SYSTEM OF OCCURRENCE OF GAS-CONTAINING WATERS OF ARTESIAN WELLS ACCORDING TO REGION AND DEPTH IN THE SOUTHERN PART OF THE HUNGARIAN BASIN

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In the Hungarian basin there are many artesian wells, and water-prospecting and test drillings of low or medium depth, which produce gases of various compositions together with the water. These cause technological problems during the production and utilization of the water, while there is a danger of explosion in the case of combustible gases. Attention was directed to the problems of gas-containing water wells by these practical difficulties, by a number of accidents, by the lack of a solution to certain scientific questions connected with the gases coming to the surface together with the water, and by the possibility of utilizing in hydrocarbon prospecting the consequences to be drawn from the results of the investigations.

The question of the origin of the gases is still unclarified. It is not decided whether these are marsh gases partially or completely of biogenous origin, or whether they are natural gases formed in the deeper layers of the Hungarian Plain, mainly in the inland-sea and lake formations of the Pannonian Age, and dissolved in the layer-water, after permeating upwards by migration. According to the literature, the marsh gas "may be distinguished from fossil hydrocarbon gases in part *on the bas of the conditions of occurrence*, and in part *by establishing the chemical composition*" (KERTAI, 1972, p. 67).

The different authors in general agree that geochemical examinations might give an answer as to the origin, for in young marsh gas, which is a gas mixture of mainly hydrocarbon, carbon dioxide and nitrogen, the only hydrocarbon present is methane (CH_4); in contrast, true natural gas, fossil hydrocarbon gas migrated from older geological formations, contains not only methane, but also higher molecular weight hydrocarbon gases: ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), etc. However, the gas analyses carried out sporadically earlier in the area under study do not give the detailed exact composition as regards the gas components (the combustible gases are uniformly listed as methane), while the low number of more recent and more detailed gas-analytical examinations do not permit the question to be decided on a geochemical basis.

This problem has been touched on by many authors in the course of research into the formation, migration and accumulation of hydrocarbons. The fundamental investigations of DANK (1970), KERTAI (1972), KÖRÖSSY (1971, 1973), TÓTH (1970), HUNT (1968), SHOKHOLOV—CHEREMISINOV (1971), SMITH—ERDMAN—MORRIS (1971) and others consider the question primarily on mineral-oil geological and geochemical bases. SCHMIDT (1939—40, 1940), STEGENA (1972), ERDÉLYI (1973), and most recently BÉLTEKY—KORIM (1974), treat the regional location of the gas-containing wells, and the possibilities of their migrational connec-

