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HYDROSTRATIGRAPHIC UNITS

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The close relationship between lithologic units and the occurrence and movement of ground water has long been recognized by hydrogeologists and hydrologists. As a result, many aquifers have been described as being essentially synonymous with well recognized formations. Similarly, relatively impermeable formations have been described as aquicludes and aquitards. Numerous examples occur in the literature, and notable aquifers include the Ironton-Galesville Sandstone, the St. Peter Sandstone, and the Edwards Limestone. Well known aquicludes and aquitards include the Maquoketa Shale, the Eau Claire Shale, the limestones overlying and underlying the St. Peter Sandstone (in Illinois, the Galena-Platteville interval and the Shakopee Dolomite), and the chalky limestones and clays overlying and underlying the Edwards Limestone. Indeed, this practice has resulted in a valuable qualitative description of nearly all, if not all, of the important water-yielding formations in the United States.

In the past two or three decades, as a result of development of various quantitative methods for analyzing and interpreting the nature of aquifers and confining beds, it has become evident that satisfactory definition of these units can seldom be accomplished by the lithologic, paleontologic, and other criteria commonly used to define rock entities such as formations and members, although these criteria are still basic factors in such definition. Other parameters, not commonly utilized in the critical definition of rock units but important to geohydrologic units, include, among many, the nature of movement, storage, and release of water in and through various media; the detailed complexities of interstratification, facies, sorting and packing of grains, distribution and degree of interconnection of joints and other fractures; the degree and depth of weathering and the development of solution channels and caves, both near the present land surface and at levels of former weathering and erosion that are now buried; and variation in methods of ground-water recovery, primarily in well construction and location.

Obviously there is a definite need for use of additional descriptive data applying not only to specific lithologic characteristics but to the factors involved in the various parameters that apply especially to water movement,

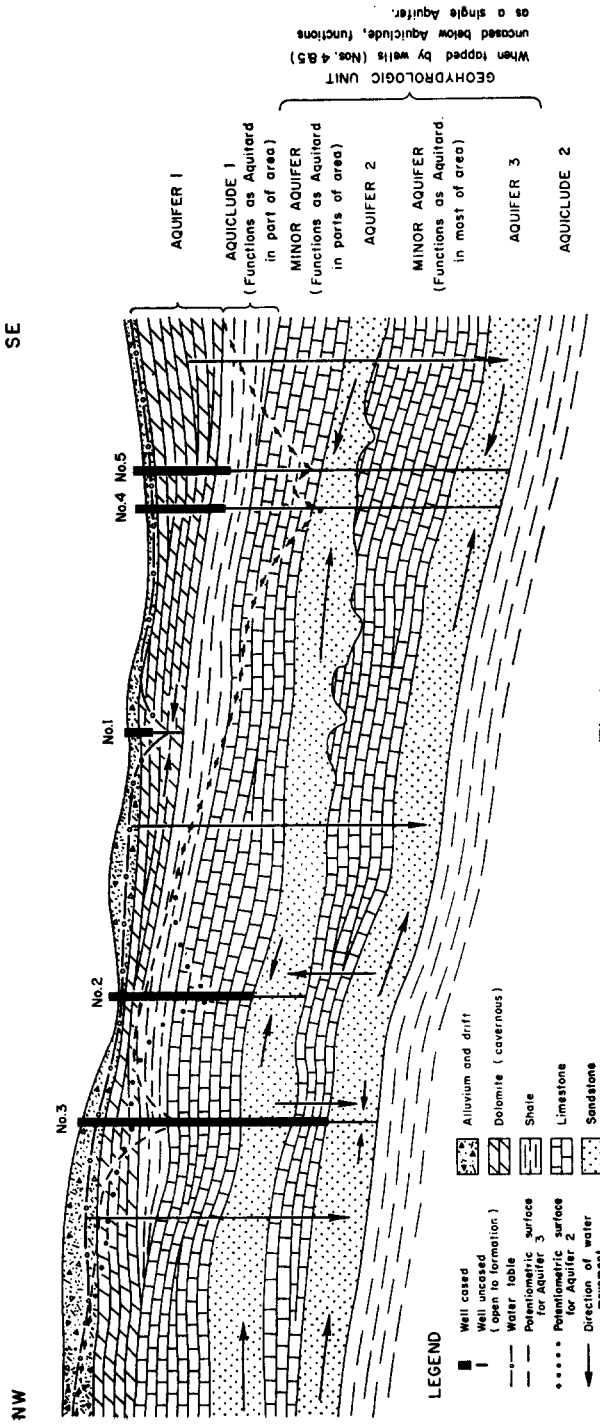
SE
NW
No.1
No.2
No.3
No.4
No.5
AQUIFER 1
AQUICLUDE 1
(Functions as Aquitard
in part of area)
MINOR AQUIFER
(Functions as Aquitard
in parts of area)
AQUIFER 2
MINOR AQUIFER
(Functions as Aquitard
in most of area)
AQUIFER 3
AQUICLUDE 2
GEOHYDROLOGIC UNIT
When tapped by wells (Nos. 4 &5)
uncased below Aquiclude, functions
as a single Aquifer.
LEGEND
Well cased
Well uncased
(open to formation)
Water table
Potentiometric surface
for Aquifer 3
Potentiometric surface
for Aquifer 2
Direction of water
movement
Alluvium and drift
Dolomite (cavernous)
Shale
Limestone
Sandstone

