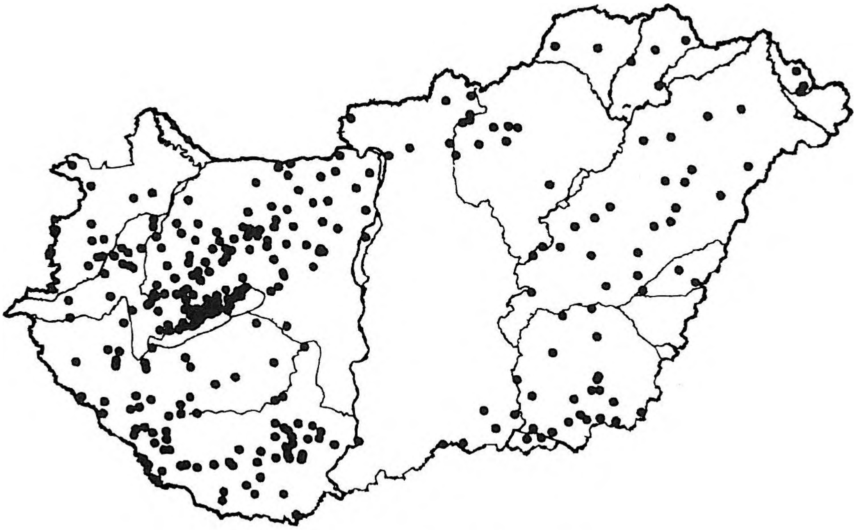

*Fig. 1*. Location map of rock samples
*1. ábra*. A mintavételi helyek eloszlása

ference, a high-pressure laboratory would be needed, but for the loss of pore water the following correction factor was applied

$$\sigma = \sigma_0 + \frac{2670 - \sigma_0}{2670}$$

where $\sigma_0$ is the air-dried density, and 2670 $kg/m^3$ is the specific gravity of quartz. The correction factor depends on the porosity of the samples, the higher the porosity the bigger the correction. Quartz was taken as standard because that is the main component of the Pannonian sediments.

The density values obtained were stored randomly on typed sheets in the sequence of measurements and were not analysed. The terminology (rock types, geological ages) used for the samples was far from uniform because the samples were collected by many different companies and geologists.

In order to process the data, they should first be standardized, and they then have to be converted to computer readable form. The data bank established contains all information about the samples, i.e. locality, designations of the borehole, depth, rock type, age, density.

After the completion of the preparatory phase the data were statistically analysed. The results are presented in histograms (*Figs. 2–6*). The