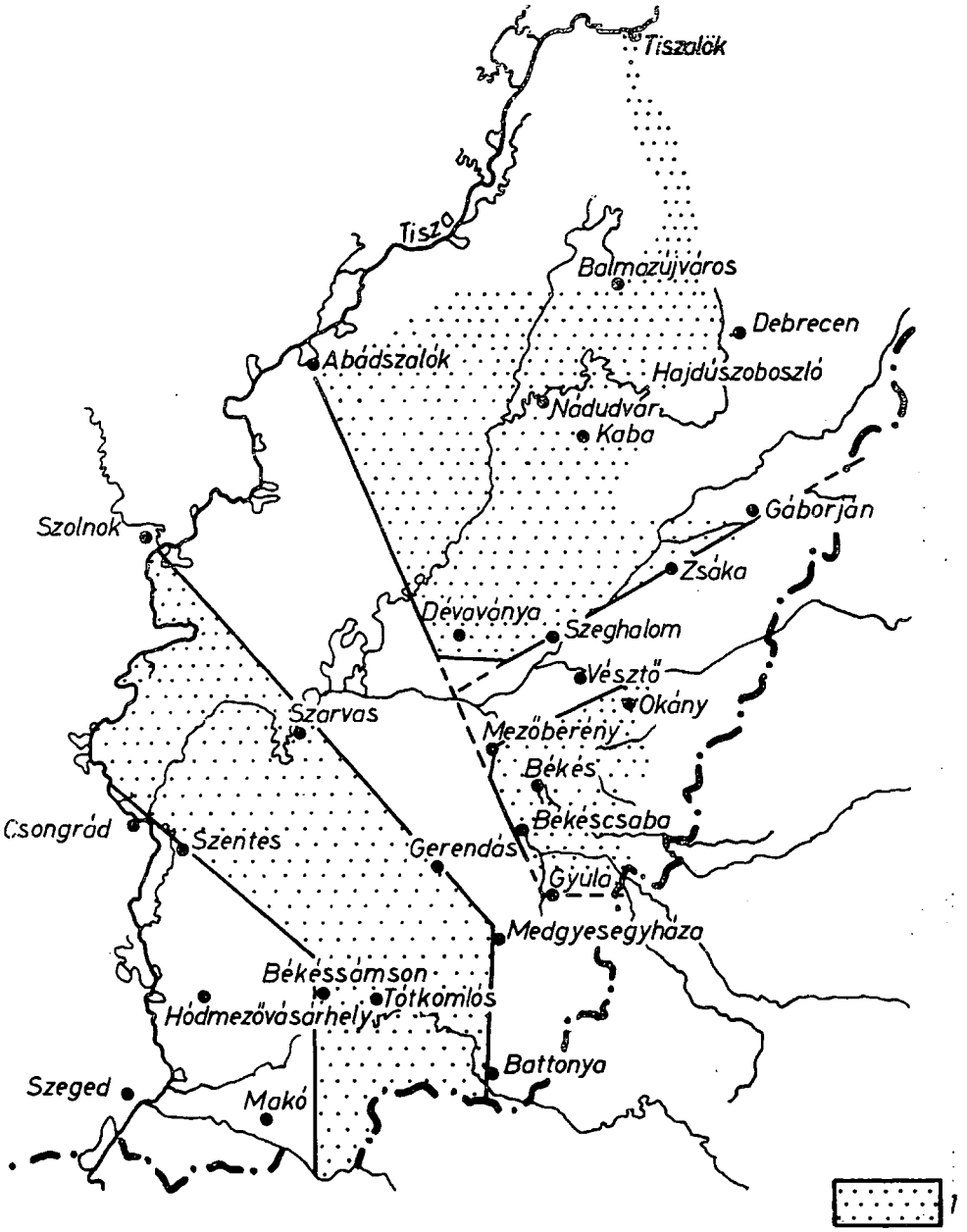

Fig. 1. Natural-gas regions east of the Tisza on the Hungarian Plain (after SCHMIDT, 1940).

tion with the natural-gas sites, mainly in the light of hydrological and hydrogeological aspects.

After a study of several thousand Hungarian artesian wells, as early as 1940 SCHMIDT constructed a map in which he classified practically all of that part of Hungary east of the Tisza as gas-bearing (Map 1). From the fact that the gas-bearing areas on his map form a band 80—100 km wide, lying by and large in the N—S direction, Schmidt came to the conclusion of the existence of a plain fracture-system, which, starting from the valley of the Hernád, cuts across the whole of this area beyond the Tisza in the N—S direction. In his view this rupture-system facilitates the gas migration from the deep-lying gas-storing structures, and upwards from the mother rock; this might have caused the accumulation of gas in the less deep layer-waters. Schmidt also pointed out that there are significant differences in the gas contents of the wells in the various regions and at the various depth levels.

The picture of the regional distribution of the gas-containing wells was added to and made somewhat more accurate by the map of ERDÉLYI (1973) (Map 2). This plots the area of extent of the gas-containing waters originating from the water supplies at depths of 100—400 m as a contiguous region including the major par of the country east of the Tisza, and within this also indicates smaller areas where the wells not so deep as 100 m are gas-bearing. Erdélyi further maps the scatteres gas-yielding wells too.

From a comparison of the maps of Schmidt and Erdélyi with the map illustrating the Hungarian hydrocarbon gas sites BÉLTEKY—KORIM (1974) came to the conclusion that "the not too deep drinking-water wells above the natural-gas fields in the counties east of the Tisza contain gas, while the water of wells drilled to date in low-depth drinking-water levels above the hydrocarbon sites west of the Danube and in the region between the Danube and the Tisza has not been shown to contain gas" (p. 84).

These findings are contradicted by the publication of STEGENA, who subjected the gas from drinking-water wells at depths of 200—300 m (2 in Felgyő and 2 in Csongrád) to gas-chromatographic analysis. He decided that the gas does not originate from the deep-lying hydrocarbon sites, but is formed in biogeneous processes near to the surface.

To promote decisions in connection with the undoubtedly large number of open questions, the present author wishes to contribute with a detailed investigation of the conditions of occurrence of gases coming to the surface with the water of the wells.

In the first phase of the work the area of the South Hungarian Plain was investigated; via the study of the documentation of every water-prospecting drilling made up to the end of 1974, the data of 18,052 water wells were processed. Of these, 2560 proved to contain gas, i.e. 14.17% of the total number of wells. The distribution of the wells on the South Hungarian Plain is very uneven. The average density fluctuates between 0.04 and 4.64 wells per km^2. In our view, therefore, the extent of gasification of the water-yielding layers in a given area may be assessed more realistically from the ratio of the gas-bearing and not gas-bearing wells, rather than from the absolute number of gas-bearing wells there. For example, in the region of Kiskőrös 9 of the 1081 wells contain gas and in the region of Méhkerék 4 of the 11 wells contain gas. 9, of course, is larger than 4, but nevertheless the region of Méhkerék must be considered to bear more gas, for the percentage of affected wells