Fig. 1.

occurrence, and storage. The definitions of well established terms, indeed the very concepts they describe, need to be clarified and expressed in a manner that allows for more quantitative consideration of hydrologic and hydrogeologic phenomena. In order to crystallize meanings, to set apart clearly these geohydrologic units from lithologic or other units, and to clarify usage in application of hydrogeologic knowledge to water problems, it is *proposed that a category of hydrostratigraphic units* be recognized, these units to be defined as "bodies of rock with considerable lateral extent that compose a geologic framework for a reasonably distinct hydrologic system."

In common usage an *aquifer* is a lithologic unit (or combination of such units) that has an appreciably greater transmissivity than adjacent units and that commonly stores and transmits water that is recoverable in economically usable quantities. The lithologic units of low permeability that bound the aquifer are commonly called *confining beds* or *aquicludes*. If appreciable quantities of water move through confining beds the beds are called *aquitards*. The term confining bed(s) or preferably confining unit(s) usually is properly used in a general way to include both aquicludes (beds which allow essentially no water to move through them) and aquitards (beds that allow movement of appreciable amounts of water).

An aquifer, a confining unit, or a combination of aquifers and confining units that compose a framework for a reasonably distinct hydraulic system is a *geohydrologic unit*. The latter compound unit may be designated by a proper name preceding the term aquifer. For example, a report on the Chicago region [1]), combined the complex of formations making up the interval between the top of the Eau Claire Formation and the bottom of the Maquoketa Formation into a single *geohydrologic unit* called the Cambrian-Ordovician Aquifer.

Single lithologic units that function as aquifers or confining units may be designated by the use of the formational name preceding any one of the terms aquifer, aquiclude, or aquitard. Thus, in the Chicago region, the Mt. Simon Sandstone when referred to as a water-yielding unit is called the Mt. Simon Aquifer [1]), and the Maquoketa Formation might well be called the Maquoketa Aquitard. It is suggested that the term geohydrologic unit, although used essentially as a synonym for hydrostratigraphic unit in this paper, has value as a general descriptive term and should be reserved for this purpose. Similarly the term confining unit(s) may be used in a general sense. A specific hierarchy for these terms is not necessary and is not recommended in this paper.

Fig. 1 is a diagram of a field example in which advantageous use of these terms is employed. It is obvious that lithologic character (each lithologic symbol used represents a well known formation or other rock unit), thick-