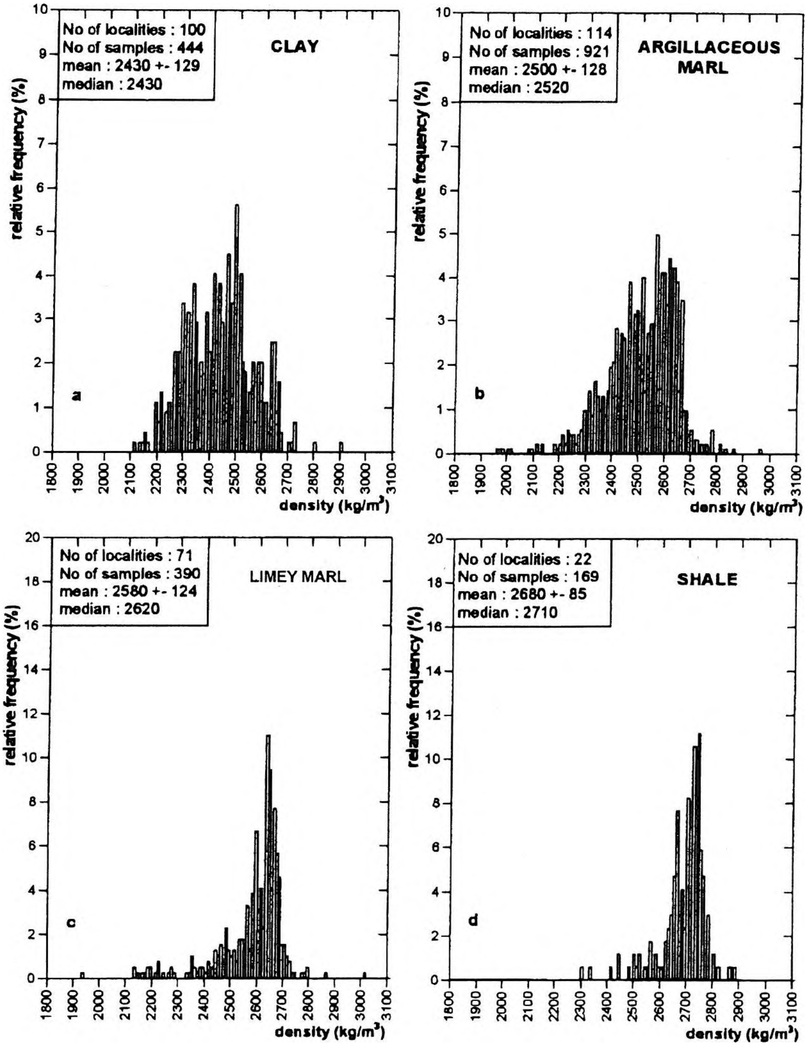

*Fig. 2.* Density histograms

*2. ábra.* Agyagok, agyagmárgák, mészmárgák és agyagpalák sűrűség hisztogramja

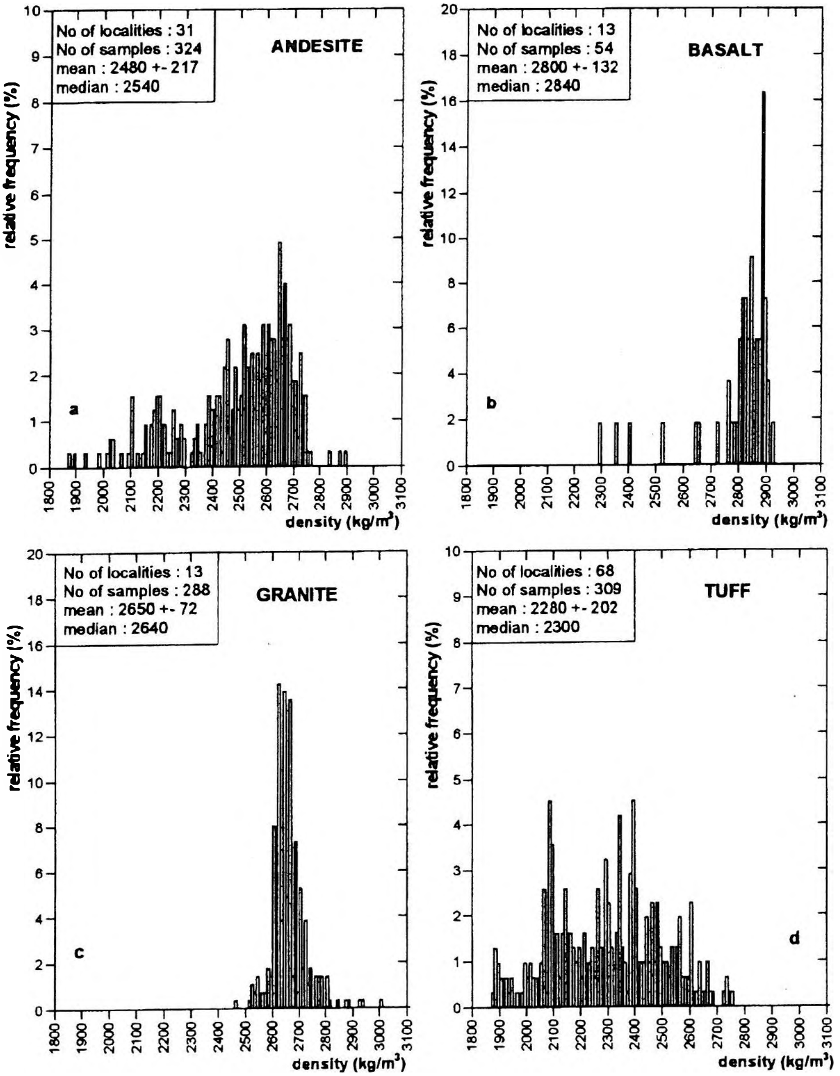

*Fig. 3.* Density histograms

*3. ábra.* Andezitek, bazaltok, gránitok és tufák sűrűség hisztogramja

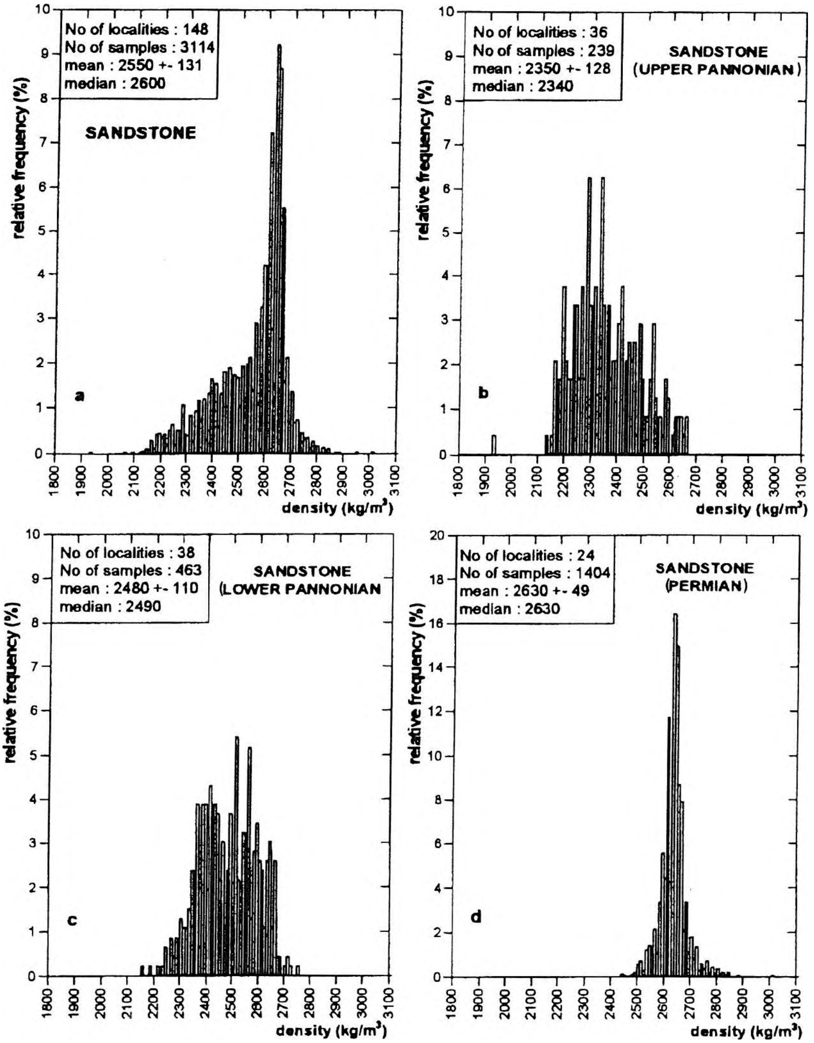

*Fig. 4.* Combined density histogram of sandstones and histograms of those classified according to age: Upper Pannonian, Lower Pannonian, Permian

*4. ábra.* Homokkövek egyesített, valamint koronként (felsőpannon, alsópannon és perm) osztályozott hisztogramjai

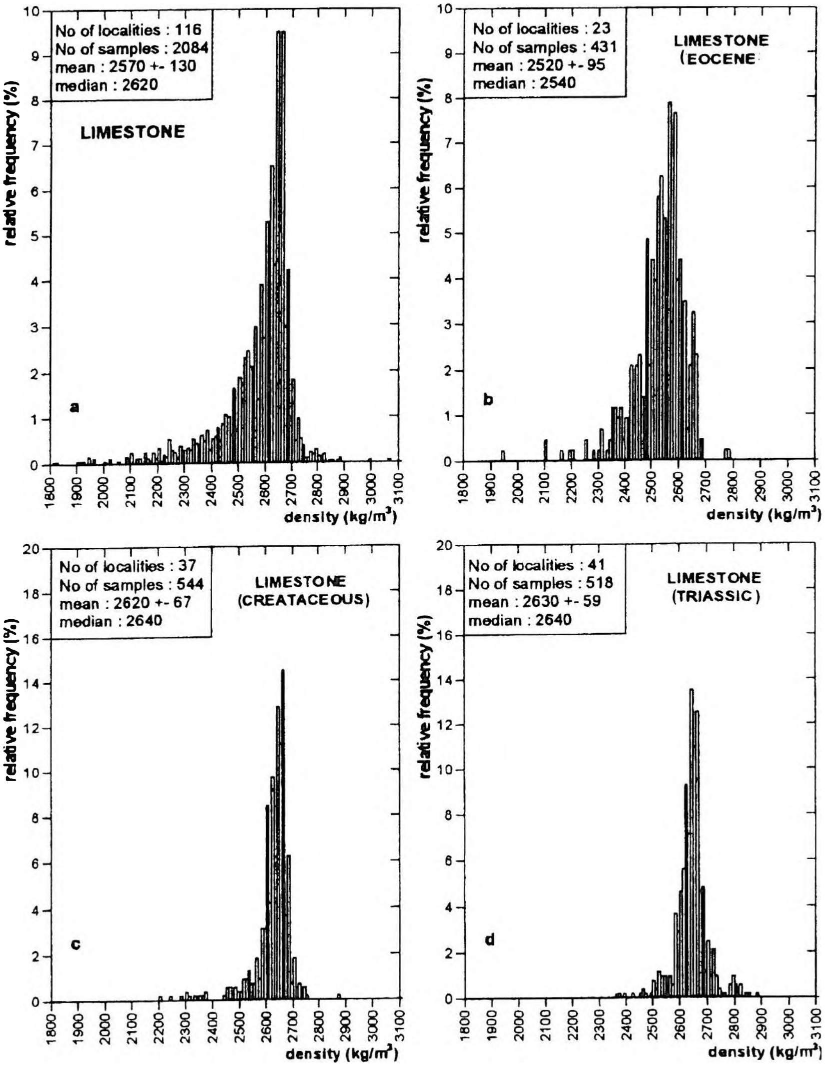

*Fig. 5.* Combined density histogram of limestones and histograms of those classified according to age: Eocene, Cretaceous, Triassic