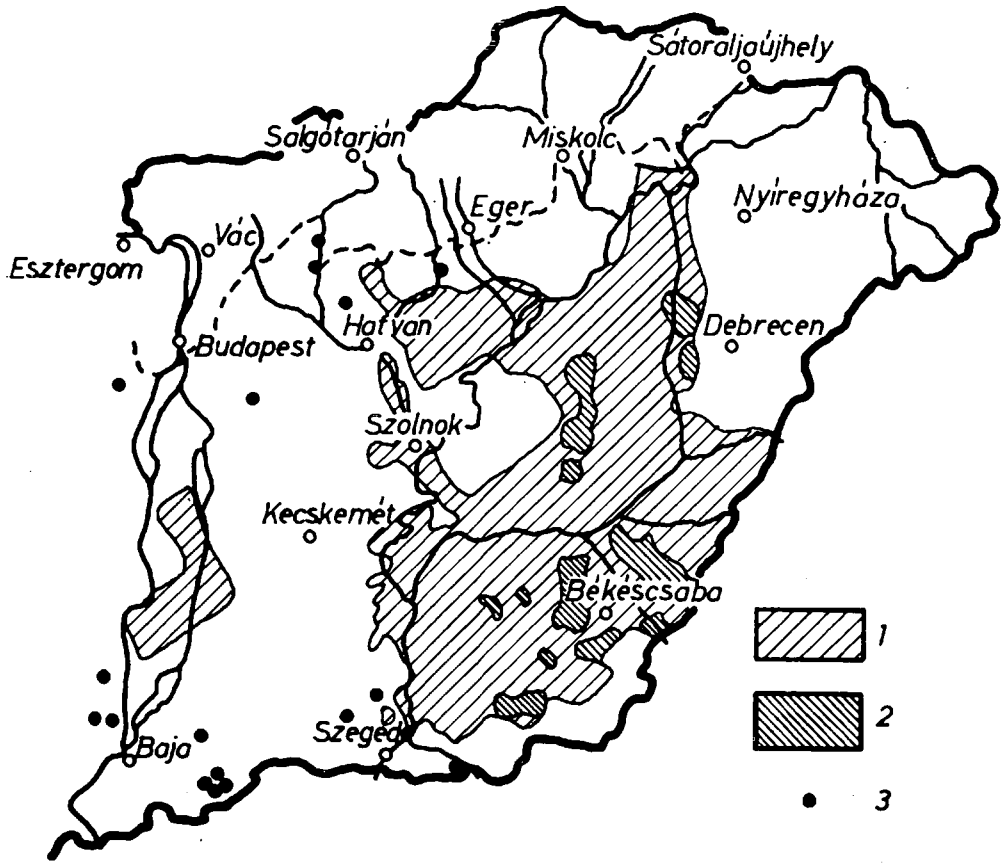

Fig. 2. Gas-containing layer-water wells on the Hungarian Plain (after ERDÉLYI, 1973)
1 = gas-bearing area, where the depth of the water-yielding layer is 100—400 m
2 = area where wells not deeper than 100 m are also gas-bearing
3 = gas-containing layer-water wells outside the gas-bearing area

is 36%, whereas at Kiskőrös it is less than 1%. It is not advisable to draw far-reaching conclusions from these rough percentage values, but it may be accepted that the higher value expresses a higher degree of gasification of the area.

For an analysis of the conditions of occurrence of the gas-containing waters, it is essential to map their geographical extents so as to show the regional differences in the degree of gasification, and the regional characteristics of the relative frequency of the gas-bearing wells in both horizontal and vertical directions. This was achieved by the following method: The administrative districts of the settlements served as the regional units. Every well in the inner and outlying areas of each community was taken into account, and the percentage ratio of the number of gas-bearing wells to the total number was determined. The total area of the community on the map was given a categorizing number in accordance with the percentage value, to express the degree of gasification. But there are some communities where the

total number of controllable wells is only 1—2. The areas of these were considered uncategorizable; they are symbolized on the map by (—), to distinguish them from those districts where the proportion of gas-bearing wells can be evaluated, but is 0%.

Map 3, which shows the regional distribution and proportions of the gas-bearing wells on the South Hungarian Plain, well expresses the regional differences, but it does not permit a vertical evaluation of the gas-containing watery-ielding layers. On the basis of this map, the regions of low-depth, gas-bearing (in all probability marsh gas) wells can not be distinguished from the regions of wells several hundred metres deep and containing gas presumably as a result of the migration of real natural gas. For this reason the above method was applied to determine the proportions of the gas - bearing wells of different depths (0—30 m, 30—200 m, 0—200 m, 200 — 500 m and greater than 500 m) as percentages of the total number of wells at the given levels.

Even in the present stage of the research, the results of our investigations, Maps 3, 4 and 5, and the graphical diagrams showing the distribution by depth of the gas — bearing wells for the individual communities provide an information basis suitable for a more detailed recognition than hitherto of the regional and vertical systems of the gas — bearind wells on the South Hungarian Plain, and for the drawing of certain conclusions.

These maps clearly prove that the rock facies conditions play an important role in the geographical distribution of the gas — containing water — yielding layers of different depths on the South Hungarian Plain. It can thus be explained why there are only scattered gas — containing wells in the area between the Danube and the Tisza, which exhibits a sandy talus structure, why there is virtually no gas at all in the wells ob the Ősmaros grawelly — sandy talus in the district of Kunágota in the south-east, and why gas-containing waters are relatively very frequent in the region of the potamogenous plain east of the Tisza, which is richly endowed with limnic clays and impermeable flood-area mud layers.

Although Map 3 does not completely contradict the earlier-mentioned finding of Bélteky—Korim, it does not support their assumption of the direct connection of the gasification of the water-yielding wells and the natural-gas fields. Our map indicates that above and in the close environment of the most important natural-gas fields the proportion of gas-bearing wells varies between 0 and 25%. In contrast, the highest proportion of gas-bearing wells proves to be found in just those deep-lying parts of the basin to the east of the Tisza in which mineral-oil and natural-gas deposits are not known. For instance, around Földeák and Tiszazug the relative frequency of gas bearing wells is 78%, while in the area enclosed by Öcsöd, Eperjes and Hódmezővásárhely and in the districts of Tarhos and Murony in the region of the Békés depression it is 51—75%.

On the basis of the detailed map processing, the regional distribution of the gas-bearing layer-water wells east of the Tisza does not confirm the linearity along the N—S fracture line assumed by Schmidt, and nor is it in agreement everywhere with the earlier maps. The map of Erdélyi indicates gas-bearing wells not deeper than 100 m on a fairly extensive area to the west of Békéscsaba. Our investigations show that the frequency of gas-bearing wells here with depths of 0—30 m is 0%, and down to 500 m is at most 0—10%. On the other hand, higher values than this were found in the adjacent areas.

