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Hydrographical Characteristics of the Loess Area near Grabowiec

Гидрографическая характеристика лёссовых районов окрестностей Грабовца

Hydrograficzna charakterystyka lessowego obszaru okolic Grabowca

The area „Działy Grabowieckie" forms one of the largest patches of loess within the Lublin Upland. The Wolica river basin lies in the southern part of this area and is entirely covered with loess. The upper part of the basin has been investigated. Field work was carried out in the form of hydrographical mapping, according to the instructions of the Hydrographical Map of the Polish Academy of Sciences. The method adopted did not allow sufficient accuracy in the recording of many facts, especially in hydrogeology. Interviews with the users, and even with the constructors of wells, usually supply inadequate and not always reliable data on water-bearing materials and the ground-water system. We tried to fill these gaps in our knowledge by creating the densest possible net of measured points.

The basic morphological elements of the Działy Grabowieckie date from the Tertiary Epoch. This old form was later changed by destructive and accumulative processes. The rocks which compose this form were laid in the Upper Cretaceous sea. They are chiefly marls, limey „opoka", and argillaceous limestones of medium resistance. The strata lie nearly horizontally; the area described lies near the axis of the deep Lublin — Lwów Cretaceous syncline. The Cretaceous rocks are strongly fissured at levels nearer to the surface. This has significance for ground water occurrence. Some observations show that it is possible for karst phenomena to develop in some levels of the limestone. The more resistant opoka-limestones are exploited by the country people in cavern-like quarries several metres long (Stara Lipina and Wysokie). No Tertiary rocks were encountered in the area investigated.

Pleistocene deposits are represented mainly by loess and silt deposits similar to loess. Loess is the most important factor of the landscape on account of its universal occurrence and considerable depth. The loess layer in this area is exceptionally compact. Only the bottoms of valleys and some sectors with very steep slopes remain uncovered. Although the aim of the investigations was not to examine the stratigraphy of loess, the material gathered in many profiles allows us to say that the loess layers do not have a homogeneous character. In profiles taken on upper slopes it is usually possible to distinguish an upper layer of loess, light yellow in colour and showing many characteristics of typical loess, several metres in depth; below this are silt deposits like those which Mojski (12) distinguished in a neighbouring area as an older loess. Deposits on the lower extremities of slopes are more difficult to classify. Towards the bottoms of the valleys these deposits are on the whole less and less like typical loess and when a profile is made they appear as a complex of silty loams of various colours and composition with great variation in perpendicular profile.

Besides loess and other silt deposits, boulder clays, sand, boulders, and clayey debris can occasionally be found as slope deposits in a profile. With the exception of these last deposits, the remaining deposits occur in small horizontal patches of inconsiderable depth. Nor does it seem as if they played any great rôle in the formation of water-bearing conditions. The above-mentioned slope deposits occur frequently on inclined surfaces of the Cretaceous bottom. Because only a small portion of these surfaces have been uncovered, a more accurate investigation could not be carried out. They probably cover a large area and reach considerable depths (A. Jahn 4). In the village Stanisławka in a well on a slope, glacial granite boulders were observed under a 4 m layer of rock-waste of Cretaceous age.

The characteristic features of the landscape of this area have been described by Chałubińska and Wilgat (1) and by Jahn (4). Here it is worth recalling some morphological features of the investigated area which have some significance in hydrography. In contrast to other parts of the Lublin Upland the plateaux are not large and form a minute proportion of the whole surface area. The processes of erosion have created a system of valleys, but in spite of comparatively large falls and suitable material a net of recent erosional forms is rare.

Such forms are of medium size. The asymmetry of valley slopes is striking. On the steep eastern and north-eastern sides Cretaceous rocks are usually found uncovered. On the more gently inclining slopes opposite, Cretaceous rocks are to be found at considerable depth under thick layers of more recent deposits. The bottoms of the bigger valleys are flat and usually well watered. In the central and lower part of the Wolica valley an alluvial terrace can be distinguished. At the bottom of the valley this forms peculiar islands and peninsulae.

The highest points in the investigated area reach somewhat more than 300 m above sea level, the floors of the valleys are at a height of about 190 m in the west and correspondingly higher in the east. The bottom of the Wolica valley slopes gently.

Only small sectors of the investigated area are wooded. The majority of the land is under tillage. The slopes of the valleys support a bushy vegetation, and steep inclines in the bigger valleys are used as pastures. The valley floors contain inundation meadows.