5. *ábra.* Mészkövek egyesített, valamint koronként (eocén, kréta, triász) osztályozott hisztogramjai

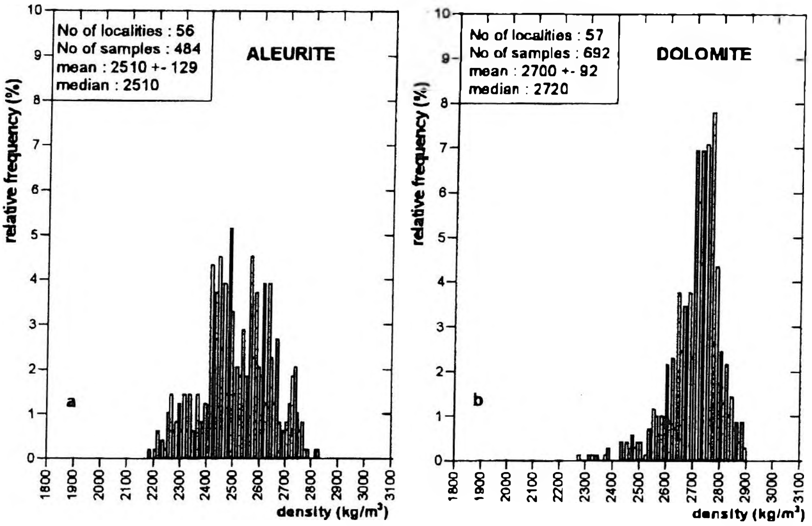

*Fig. 6.* Density histograms of aleurites and dolomites

*6. ábra.* Aleuritok és dolomitok sűrűség hisztogramja

fundamental data such as rock type, age (if it is relevant), number of samples, sample mean, sample median, and r.m.s. error are presented in the figures. The histograms are considered to be self-explanatory.

For rock types which have depth-dependent characteristics the exponential density function was determined in the same form as it was given in Athy's classical paper [ATHY 1930], viz.

$$\sigma_h = a + b(1 - e^{ch})$$

where *h* is the sampling depth in km. It has to be mentioned, however, that the exponential approximation seems to be somewhat artificial in certain cases, still we decided to use the well-known formula.

In some cases (e.g. sandstones and limestones) the histograms deviated from the normal distribution. After separating the samples according to their geological age and representing them in separate histograms the r.m.s. errors became smaller than in the case of the combined histograms. The sandstones could be separated into Upper Pannonian, Lower Pannonian and Permian subgroups (Fig. 4). The limestones could be separated into Eocene, Cretaceous and Triassic groups (Fig. 5). *Tables I* and *II* provide a summary of the densities based on their geological age and rock type.

| Geological age | No of localities | No of samples | mean | median |
|---|---|---|---|---|
| UPPER PANNONIAN | 59 | 926 | 2380 ± 132 | 2380 |
| LOWER PANNONIAN | 58 | 1232 | 2490 ± 128 | 2530 |
| MIOCENE | 89 | 1295 | 2430 ± 167 | 2470 |
| LATE MIOCENE | 18 | 145 | 2350 ± 184 | 2390 |
| MIDDLE MIOCENE | 40 | 539 | 2420 ± 153 | 2440 |
| OLIGOCENE | 23 | 475 | 2440 ± 84 | 2440 |
| EOCENE | 39 | 853 | 2480 ± 146 | 2530 |
| LATE EOCENE | 11 | 49 | 2530 ± 98 | 2530 |
| MIDDLE EOCENE | 17 | 342 | 2520 ± 86 | 2550 |
| EARLY EOCENE | 9 | 102 | 2550 ± 96 | 2560 |
| CRETACEOUS | 48 | 1038 | 2580 ± 101 | 2610 |
| LATE CRETACEOUS | 22 | 526 | 2570 ± 110 | 2610 |
| MIDDLE CRETACEOUS | 17 | 175 | 2570 ± 74 | 2600 |
| NEOCOMIAN | 13 | 142 | 2590 ± 97 | 2630 |
| JURASSIC | 16 | 285 | 2580 ± 189 | 2640 |
| MIDDLE JURASSIC | 7 | 86 | 2580 ± 137 | 2640 |
| EARLY JURASSIC | 7 | 117 | 2590 ± 207 | 2650 |
| TRIASSIC | 69 | 1639 | 2650 ± 76 | 2650 |
| LATE TRIASSIC | 37 | 345 | 2640 ± 67 | 2650 |
| MIDDLE TRIASSIC | 11 | 236 | 2660 ± 69 | 2655 |
| EARLY TRIASSIC | 11 | 638 | 2650 ± 59 | 2650 |
| PALEOZOIC | 79 | 2869 | 2640 ± 78 | 2640 |
| PERMIAN | 26 | 1780 | 2630 ± 69 | 2630 |
| CARBONIFEROUS | 21 | 426 | 2640 ± 96 | 2640 |
| SILURIAN | 9 | 136 | 2680 ± 72 | 2720 |
| OLDER THAN LATE CRETACEOUS FORMING THE PRE-AUSTRIAN BASEMENT | 154 | 5127 | 2640 ± 91 | 2640 |

*Table I.* Summary of laboratory density data according to their geological age
*I. táblázat.* A laboratóriumi sűrűség adatok földtani kor szerinti megoszlása

The unconsolidated young sediments have a wide bell curve indicating that their density is a function of depth. In these cases we present their density–depth functions (*Figs. 7–9*). Exponential functions were used to approximate their density distribution.

