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The Explanation of Artesian Wells.

Most of us have at one time or another seen a true artesian well, that is a well where the water naturally rises above the surface of the ground. To those who are of an inquiring mind the question then arises: why does the water do this? To most people "artesian" is synonomous with "deep" and this leads to erronious ideas. If we make inquiries as to flowing wells we will find that they are in truth often quite shallow. Hundreds in this state are less than a hundred feet deep. We must conclude then, that depth has little to do with the cause of the flow. If we look further, ~~however,~~ we will find that artesian wells are always found in comparatively low ground, in valley bottoms for instance. In Wisconsin they are also found in the lowlands adjacent to the Great Lakes. Let us next examine the kind of ground passed through in sinking flowing wells. If we do this, we will discover that they derive their supply from some comparatively porous material, sand, gravel, sandstone, or broken and creviced rock, but rarely, if ever from a stream flowing in an open cavern or cavern. In nearly every instance this water-bearing stratum is found beneath some less pervious material such as clay, shale, or dense rock. It is the depth to this water-carrying layer, then, which determines the distance it is necessary to go to secure a flow, but depth alone has nothing to do with the heights to which the water will rise.

Let us next examine the relative heights to which water will rise in the wells of a region, whether or not they flow. We will find that in nearly every instance the water in wells situated on high ground stands higher than it does near or in the valleys. This is due to the outward seeping of the water derived from rain, from beneath the hills to the low ground and is to a large

extent independent of the kind of material which lies beneath the surface. Much water often escapes into the valleys from springs, but at other places the valley bottom is filled with clay so that the water is trapped beneath under pressure. When a well is put down through the impervious clay a free escape is furnished and a flow secured. Sometimes, however, the mere fact that water will flow more readily through a pipe than through the sand accounts for the artesian conditions. Such is the explanation of most river-bottom wells. The height to which the water will rise above the surface is called the artesian "head". Obviously this height depends ~~both~~ not only upon the height of the ground but also upon the distance from the relatively higher level of the underground water beneath the adjacent hills. Thus it comes about that flows are not absolutely confined to the lowest ground of a valley but are best on low ground near to high areas which feed water rapidly into the valley.

A somewhat different condition under which water is caught and held under pressure in the earth is where a relatively pervious stratum passes beneath a comparatively impervious one, as followed from the surface. Sometimes a sandstone passes beneath a limestone, sand and gravel beds beneath clay or the porous rock is covered by a clay bed. Now, as water seeps down the inclined pervious layer it may come to a place where the surface of the ground above is lower than the height of the water-level where the water enters the stratum. A well put down at such a place furnishes a ready outlet, and a head of a hundred feet or more above the surface can sometimes be secured. Because it is sometimes necessary to drill to a great depth to find a pervious water-bearing layer,

many artesian wells are very deep. This is the explanation of the strong flows of the Lake Michigan shore and Fox River Valley. The weaker flows from shallow wells of this region are due to the trapping of water between the sloping rock surface and the overlying clays. As has been mentioned, true "underground rivers" are extremely rare in this part of the county although they do occur in regions where caverns are abundant. They ~~rarely~~ seldom have anything to do with artesian conditions

Forecasting Artesian Flows.

Whenever a well is required everyone hopes that an artesian flow can be secured. Some think that if only they can go deep enough some mysterious force will send water to the surface. We have explained, however, that the cause of artesian flows is no more mysterious than the flow of water in a river. It is simply that the well furnishes a ready outlet to water imprisoned in the earth under pressure caused by the surface of this water standing at a higher level elsewhere than the surface of the ground at the well. The requisite conditions to secure an artesian well are then as follows:

There must be a porous material found beneath the site in question.

This porous stratum must at some point reach the surface of the earth so that rain water may enter it.

The surface of the water standing in this stratum must be sufficiently higher than the well site to give the pressure requisite to force the water to and out of the well.

Natural escapes for the water such as cracks in the rock must be more difficult paths to follow than the well will be, else the pressure will be insufficient.