The surface water drainage of the area is typical of the Lublin Upland. Streams are few (about 0.2 km/sq km) and relatively scanty. The bottoms of wide valleys are often damp. A characteristic feature of these valleys is the process of filling up and raising the level of the bottom. This is a consequence of the considerable levellings and falls on one side and the nature of the material forming the slopes on the other side. The soil erosion is very distinct. Some examples can illustrate the intensive nature of these processes. In the village of Szorcówka the bottom of a little valley, a tributary of the Wolica valley, has risen at its outlet into the Wolica valley by about one metre during the last 40 years (the lower masonry of a house has vanished below the surface). In Rozdoły some scanty springs have become completely silted up; elsewhere it has been necessary to dig deep ditches to lead off the water. The bottom of a little valley at Wolica Uchańska which was formerly swampy (and was so marked on a map in 1936), is now absolutely dry, without a trace of swampy soil. The constant washing down of material from the slopes and depositing of it on the valley floor causes the formation of a deep layer of only partly permeable deluvia. Because of this, in some sections of the valleys can be observed a marked lack of contact between surface and underground waters. The valley in which the villages of Stara Lipina and Wysokie are situated furnish an example of this. On the valley floor there flows a scanty stream supplied by springs in the upper part of the valley. On the bottom of the central part of the valley the level of water in wells several metres away from the stream lies 12—15 m lower than the valley floor. (There are no wells with a higher level of water). The valley bottom is not damp, and the stream flows in an artificially constructed ditch, disappearing underground after flowing about 4 km, i.e. 3 km before reaching the Wolica valley. In the western area of the Uplands, streams can be seen which are fed by springs of similar outflow (about 1 m 1/sec.), disappearing underground after flowing only a few hundred metres. Several such disappearing streams, fed by springs of higher water levels, have been noted.

There are not many springs in the area, but their uniformity of type and morphological situation is immediately striking. Almost all are supplied by water from fissured layers of Cretaceous rocks. Usually these springs arise at the foot of steep slopes in the bigger valleys, either in a cluster or in a line. In smaller tributary valleys this can be seen very clearly. Thus most of these springs have a western exposure. It is remarkable that the springs do not occur in the upper sectors of the valleys. Sometimes, even, the stream appears near the valley mouth. This can be explained by the theory that springs occur where the level of the valley floor attains the height of the principal level of the Cretaceous waters. In the Wolica valley springs occur at the foot of slopes on both sides. However, they are to be met with more frequently where slopes are steeper and Cretaceous rock occurs on or near the surface.

As a result of these investigations one might presume hydrological data similar to those of the Uplands area to the west of the Wieprz valley, which has been described (Wilgat 13, 14). Both the morphology and geology of the two regions separated by the Wieprz valley are similar. But we were convinced of a marked difference when we began investigating the ground waters. Instead of the expected water of the first level on upper heights, from Cretaceous rocks, in numerous instances water was being used which thoroughly permeated the Pleistocene silt deposits.

It was decided to pay special attention to these levels of ground waters. A weighty argument in favour of this procedure was that the specific hydrogeological situation seemed to depend on the universal occurrence of loess and silt deposits of considerable depth over the area described.

The oldest rocks from which water arose at a useable level in this area are marls, opoka and limestone of the Cretaceous period. Semipermeable but strongly fissured, they form the main reservoir for underground waters. The occurrence of those waters is not radically different from that described in the region to the west of the Wieprz valley. Because the plateau is broken up into small fragments relatively slight in surface it is difficult to see the higher levels of Cretaceous waters to any considerable extent. The lowest level is here to be called the principal level. It can be observed over almost the whole of the area described. Its absolute height depends on the altitude of the bottoms of the bigger valleys; in the east it is something over 200 m above sea level, and in the west drops with the level of the Wolica valley.

It was very difficult to investigate water arising from the Pleistocene deposits. Only a few wells supplied by water arising from sands could confidently be listed among these. During the investigation of waters arising from silt deposits it was not easy to determine from which deposits they came. The users of the water employed folk terminology to designate the rock in which they found their water: „glina" (potter's clay), „ił" (loam) or „mada". The colouring of these deposits ranges from reddish-brown, through light cream to dark grey. The deposit known everywhere as „mada" has characteristics similar to running sands. Fine material saturated with water silts up the wells, making it difficult to use them and often impossible to dig them. Where technical possibilities allow, this layer is penetrated to reach the Cretaceous waters below. Various depths of „mada" are encountered, from less than one metre to more than 20 metres (Grabowiec).