| Rock types | No of localities | No of samples | mean | median |
|---|---|---|---|---|
| CLAY | 100 | 444 | 2430 ± 129 | 2430 |
| PANNONIAN | 45 | 164 | 2400 ± 131 | 2365 |
| MIOCENE | 21 | 42 | 2430 ± 163 | 2440 |
| OLIGOCENE | 12 | 47 | 2440 ± 70 | 2460 |
| CRETACEOUS | 16 | 96 | 2460 ± 74 | 2460 |
| ARGILLACEOUS MARL | 114 | 921 | 2500 ± 128 | 2520 |
| UPPER PANNONIAN | 39 | 184 | 2410 ± 104 | 2410 |
| LOWER PANNONIAN | 46 | 371 | 2530 ± 121 | 2560 |
| EOCENE | 17 | 50 | 2480 ± 113 | 2510 |
| CRETACEOUS | 14 | 75 | 2530 ± 103 | 2520 |
| TRIASSIC | 8 | 74 | 2630 ± 57 | 2630 |
| SHALE | 22 | 169 | 2680 ± 85 | 2710 |
| ALEURITE | 56 | 484 | 2510 ± 129 | 2510 |
| UPPER PANNONIAN | 21 | 217 | 2430 ± 101 | 2450 |
| LOWER PANNONIAN | 19 | 118 | 2560 ± 88 | 2580 |
| TRIASSIC | 3 | 42 | 2680 ± 59 | 2705 |
| ALEUROLITE | 20 | 161 | 2620 ± 81 | 2640 |
| ANDESITE | 31 | 324 | 2480 ± 217 | 2540 |
| BASALT | 13 | 54 | 2800 ± 132 | 2840 |
| BRECCIA | 28 | 97 | 2580 ± 147 | 2610 |
| MICA-SCHIST | 13 | 30 | 2680 ± 162 | 2710 |
| DIABASE | 16 | 71 | 2700 ± 116 | 2730 |
| DOLOMITE | 57 | 692 | 2700 ± 92 | 2720 |
| PHILLITE | 11 | 88 | 2690 ± 78 | 2710 |
| GNEISS | 13 | 29 | 2730 ± 298 | 2690 |
| GRANODIORITE | 1 | 32 | 2640 ± 36 | 2645 |
| GRANITE | 13 | 288 | 2650 ± 72 | 2640 |
| SANDSTONE | 148 | 114 | 2550 ± 131 | 2600 |
| UPPER PANNONIAN | 36 | 239 | 2350 ± 128 | 2340 |
| LOWER PANNONIAN | 38 | 463 | 2480 ± 110 | 2490 |
| MIOCENE | 41 | 260 | 2450 ± 122 | 2470 |
| TRIASSIC | 11 | 186 | 2640 ± 68 | 2650 |
| PERM | 24 | 404 | 2630 ± 49 | 2630 |
| CONGLOMERATE | 57 | 256 | 2480 ± 138 | 2530 |
| LOWER PANNONIAN | 7 | 81 | 2350 ± 126 | 2320 |
| PALEOZOIC | 11 | 92 | 2580 ± 46 | 2580 |
| QUARTZITE | 16 | 31 | 2640 ± 55 | 2650 |
| QUARTZPORPHYRY | 9 | 59 | 2630 ± 48 | 2630 |
| MARL | 92 | 620 | 2540 ± 95 | 2550 |
| LIMESTONE | 116 | 084 | 2570 ± 130 | 2620 |
| MIOCENE | 29 | 231 | 2370 ± 190 | 2400 |
| EOCENE | 23 | 431 | 2520 ± 95 | 2540 |
| CRETACEOUS | 37 | 544 | 2620 ± 67 | 2640 |
| TRIASSIC | 41 | 518 | 2630 ± 59 | 2640 |
| PALEOZOIC | 6 | 71 | 2600 ± 116 | 2640 |
| LIMEY MARL | 71 | 390 | 2580 ± 124 | 2620 |
| LOWER PANNONIAN | 21 | 60 | 2550 ± 97 | 2575 |
| CRETACEOUS | 13 | 51 | 2550 ± 117 | 2590 |
| JURASSIC | 2 | 50 | 2670 ± 52 | 2670 |
| TRIASSIC | 15 | 127 | 2630 ± 40 | 2630 |
| CALCIFEROUS SHALE | 3 | 29 | 2690 ± 22 | 2700 |
| TUFF | 68 | 309 | 2280 ± 202 | 2300 |
| MIOCENE | 24 | 122 | 2310 ± 133 | 2305 |

*Table II.* Summary of laboratory density data according to their geological formation
*II. táblázat.* A laboratóriumi sűrűség adatok földtani képződmény szerinti megoszlása

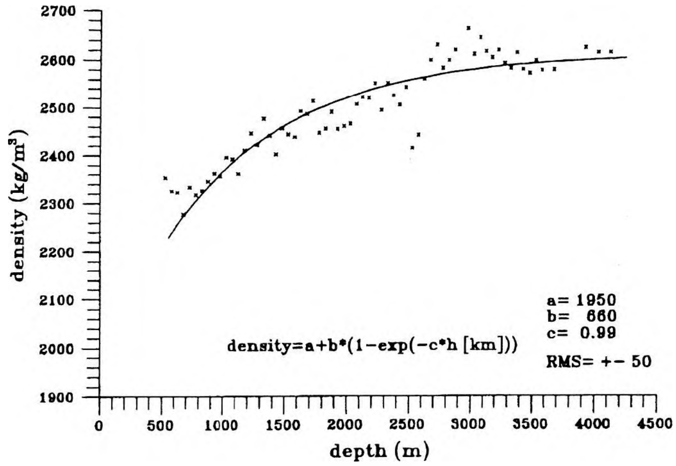

*Fig. 7.* Combined density function of Pannonian sediments
*7. ábra.* Pannóniai képződmények sűrűségfüggvénye

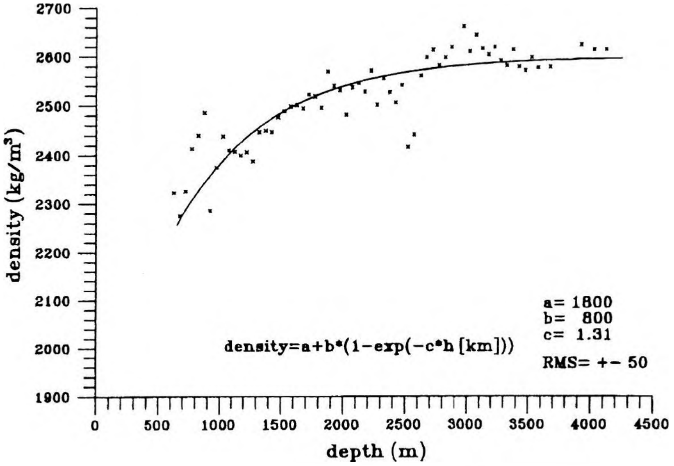

*Fig. 8.* Density function of Lower Pannonian sediments
*8. ábra.* Alsópannóniai képződmények sűrűségfüggvénye