The conditions are, in short, those of a city water system with an elevated standpipe.

In general the place to look for artesian flows is in valleys and low ground not too far removed from higher water-catching areas. Within these catchment areas it is usually hopeless to expect flows. It is also hopeless in nearly all cases to expect them where the underlying formation is granite or other similar impervious rock.

The geologists of the State Geological Survey and the Geology De-

partment of the State University are frequently called upon to make forecasts not only of the chances of obtaining an artesian flow but of the depth at which water-bearing strata will be found. Perhaps the most frequent inquiry is from persons who have struck granite or other hard rock. Where such rocks occur water is found only in the cracks and these are nearly always near the surface. The advice to those who fail to find water within 50 to 100 feet of the top of the rock is to stop drilling and shoot the hole with dynamite. This may break into some nearby water-bearing crevice. If it does not, the only thing is to try again at another place.

Next in frequence come requests for information as to the probable depth to water-bearing layers. Sometimes this can be determined by the geologist from studies and measurements made of the different layers where they come to the surface at some other locality. By inferring that these layers maintain their thickness beneath the surface, an estimate often can be made. At other places it is necessary to rely upon the records of previous wells, often some distance away. These have been secured ~~by much effort~~ from drillers, city engineers, and owners of wells. They are of all degrees of accuracy, varying from those kept only in the memory, to others which can be confirmed by samples of the different rocks passed through. The last are naturally the most trustworthy for certain characters of the rock not noted by most persons at once give a clue to the geologist as to the position of the different rock formations. When such observations have been made, profiles are drawn which show the position of the different geological formations, and the height to which water rises above the ground, at some places, or the distance it is beneath the surface at others. The slope of the surface of the water ~~in the earth~~ is thus determined and if we know the elevation of the surface

at the point it is desired to test, it can soon be seen whether or not the water will rise high enough to flow.

When all information is available such forecasts are quite reliable and the most progresive well-drillers often make them themselves. When adjacent areas have not been tested, however, one has to fall back upon general knowledge and experience in similar localities. This too is often surprisingly reliable. The greatest difficulties lie in lack of accurate knowledge of elevations and in the unreliability of well records. Only a small part of Wisconsin has been surveyed by the U. S. Geological Survey and of that part only a fraction of the maps are ~~at all~~ accurate, most having been drudely done long ago.

The defect of unreliable well records is being gradually remedied by the collection of samples from deep wells. All persons drilling such wells are urged if in doubt, to first communicate with either the State Geologist or the Geological Department of the University as to the chances of success. If it seems desirable, sacks and labels for preserving samples will be sent free of charge. The samples will also be examined and a description of the geological formations sent for future reference.

The information thus gained is of great value from the bearing it has upon work in other localities. Some fear the giving away of information to competitors but this fear is largely baseless. The immense gain to the general knowledge of underground conditions helps the good of the business of searching for underground water supplies, and by increasing the accuracy of forecasts prevents loss from useless drilling. These considerations should far outweigh any others. It is only by putting together much scattered information that the most important general facts can be ascertained, and ~~this~~ it is impossible for any one individual to accomplish from his own experience alone.

The Failure of Artesian Wells.

Most of us have seen artesian wells which flowed strongly when first put down but have gradually wasted away until they now only give a fraction of their former discharge or have even ceased entirely to flow. The question why, naturally arises. Has the well drawn off all the water that was in the ground? Has it become choked? Has it concealed leaks? In the flow like that of an oil-gusher which fades away as the gas pressure is released? Or have other wells in the vicinity taken away the water?

As we have explained in a previous article, the conditions which give rise to artesian wells are not like those which cause oil and gas to come from the ground, often under tremendous pressure. The catchment area of an artesian region may be likened to the stand pipe of a city water supply. The water-bearing stratum confined above by relatively impervious material corresponds to the distributing pipes while the wells may be regarded as the faucets.