Investigation of the texture and structure of „mada" is complicated. Unfortunately it is impossible to carry out tests which will simultaneously determine the material and structure of „mada". In digging or deepening a well in another way, the structure of the lumps is broken up by the movement of masses of earth sliding down to the opening and causing it to silt up. In a macroscopic examination this material seems very much like loess. An analysis of „mada" from 3 wells while they were being dug gave the following results:

The results of the analysis show marked differences between individual samples, but the silt fraction, characteristic of loess, predominates in all. The differences are understandable because the samples represent different sorts of „mada". It is known that a condition of the transformation of the deposit in a flowing state is on the one hand a silty or fine-sand fraction and lack of stony fragments, while on the other hand there must be a relatively high degree of porosity and per-

Locality	Mechanical composition, fractions in mm					
mm	0,5	0,5—0,1	0,1—0,05	0,05—0,01	0,01—0,001	0,001
kol. Hołużne		4.0%	26.0%	38.0%	30.0%	2.0%
Sady	1,0%	6.0%	7.0%	38.0%	45.0%	3.0%
Rogów		4.0%	10.0%	55.0%	22.0%	2.0%

meability. On the basis of these data it may be concluded that the conditions in the investigated area described above most closely correspond to those of loess. It also seems that typical loess ought to have a greater tendency to become liquid if saturated with water, since typical loesses are the most porous. Slope silt deposits, which are less porous and contain more colloidal particles, ought to behave also as „mada" does, but with slightly different properties, that is, more stability, and less liability to be water-bearing. These theoretical conclusions find support in field observations. The piercing of a layer of „mada" is sometimes possible, sometimes very difficult, and sometimes quite impossible. Other factors may of course come into play, above all the depth of the layer and the technique used in sinking a well. There is also an uncertainty as to why slopes, where thick layers of semi-liquid rock occur, do not show any signs of instability. It seems that instability and the characteristics of quicksands are features of loess saturated with water only when the natural structure of these deposits is disturbed, as for instance when wells are dug. On the one hand, the mechanical process alone is at work; on the other hand, when water is drained out of the pit, this causes movement of water in the direction of the depression which has been made there. Because of this, there is disturbance of the critical saturation value and disturbance of the capillary system which in loess normally allows movement of water only in a vertical direction.

For a better knowledge of the properties of the waters described, an investigation of the kind and the properties of the impermeable strata beneath them would be invaluable. Unfortunately in the majority of cases investigation of these underlying layers was not possible. It would seem that, in a geological profile typical of this region, where directly beneath the loess lies weathered and fissured Cretaceous rock, there is no separate markedly impermeable layer. However, in observing the process of weathering in Cretaceous rock formed of marls, argillaceous limestones and „opoka" it can be seen that when acted upon by the atmosphere this rock is transformed into an argillaceous deposit containing rock fragments. This observation is confirmed in the literature on the subject (K r i e c h b a u m 15 and M o j s k i 12). On the surface of the rock-rubble lying below ground a hard reddish crust sometimes forms, caused by iron compounds saturating the deposit. Most probably in the area investigated the most often encountered impermeable strata are formed of such Cretaceous rock-waste. This does not mean that water occurs everywhere within the rock-waste layer. Here the relief of the surface of the Cretaceous rock and the general hydrographic conditions play a part. Very probably the impermeable strata may also be more clayey strata within the loess layers. Sometimes it is difficult to distinguish the impermeable strata if the fractions and appearance of the material obtained remain unchanged, and water occurs in the profile. It may happen when the water saturating the loess is held there by deposits of the same (loess) origin but with a variant structure. The occurrence of such a water level over a considerable area may be an indication of a certain bipartite nature in the loess in the area investigated.

It is difficult to classify the water occurring on the fringes of silt and Cretaceous deposits. This chiefly concerns water found at the point where the two strata meet. Three different cases may occur:

1. Water in silt deposits is to be found above an impermeable stratum formed as a result of the weathering of Cretaceous rock; a so-called well-reservoir is dug in the rock-waste. Often it is possible where, thanks to the relatively slight permeability of Pleistocene sediments, the flow of water into the wells is slow. When digging, intensive emptying is necessary, while simultaenously deepening the pit and shoring it up with concrete. Sinking the bottom of a well considerably deeper than the water level is a technique universally adopted in silty deposits in order to ensure an adequate store of water. Such wells are supplied exclusively from the Pleistocene aquifer.

2. Water saturates the Pleistocene strata, silt and Cretaceous strata beneath it. Between the silt strata and Cretaceous rock there is no sufficiently impermeable stratum of rock-waste. When digging a well we pierced the silt soaked with water and reached Cretaceous aquifer. The water level in such a well occurs at the depth of the water level in silt deposits. This situation is to be met frequently in drilled wells. In such wells the water originates often both from the Pleistocene and Cretaceous levels.