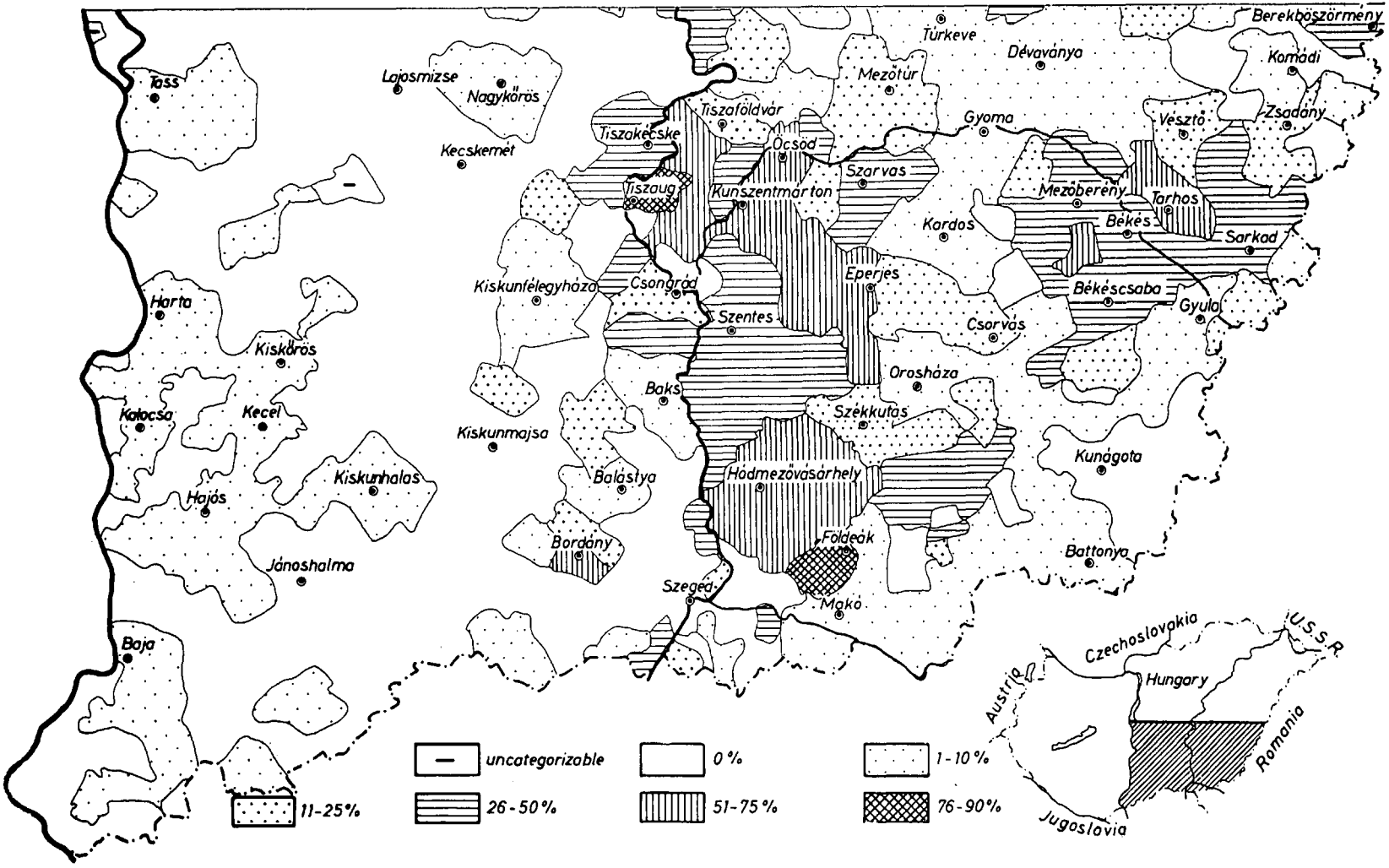

Fig. 3. Proportion of gas-containing layer-water wells on the South Hungarian Plain