We all know that such a system must be kept free from leaks and obstructions in the pipes and will in any event furnish water continuously only at the rate it is put into the standpipe. The artesian water system has many of these defects. The flow of water through sand or rock is difficult and slow, resulting in much loss of pressure. The rate of flow is usually less than a mile a year. Further, there is always more or less seepage to the surface. Under no circumstances can water be drawn off continuously faster than it is supplied by rain on the catchment area.

Everyone has noticed that when a faucet at a low elevation is opened, those above, and especially those farther along the pipe from the source of supply, have their flows diminished or even entirely cut off. The same thing happens with artesian wells. Those with low outlets or which are nearest the source of supply get an undue proportion of the water. A law was once framed in Wisconsin to prevent the allowing of wells to flow continuously and the resulting enormous waste of water. It sought to compel owners of wells to check their flow to actual necessities so that all could get water. Unfortunately the Supreme Court declared this an infraction of the rights of property owners. This decision cannot be too strongly condemned, for the great ~~sea~~ mass of underground water is independent of man-made property lines and should if possible be conserved for the equal use of all.

Another important factor which causes the cessation of flows is the clogging of the wells by sand or iron deposit. Then too, leaks in the casing or cracks in the rock often permit the water to escape underground. Often much water is lost into porous layers, which although water-bearing, are under less pressure than the water in the well. This can usually be remedied by carrying the casing to a greater depth.

~~Then, xtha~~ These, then, are the factors which cause the failure of so many artesian wells, and if known, can to a large extent be remedied. The regulation of the flow of wells to actual necessities, cleaning, and proper casing will nearly always serve to better conditions.

What is a safe drinking water?

The question of what is, or is not, safe water to drink is everywhere a vital one. In our part of the country water is almost wholly taken from wells, springs, less often from streams or lakes. The source of contamination of the last two are now well understood. The factors which determine the suitability of well or spring water, however, mainly lie beneath the surface of the ground and it is here that the geologist can be of great help. In nearly all parts of Wisconsin the soil, and rock beneath, is relatively pervious to the rain that falls upon it so that springs are common and wells can be obtained nearly everywhere. The water entering the ground passes through the soil and rock to a depth at which the entire ground is filled up or saturated with water. The depth at which this condition occurs depends upon the permeability, the rainfall, and the ease of escape of this "ground-water" by flow to lower points. This flow has been measured and on account of the great resistance offered is never more than a few feet per day. The surface of this great mass of underground water is called the "water table" and is the level at which water will stand in a well. At places where the water table comes to the surface springs occur.

The great advantage of spring water lies solely in the fact that as the spring flows, fresh underground water is continually being supplied. In a well, on the other hand, nearly stagnant water may be found. But when we consider the source of the spring water we may find that its coolness and apparent freshness may conceal contamination. Springs usually occur simply because a relatively impervious layer in the earth forces the ground

water to the surface. This means that near by the water table is not far from the surface. This makes the danger of contamination great because other things being equal, the amount of unsaturated earth that rain water has to pass through before reaching the permanent ground water, determines the amount of purification it undergoes by the bacteria of the soil. Add to this the danger from surface wash into the spring, and pollution by animals and dust and one can readily see that undesirable features may exist. The probable source of spring water should always be considered. The writer has in mind a spring whose water is widely advertised, which owes its existence to the fact that a relatively impervious layer of limestone occurs not far below the surface. This brings the water out at the edge of a gentle slope entirely covered by houses and having a large cemetery at the top! That the water is not dangerously contaminated at present is the merest chance.

Turning to well water, we must distinguish between dug and drilled or driven wells with metallic casing, between shallow and deep wells, and between little and much-cased wells. The principles heretofore explained show us that a deep well with impervious metallic casing to shut out surface water and underground animals, and which is pumped sufficiently to always have fresh water is by all means the safest source of drinking water. Even if water is found near the surface the casing should be carried quite deep if possible, so as to secure a maximum amount of filtration of the water entering the well.