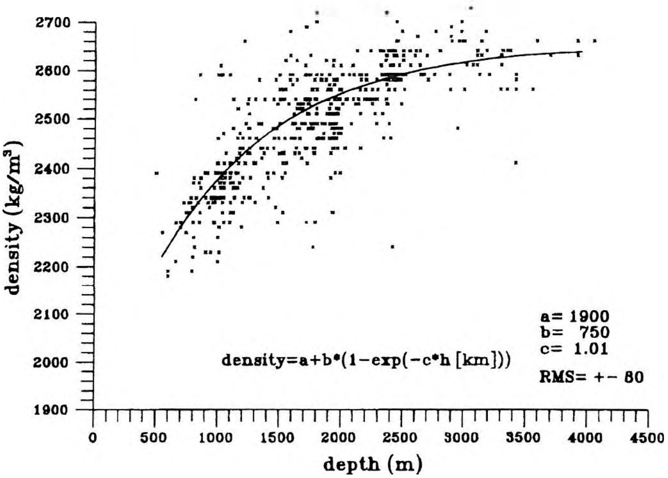

*Fig. 9.* Density function of Pannonian clays

*9. ábra.* Pannóniai agyagok sűrűségfüggvénye

For regional studies we present the densities of the whole Tertiary sequence in one diagram (*Fig. 10*) without taking into consideration the actual ages.

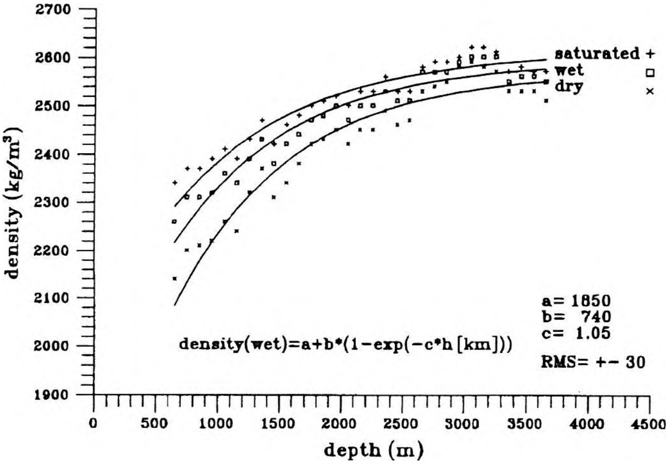

*Fig. 10.* Density function of Tertiary sediments

*10. ábra.* Harmadidőszaki képződmények sűrűségfüggvénye

## 3. Well-log data

The advantage of density values obtained from gamma-gamma logs over the laboratory data is that in the case of the latter, the samples are removed from their natural environment but the well-log data represent the 'in situ' parameters of the rocks. Preliminary assessment has proved that in Hungary only the well-log data taken after 1980 are of sufficiently high quality for accurate density determination. 69 boreholes were at our disposal to carry out the investigations; the total length of the logs was 145000 m; the depth of the bore-hole varied from 330–4780 m; the original sampling rate of the logs was 20 cm. For the evaluation we averaged the density data for 100 m intervals and represented them as a function of depth, separating them according to age. The different age groups could be separated further in accordance with the characteristics of their curve. The Upper Pannonian sediments (*Fig. 11*) could be separated into two groups, viz. the Hegyfalu type (*Fig. 12*) and the Pálmonostora type (*Fig. 13*). The locations of the different types are represented in *Fig. 14*.

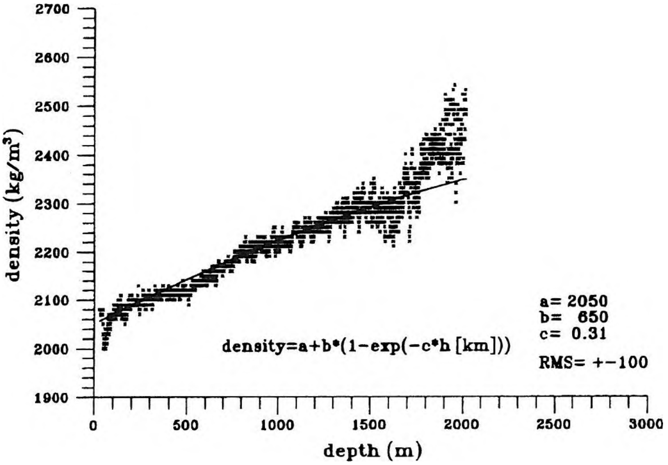

*Fig. 11.* Combined density function of Upper Pannonian sediments
*11. ábra.* Felsőpannóniai képződmények egyesített sűrűségfüggvénye

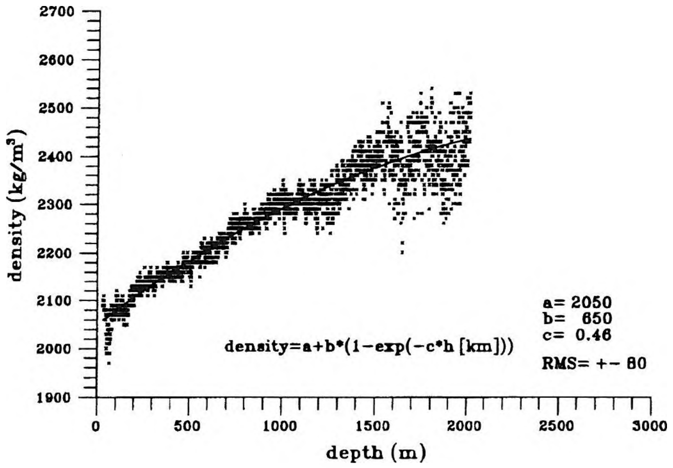

*Fig. 12.* Density function of Hegyfalu-type Upper Pannonian sediments
*12. ábra.* Hegyfalu típusú felsőpannóniai képződmények sűrűségfüggvénye

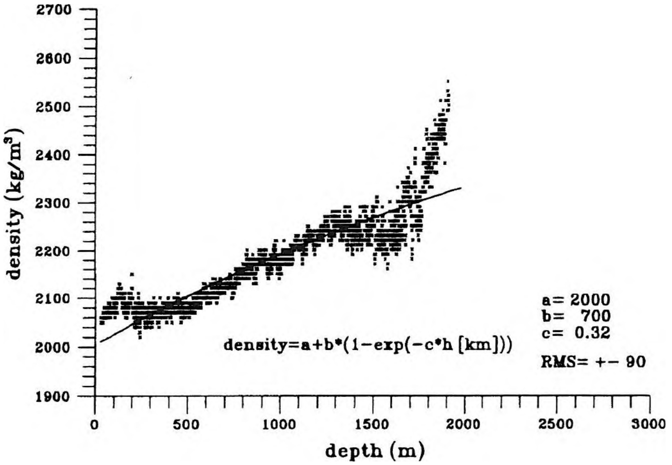

*Fig. 13.* Density function of Pálmonostora-type Upper Pannonian sediments
*13. ábra.* Pálmonostora típusú felsőpannóniai képződmények sűrűségfüggvénye