3. As in the previous case, water saturates the Pleistocene and Cretaceaus strata under it, although they are separated by an impermeable stratum. Sometimes, especially near the bottom of valleys, the Cretaceous waters have the features of sub-artesian waters. When the Pleistocene level has been broken through and cut off, the level of Cretaceous water in the well sometimes rises to the height of the Pleistocene water level. However, the water belongs to the level of the Cretaceous strata.

Analysing the map with the well locations from the point of view of their use, it is hard to find any kind of regularity. Quite independently of the morphology of the terrain, one may encounter wells side by side, of which some use water of silt origin, others use water from the Cretaceous strata. Cretaceous wells are not found on the bottoms of the bigger valleys. We obtain another picture if we map all the points where water was found in silt deposits regardless of whether this water is used or not. The use of water from a given level does not depend only on its abundance. Technical considerations also play a part. In fact scanty supplies of water are sometimes tapped and left unused in silt deposits, while sometimes very abundant supplies are also left unused. Most often use is made difficult by the semi-liquid consistency of the rock silting up the opening. These levels are cut through as far as possible when deep wells going down to the Cretaceous rock are installed.

From a map made in this way (showing all the water levels encountered when sinking wells) it can be observed that the occurrence of ground waters in loess and other silt deposits is virtually universal in the area under investigation. The reasons for the absence of these waters in certain areas ought rather to be sought. A certain regularity can then be perceived. The marked morphological and geological asymmetry of the valleys in this area causes a kind of hydrographical asymmetry. Water is seldom found in silt deposits near steep high slopes. It seems that the absence of this water is linked with the presence of small basins in steep slopes, among other factors. Moreover, the considerable angle of the steep slopes together with their height provides good drainage, both surface and underground. On a high steeply inclined slope Cretaceous rock cannot maintain a corresponding stratum of rock-waste which could continue to act as an impermeable layer.

On the side of the more gentle slope the hydrogeological situation is more complicated. The variation of more recent deposits in a perpendicular profile is large and includes differences in permeability and water-capacity. An additional difficulty in recognizing the water system of the more gentle slopes is the meeting of the water levels in the Pleistocene and Cretaceous rocks. Normally, the underground water level in Cretaceous rocks is almost horizontal. The water level in Pleistocene deposits is to a large extent the same as the surface of impermeable layers lying beneath a saturated layer. Impermeable layers, i.e. the level of rock-waste and the less permeable levels in loess, decline gently from the upper surfaces of the slope towards the valley, in agreement with the main features of the surface morphology. The zone of aeration lying between the water levels in this situation edges away beneath the slope. One may encounter here in the profile several separate water-bearing layers, divided more or less by an impermeable stratum. Sometimes the lower levels have the features of sub-artesian water. It is difficult in such a situation to follow exactly the principal level of the ground waters. The general picture of this level is clear enough, but locally undergoes considerable distortion because of the particular hydrogeological conditions mentioned above. The neighbourhoods of Grabowiec, Świdniki, Szystowice and Ornatowice supply an example of such complications in the ground water system.

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РЕЗЮМЕ

Рассматриваемый район охватывает верховья бассейна реки Волицы и находится полностью в пределах сомкутого лёссового пласта так называемых Дзялов Грабовецких. Сеть поверхностных вод в этом районе очень скудная (0,2 км/км²). Потоки обычно ничтожные, текут по плоским заболоченным днам. Наблюдается значительное усиление денудационных процессов на склонах и связанный с ним процесс постоянного повышения пойм.

В исследованном районе констатировано наличие нескольких потоков, которые начинаются ключами, вытекающими из более высоких водоносных горизонтов меловых отложений, и которые исчезают в своих долинах, не достигая главных долин. В исследованном районе количество ключей невелико. Они находятся главным образом у подошвы крутых склонов долин, часто группами или в виде линейнего выплыва. Ключи питаются почти исключительно водами меловых горизонтов.

Главным бассейном подземных вод является трещиноватая меловая горная порода. Грунтовые воды здесь не имеют одного сплошного горизонта; можно выделить несколько водных горизонтов, залегающих друг над другом. Простирание высших горизонтов ограничено из-за сильно расчлененного рельефа местностей и небольших приводораздельных пространств. Самый нижний горизонт залегает сплошь почти по всему исследованному району. Его высота определяется абсолютными высотами местных, более значительных речных долин.