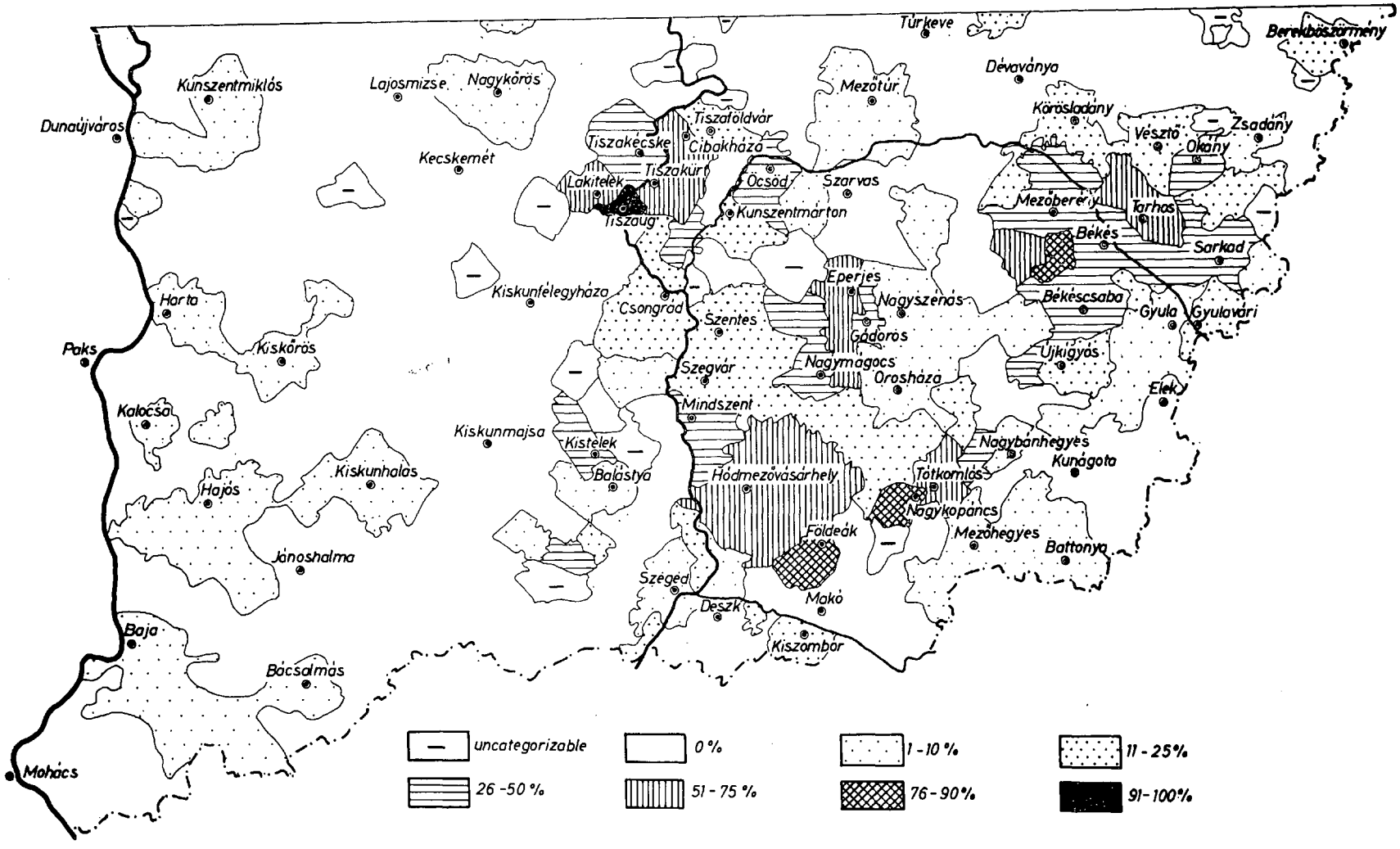

Fig. 4. Proportion of the gas-containing layer-water wells at a depth of 0—200 m

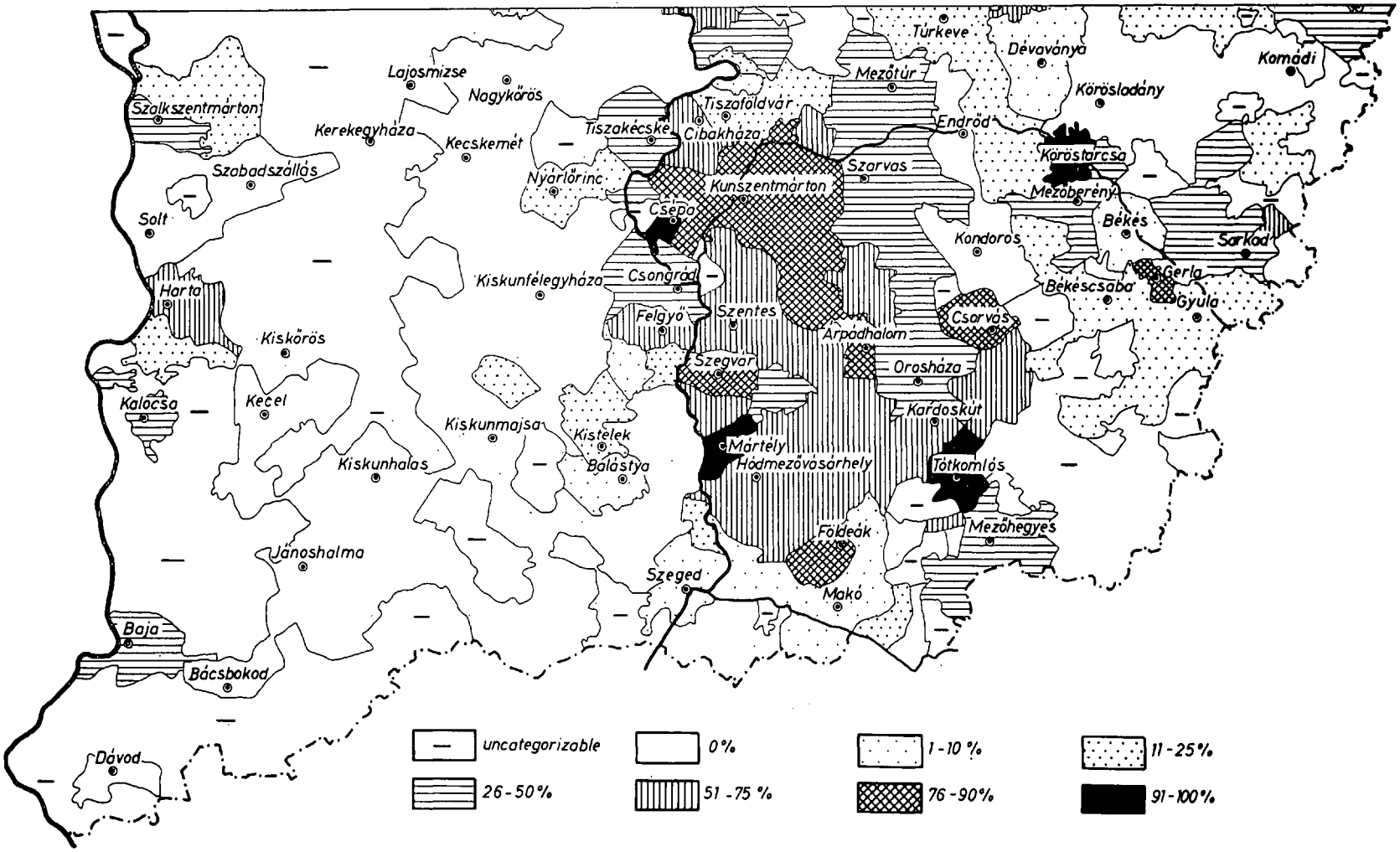

Fig. 5. Proportion of the gas-containing layer-water wells at a depth of 200—500 m

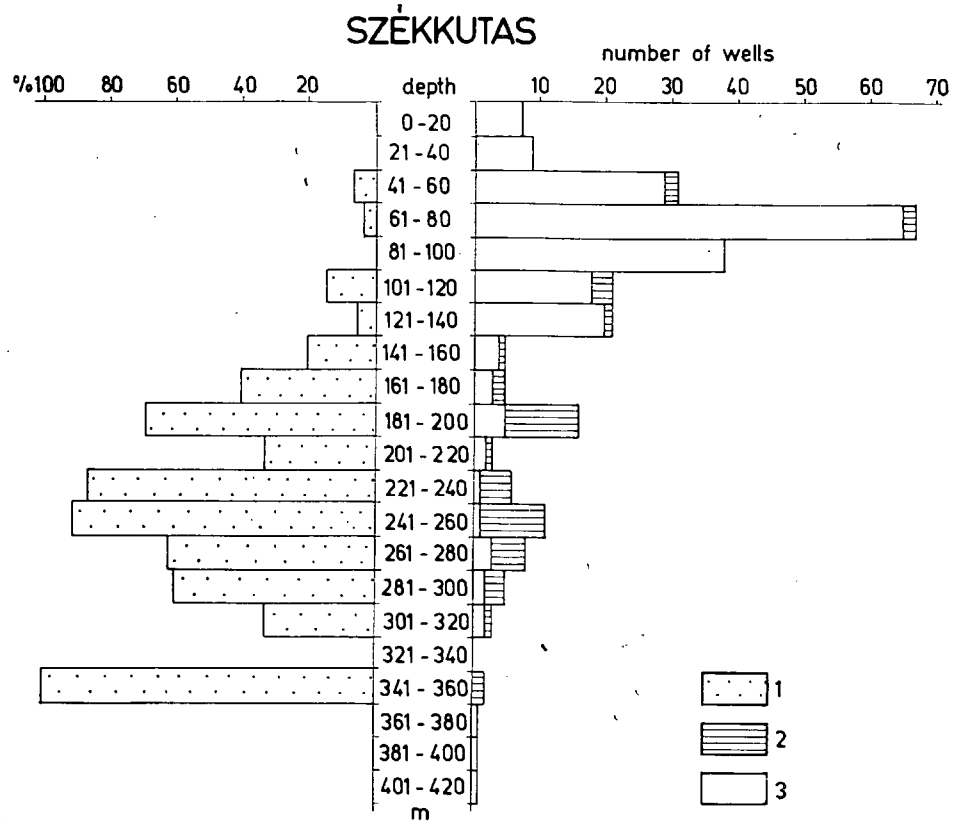

Fig. 6. Distribution by depth of layer-water wells of Székkutas
1 = proportion of gas-bearing wells
2 = gas-bearing wells
3 = not gas-bearing wells

From a comparison of Maps 4 and 5 it can be stated in generality that the proportion of gas-containing water wells on the southern part of the region east of the Tisza increases with the depth. Whereas at the 0—200 m level a value above 75% was obtained in only 4 communities, at 200—500 m the proportion of gas-bearing wells was 76—90% in 15 communities, and 91—100% in 4 communities. Although far fewer evaluable data are available for depths in excess of 500 m, it it appears that the occurrence of gas in the water-yielding wells is ven more general there. (For example, at Szentes 18 out of 20 wells contained gas, at Szarvas 12 out of 17, at Mezőtúr 6 out of 9, at Túrkeve 3 out of 3, at Mindszent and Tiszasziget 3 out of 5, at Békés and Gyula 4 out of 5, and at Fábiánsebestyén 6 out of 6.)