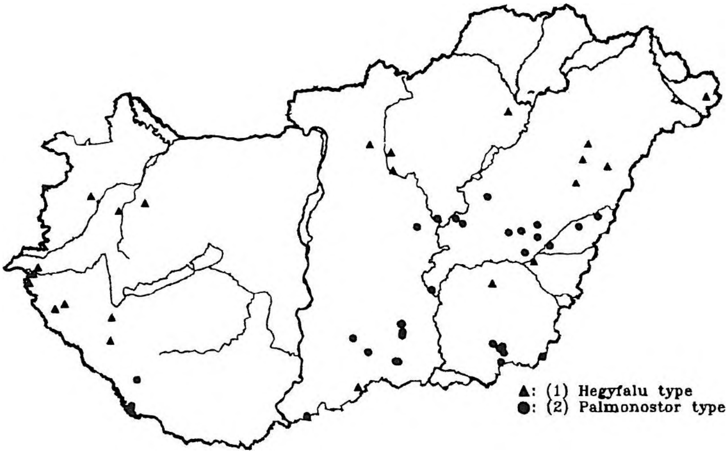

*Fig. 14.* Location map of Upper Pannonian sediments of different types

*14. ábra.* A különböző típusú felsőpannóniai képződmények eloszlási térképe

The Lower Pannonian sediments (*Fig. 15*) form three different types: Hegyfalu (*Fig. 16*), Pálmonostora (*Fig. 17*), and Kondoros (*Fig. 18*). *Figure 19* shows the location of these sediments.

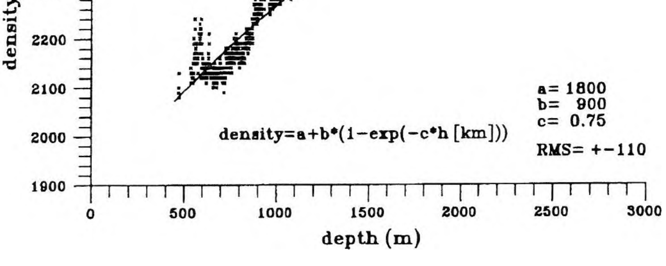

*Fig. 15.* Combined density function of Lower Pannonian sediments

*15. ábra.* Alsópannóniai képződmények egyesített sűrűségfüggvénye

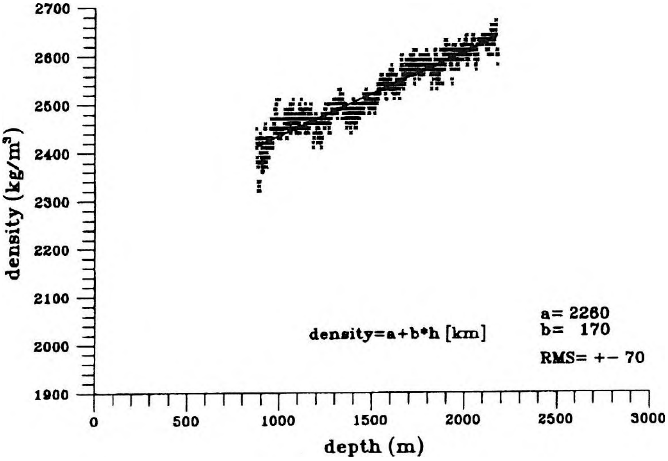

*Fig. 16.* Density function of Hegyfalu-type Lower Pannonian sediments
*16. ábra.* Hegyfalu típusú alsópannóniai képződmények sűrűségfüggvénye

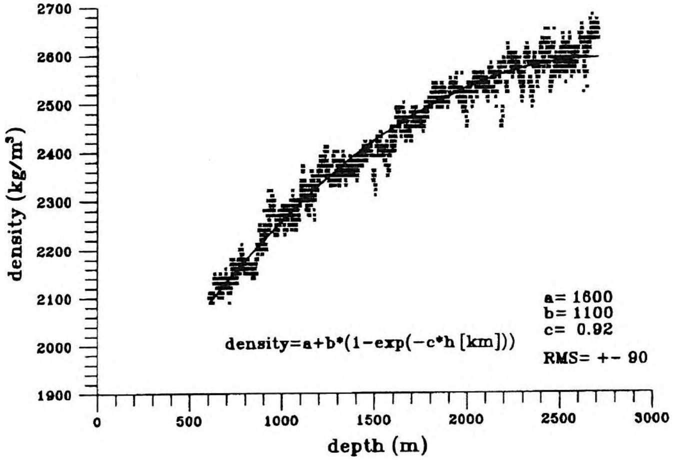

*Fig. 17.* Density function of Pálmonostora-type Lower Pannonian sediments
*17. ábra.* Pálmonostora típusú alsópannóniai képződmények sűrűségfüggvénye

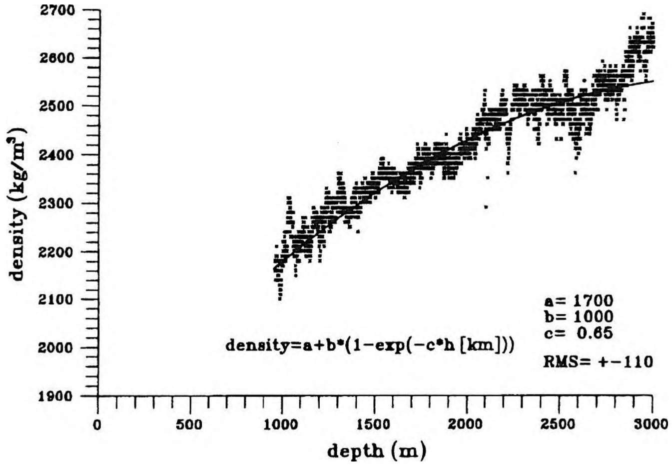

*Fig. 18.* Density function of Kondoros-type Lower Pannonian sediments
*18. ábra.* Kondoros típusú alsópannóniai képződmények sűrűségfüggvénye

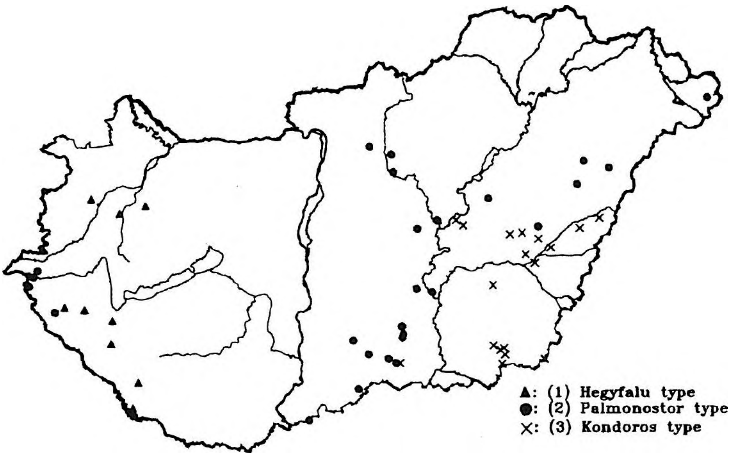

*Fig. 19.* Location map of Lower Pannonian sediments of different types
*19. ábra.* A különböző típusú alsópannóniai képződmények eloszlási térképe

Similar to the laboratory data we have prepared one diagram for the whole Tertiary sequence as well. (*Fig. 20*). Based on the characteristics of the curves we could separate the Tertiary curves into two groups: one of them is typical for the Great Hungarian Plain (*Fig. 21*), the other is typical for Transdanubia (*Fig. 22*). The second one has higher density values, indicating a possible post-Pannonian erosion which removed the least consolidated upper parts of the Pannonian layers. A summary is given in *Table III* of the laboratory and well-log data for the Tertiary sequence.