Особенной чертой района является повсеместное залегание грунтовых вод в пылеватых плейстоценовых отложениях — в лёссах и лёссовидных суглинках. Воды удерживаются непроницаемыми слоями, образововшимися из выветрившихся иловатых меловых горных пород, подстилающих лёссы или же, иногда, на оглиненных средилёссовых слоях. Смесь этих вод с пылью дает в итоге жидкую массу и поэтому воды этих горизонтов не охотно используются местным населением.

Морфологическая асимметрия долин и асимметричное размещение пылеватых отложений ведет к своего рода гидрографической

асимметри. У крутых склонов используются почти исключительно воды меловых водоносных горизонтов, чаще всего из самых нижних горизонтов. Со стороны пологих склонов картина становится более сложной. Здесь находится иногда несколько горизонтов вод расположенных почти непосредственно друг над другом. Это явление вызвано непараллельным залеганием меловых водных горизонтов, почти горизонтальных по отношению к плейстоценовым горизонтам вод, согласных топографической поверхности. Таким образом меловые и плейстоценовые горизонты вод тесно смыкаются на пологих склонах долин, разделены лишь изолирующими слоями горных пород.

STRESZCZENIE

Badany obszar obejmuje górną część dorzecza Wolicy i leży całkowicie w obrębie zwartego płata lessowego Działów Grabowieckich. Sieć wód powierzchniowych na tym obszarze jest uboga (0,2 km/km^2). Strugi wodne są naogół nikłe i płyną w głęboko wciętych, a przy tym szerokich dolinach o płaskich a często i podmokłych dnach. Obserwuje się duże nasilenie procesów denudacyjnych na zboczach i związane z nimi zjawisko stałego podwyższania den dolinnych.

Stwierdzono na badanym obszarze istnienie kilku strug, które biorą swój początek w źródłach pozostających w związku z wyższymi poziomami wód zalegających wśród skał kredowych, a które to strugi zanikają w obrębie swoich dolin jeszcze przed osiągnięciem doliny głównej. Na tym obszarze źródła nie występują zbyt często. Pojawiają się one głównie w pobliżu den dolinnych u stóp stromych zboczy — albo grupowo albo w postaci linijnego wypływu. Źródła zasilane są prawie wyłącznie z poziomów kredowych.

Główny zbiornik wód podziemnych stanowią skały wieku kredowego. Wody te nie tworzą jednego i jednolitego poziomu, lecz można wyróżnić kilka horyzontów wodnych, zalegających piętrowo nad sobą. Rozciągłość wyższych poziomów wodnych jest przestrzennie ograniczona ze względu na silne rozcięcie terenu i niewielkie powierzchnie spłaszczeń wierzchowinowych. Natomiast najniższy poziom wodonośny daje się zauważyć prawie na całym interesującym nas obszarze. Jest on uzależniony od wysokości bezwzględnych, na których leżą dna większych dolin.

Do szczególnych cech badanego obszaru należy powszechne występowanie wód gruntowych w obrębie plejstoceńskich utworów pyłowych — mianowicie w obrębie lessów i utworów zbliżonych swoim

charakterem do lessów. Wody gromadzą się na nieprzepuszczalnej warstwie, stanowiącej ilastą zwietrzelinę skały kredowej, a niekiedy śródlessowe poziomy zglinnienia. Wody z takich poziomów wykorzystywane są niechętnie przez ludność z tego względu, że utwory pyłowe prowadzące wodę posiadają właściwości zbliżone do kurzawki.

Morfologiczna asymetria dolin oraz asymetryczne rozmieszczenie utworów pyłowych w obrębie form dolinnych powoduje także pewnego rodzaju asymetrię hydrograficzną. Po stronie zboczy stromych wykorzystywane są prawie wyłącznie wody pochodzące z poziomów kredowych i to najczęściej wody najniższego poziomu. Po stronie łagodnych zboczy sytuacje są bardziej skomplikowane. Na tych zboczach występuje niekiedy kilka poziomów wód, zalegających prawie bezpośrednio jedne nad drugimi. Zjawisko to jest wywołane nierównoległością poziomów wód kredowych (zalegających niemal horyzontalnie) w stosunku do poziomów wodnych w obrębie utworów plejstoceńskich, które przebiegają współkształtnie z powierzchniami topograficznymi. Ta nierównoległość obu grup poziomów wodonośnych sprawia, że warstwa napowietrzona pomiędzy horyzontami wód w skałach plejstoceńskich a horyzontami wodnymi w obrębie skał kredowych — wyklinowuje się w kierunku dolin, i wody różnych poziomów skalnych oddzielone są od siebie tylko warstwami izolującymi.

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Fig. 1. The distribution of wells supplied by different levels of ground-water in the environs of Grabowiec