The vertical distribution of the gasification of the water-yielding layers is presented in the included graphical diagrams. The proportion of gas-bearing well increases uniformly downwards, e.g. in the cases of Székkutas and Szegvár (Figs. 6 and 7). Another type is represented by Hódmezővásárhely (Fig. 8), where the extent

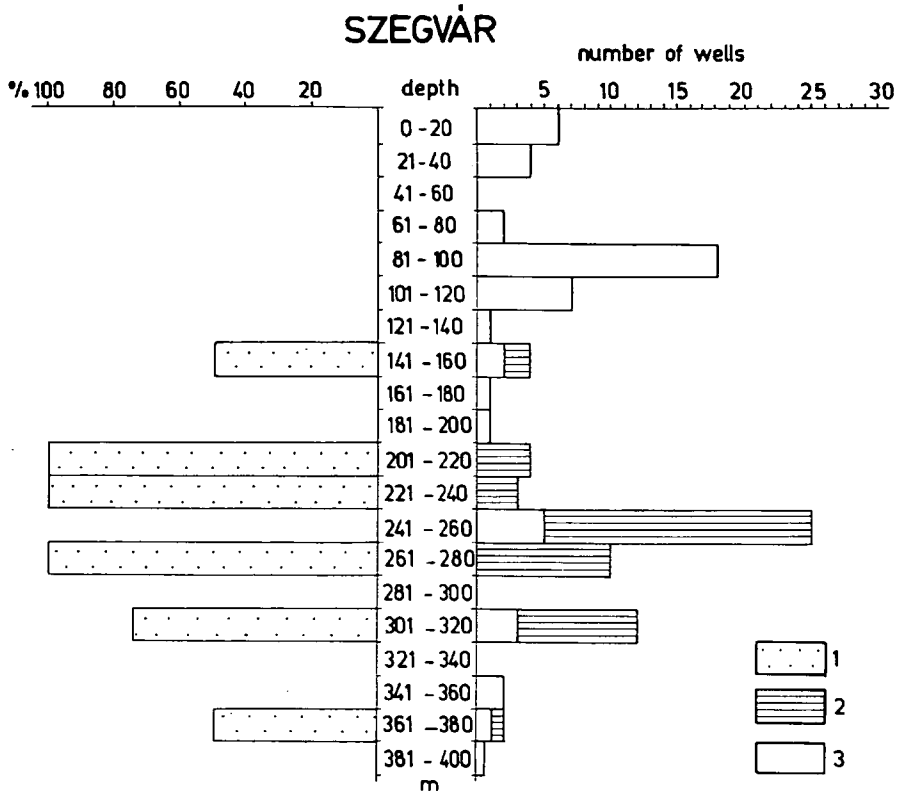

Fig. 7. Distribution by depth of layer-water wells of Szegvár
1 = proportion of gas-bearing wells
2 = gas-bearing wells
3 = not gas-bearing wells

of gasification first increases and then decreases as a function of depth. The proportion of gas-bearing wells barely changes vertically in the case of Tiszakürt, for example (Fig. 9).

There are some cases where only the uppermost water-yielding layers contain gas, gas production occurring only sporadically lower down. An instance of this is Kőrösladány, where the proportion of gas-bearing wells is 22% at 0—30 m, 6% at 30—200 m, and 0% at 200—1000 m. In such cases it is certainly the young marsh gas formed in connection with the processes of decomposition and carbonification of organic substances enclosed in sediments from the end of the Quaternary which comes to the surface with the well water.

A comparative analysis and complex natural graphical evaluation of our maps depicting the regional system of gas-containing water-yielding wells, in relation to geological facies maps, palaeogeographic, geomorphologic and tectonic maps, and maps indicating the chemical character changes and flow conditions of the layer waters is still under way. It is hoped that this work will bring us nearer to the clarifica-