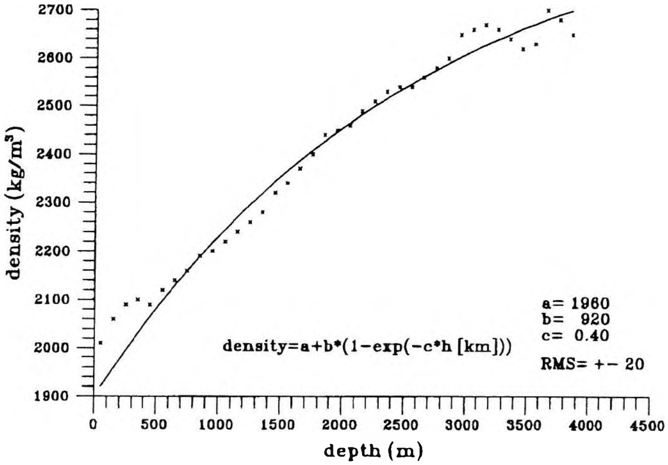

*Fig. 20.* Combined density function of Tertiary sediments
*20. ábra.* Harmadidőszaki képződmények egyesített sűrűségfüggvénye

For gravity interpretation the density of the basement is of great significance because all the model calculations based on density differences are carried out with reference to the basement. *Figure 23* presents the histograms of the density of the rocks forming the pre-Austrian basement. The laboratory measurements yielded 2640 kg/m$^3$ as the average density for the basement while the well-log data provided 2690 kg/m$^3$. The two values are very similar, their average is in good agreement with the internationally accepted value of 2670 kg/m$^3$. The higher value obtained from well-log data can be explained by the high hydrostatic pressure (25–100 MPa) pre-

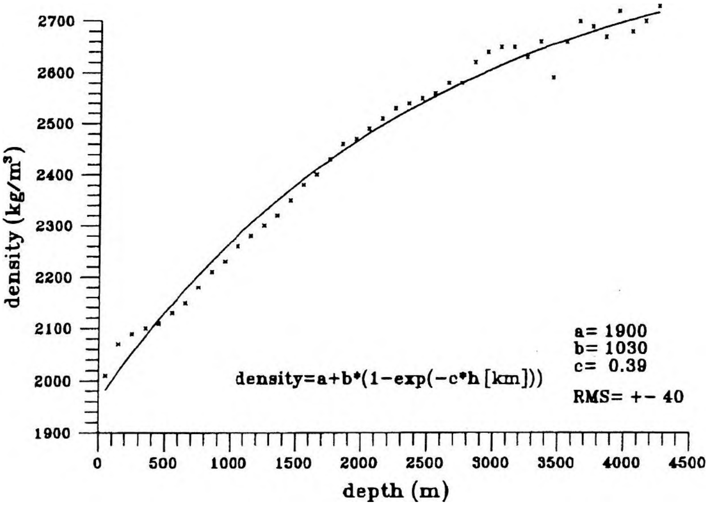

*Fig. 21.* Density function of Tertiary sediments of the Great Hungarian Plain
*21. ábra.* A Nagyalföld harmadidőszaki képződményeinek sűrűségfüggvénye

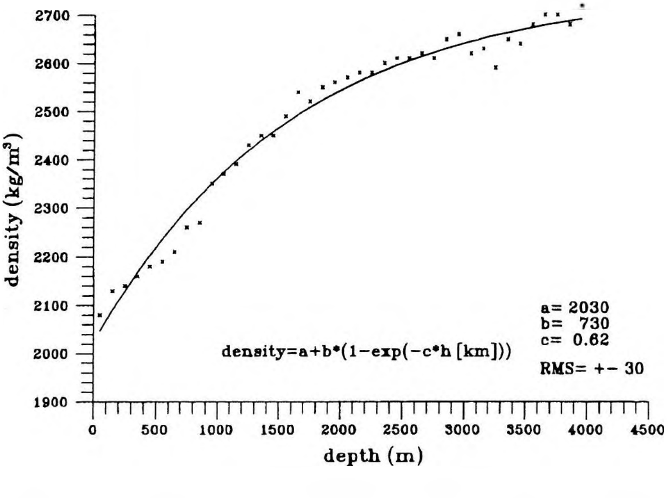

*Fig. 22.* Density function of Tertiary sediments of Transdanubia
*22. ábra.* A Dunántúl harmadidőszaki képződményeinek sűrűségfüggvénye

| | **Measured in lab.**<br>**wet** | **Measured in lab.**<br>**saturated** | **Well-logging**<br>γ-γ |
|---|---|---|---|
| depth (m) | density (kg/m$^3$) | density (kg/m$^3$) | density (kg/m$^3$) |
| 0 – 100 | | | 2010 ± 120 (2223)* |
| 100 – 200 | | | 2070 ± 110 (4726) |
| 200 – 300 | | | 2090 ± 110 (5040) |
| 300 – 400 | | | 2100 ± 100 (5182) |
| 400 – 500 | | | 2110 ± 90 (5119) |
| 500 – 600 | 2260 ±190 ( 48)* | 2340 ±150 | 2130 ± 90 (5283) |
| 600 – 700 | 2310 ±180 ( 66) | 2370 ±160 | 2150 ± 90 (5533) |
| 700 – 800 | 2310 ±200 ( 84) | 2370 ±180 | 2180 ± 100 (5560) |
| 800 – 900 | 2320 ±170 ( 98) | 2390 ±140 | 2210 ± 100 (5636) |
| 900 – 1000 | 2360 ±130 (110) | 2410 ±110 | 2230 ± 120 (5709) |
| 1000 – 1100 | 2340 ±170 ( 94) | 2390 ±150 | 2260 ± 130 (5664) |
| 1100 – 1200 | 2390 ±150 ( 99) | 2430 ±130 | 2280 ± 140 (5465) |
| 1200 – 1300 | 2430 ±190 ( 91) | 2470 ±170 | 2300 ± 130 (5362) |
| 1300 – 1400 | 2380 ±150 ( 83) | 2420 ±130 | 2320 ± 130 (5214) |
| 1400 – 1500 | 2420 ±150 ( 85) | 2460 ±130 | 2350 ± 130 (5165) |
| 1500 – 1600 | 2440 ±180 ( 98) | 2480 ±160 | 2380 ± 140 (5039) |
| 1600 – 1700 | 2470 ± 90 (158) | 2500 ± 80 | 2400 ± 150 (4928) |
| 1700 – 1800 | 2480 ±100 ( 93) | 2510 ± 90 | 2430 ± 120 (4659) |
| 1800 – 1900 | 2500 ±120 ( 78) | 2520 ±110 | 2460 ± 110 (4625) |
| 1900 – 2000 | 2470 ±110 ( 69) | 2500 ± 90 | 2470 ± 110 (4151) |
| 2000 – 2100 | 2500 ±110 ( 56) | 2530 ± 90 | 2490 ± 110 (3655) |
| 2100 – 2200 | 2500 ±120 ( 46) | 2530 ±100 | 2510 ± 120 (3455) |
| 2200 – 2300 | 2530 ±140 ( 38) | 2560 ±120 | 2530 ± 100 (3340) |
| 2300 – 2400 | 2510 ±140 ( 36) | 2530 ±130 | 2540 ± 110 (2783) |
| 2400 – 2500 | 2510 ±100 ( 51) | 2530 ± 90 | 2550 ± 130 (2412) |
| 2500 – 2600 | 2570 ± 80 ( 34) | 2580 ± 70 | 2560 ± 100 (2235) |
| 2600 – 2700 | 2570 ±100 ( 31) | 2590 ± 90 | 2580 ± 90 (2239) |
| 2700 – 2800 | 2570 ±140 ( 32) | 2590 ±140 | 2580 ± 90 (1959) |
| 2800 – 2900 | 2590 ±100 ( 15) | 2600 ± 90 | 2620 ± 90 (1635) |
| 2900 – 3000 | 2600 ± 90 ( 13) | 2620 ± 70 | 2640 ± 90 (1149) |
| 3000 – 3100 | 2600 ± 60 ( 26) | 2620 ± 50 | 2650 ± 70 ( 902) |
| 3100 – 3200 | 2600 ± 80 ( 33) | 2610 ± 70 | 2650 ± 60 ( 776) |
| 3200 – 3300 | | | 2630 ± 80 ( 607) |
| 3300 – 3400 | | | 2660 ± 70 ( 509) |
| 3400 – 3500 | | | 2590 ± 120 ( 504) |
| 3500 – 3600 | | | 2660 ± 80 ( 490) |
| 3600 – 3700 | | | 2700 ± 40 ( 400) |
| 3700 – 3800 | | | 2690 ± 60 ( 352) |
| 3800 – 3900 | | | 2670 ± 60 ( 197) |
| 3900 – 4000 | | | 2720 ± 20 ( 100) |
| 4000 – 4100 | | | 2680 ± 30 ( 100) |
| 4100 – 4200 | | | 2700 ± 30 ( 100) |
| 4200 – 4300 | | | 2730 ± 30 ( 100) |

* No of samples

⇦

*Table III.* Density data of Tertiary sediments versus depth. In brackets: number of samples

*III. táblázat.* Harmadidőszaki képződmények sűrűség adatai a mélység függvényében

vailing in the depths in contrast to the normal pressure existing under laboratory conditions.

It is to be hoped that the density information presented in the paper will be useful to all those who are engaged in gravity interpretation.

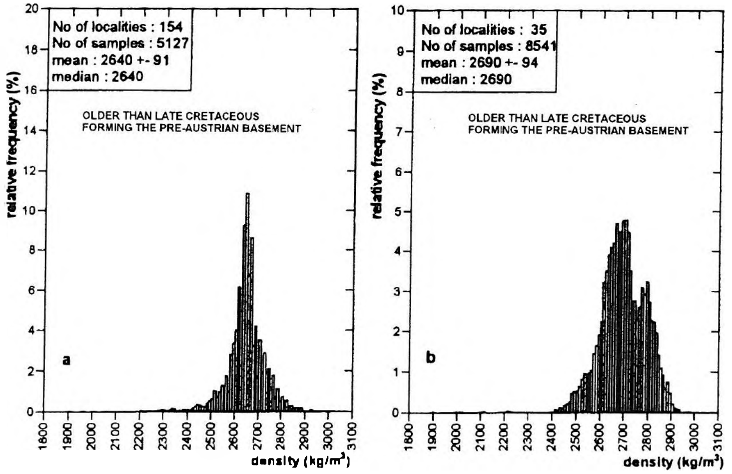

*Fig. 23.* Density histograms of pre-Austrian basement rocks:
a) laboratory data, b) well-log data

*23. ábra.* A preausztriai medencealjzatot alkotó képződmények sűrűség hisztogramjai:
a) laboratóriumi adatok, b) karotázs adatok

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## Kőzetsűrűségek a Pannon medence magyarországi részén

SZABÓ Zoltán és PÁNCSICS Zoltán

A gravitációs kutatások alapvető problémája a kőzetsűrűség. A Bouguer és terrén korrekcióhoz, valamint a gravitációs mérések értelmezéséhez egyaránt megbízható sűrűség adatokra van szükségünk. A szerzők részletes vizsgálatokat végeztek annak érdekében, hogy meghatározzák lehetőleg valamennyi fontosabb a Pannon medencében előforduló geológiai képződmény sűrűségét. A tanulmányt 12 000 db kőzetminta laboratóriumban meghatározott sűrűségadat és 69 mélyfúrás 145 000 folyóméter összhosszúságú gamma-gamma szelvényére alapozták. Az eredményeket hisztogramok, táblázatok és sűrűségfüggvények formájában közlik.

# ABOUT THE AUTHORS

**Zoltán Szabó** graduated as a geophysicist at Eötvös Loránd University, Budapest, in 1955. After graduation he joined ELGI. His main fields of interest are gravity and geomagnetics and their use in structural analysis. Between 1956 and 1959 he carried out torsion balance measurements for oil exploration in China. In the period 1960 to 1963 he took part in the development of the E-60 torsion balance. From 1964 to 1967 he was project manager of mineral exploration in a neovolcanic region (Börzsöny Mts). In 1968–71 he carried out mineral exploration in Nigeria. From 1972 until 1991 he headed the Earth Physics department of ELGI, with the principal tasks of supervising the completion of regional gravity survey of Hungary, compiling a gravity data bank, and dealing with the Tihany Geophysical Observatory, the Geodynamic Station of Mátyáshegy, and the Palaeomagnetic Laboratory. He was the project manager of seismic risk assessment for the site-selection of nuclear installations and low- and intermediate-radioactive waste repositories between 1987 and 1992. Since his retirement he acts as a consultant geophysicist and the curator of the Eötvös Collection.

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