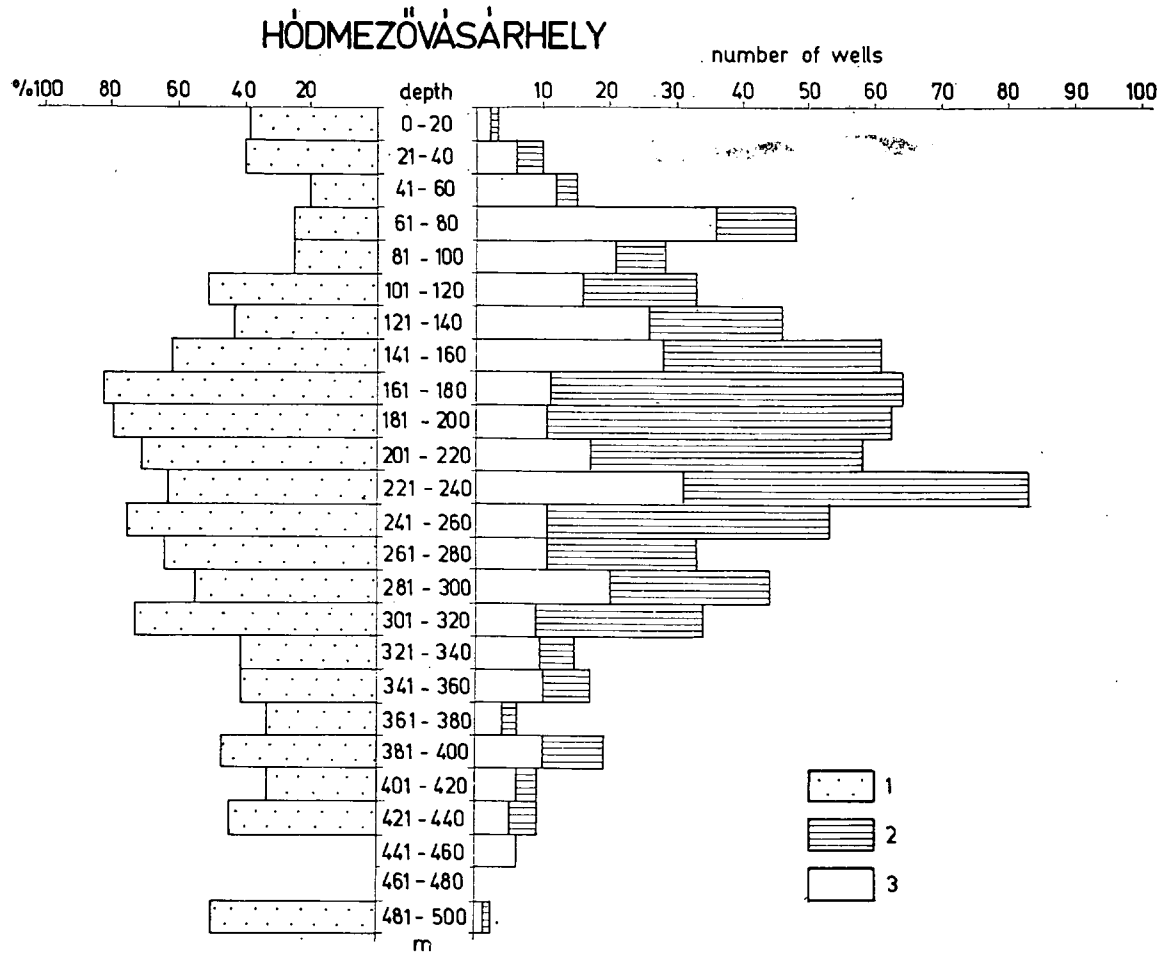

Fig. 8. Distribution by depth of layer-water wells of Hódmezővásárhely
1 = proportion of gas-bearing wells
2 = gas-bearing wells
3 = not gas-bearing wells

tion of questions of the conditions of occurrence of gas-containing waters, and of the origin of the gas. The results to date have encouraged the author to extend his investigations to the entire area of the Great Hungarian Plain.

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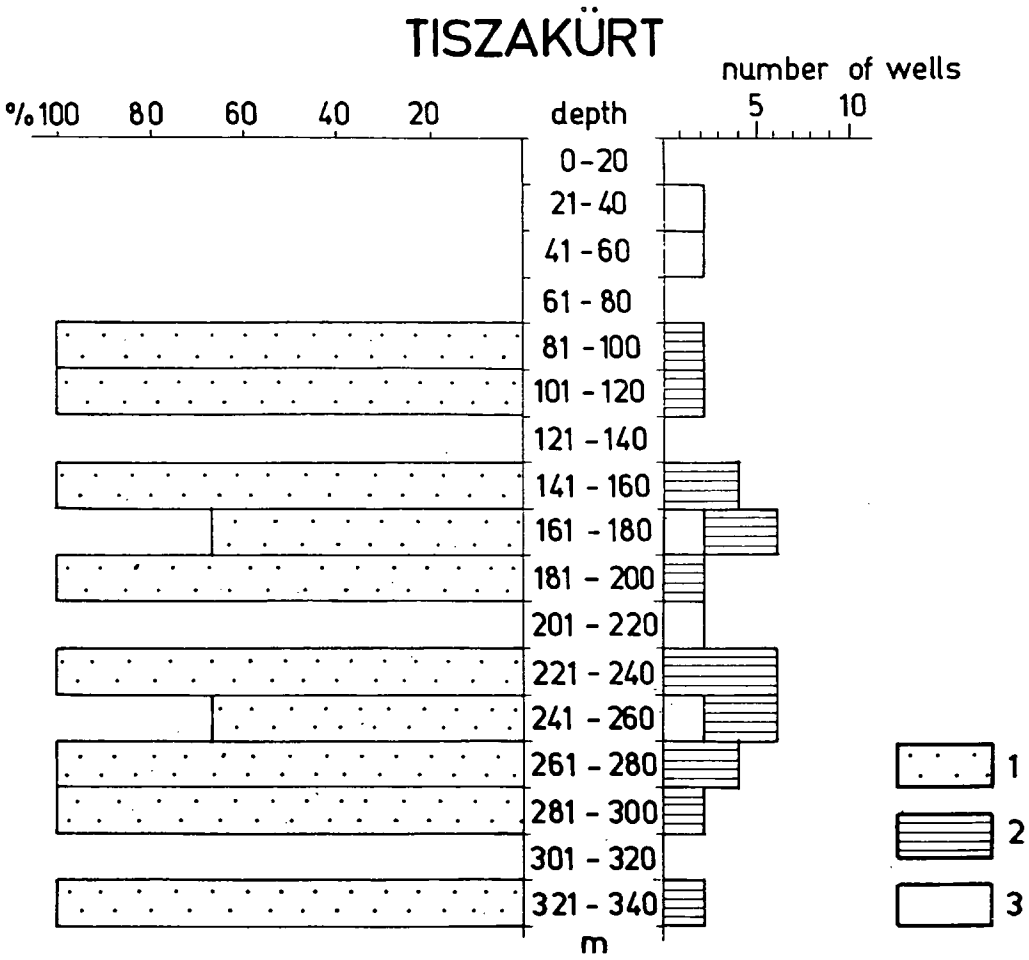

Fig. 9. Distribution by depth of layer-water wells of Tiszakürt
1 = proportion of gas-bearing wells
2 = gas-bearing wells
3 = not gas-bearing wells

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