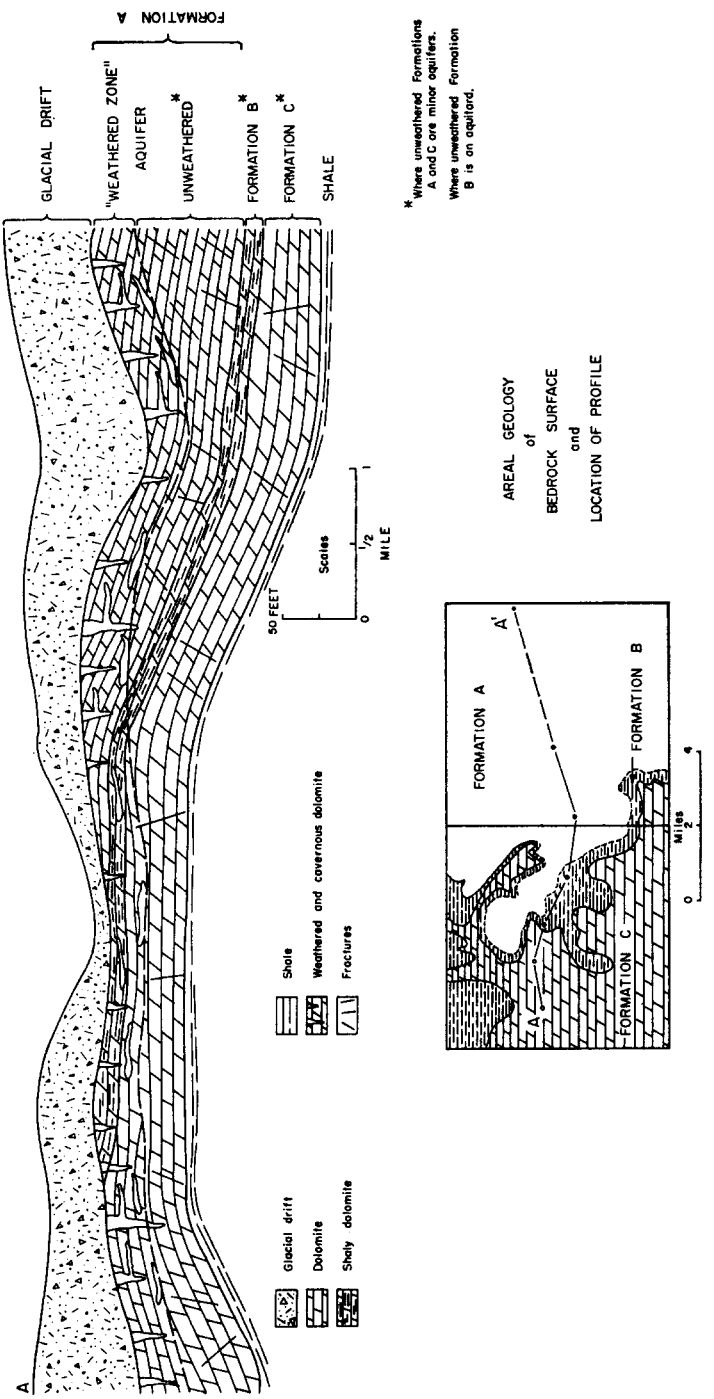
FORMATION A
GLACIAL DRIFT
"WEATHERED ZONE"
AQUIFER
UNWEATHERED*
FORMATION B*
FORMATION C*
SHALE
A
A'
*Where unweathered Formations A and C are minor aquifers.
Where unweathered Formation B is an aquitard.
Scales
50 FEET
0
1/2
1
MILE
Glacial drift
Dolomite
Shaly dolomite
Shale
Weathered and cavernous dolomite
Fractures
AREAL GEOLOGY
of
BEDROCK SURFACE
and
LOCATION OF PROFILE
FORMATION A
FORMATION B
FORMATION C
Miles
0
2
4

Fig. 2.

ness, sequence, extent, and structure are not the only criteria considered in designation of these units. Movement, storage, and occurrence of water, as well as the mode of locating, drilling, and completing wells (well logs and water level and pumpage records from the wells are virtually our only source of information except in the surficial deposits) are also elements in the definition of the units.

Fig. 2 shows how other factors, primarily pre-glacial weathering of the carbonate rock surface and well drilling practice, have produced a hydrostratigraphic unit called the Weathered Zone Aquifer for the purpose of this report. It cuts across the boundaries of three lithologic formations in the limited area shown. For many years the dolomites included in formations A, B, and C were recognized as one aquifer. Later, formations A and C were considered as aquifers separated by an aquitard, formation B. Formation A was believed to be the most productive "aquifer," primarily because a much larger area was underlain by the cavernous weathered part of it and more large yield wells were developed in it. Upon closer analysis it was learned that formation C, where weathered, also yielded large supplies of water and that even wells penetrating formations B and C, when the former is at the top of the bedrock and both B and C are weathered, produce larger supplies of water than might normally be produced from wells open only to unweathered parts of formations A or C. In other words, the specific capacities of many wells in the weathered upper fifty or so feet of the dolomites may be expected to be large, whereas specific capacities in unweathered A and C may be moderate to small and in unweathered B, very small to negligible. Thus, there are four hydrostratigraphic units in the dolomite sequence, 1) the Weathered Zone Aquifer, 2) the unweathered A dolomite, 3) the unweathered C dolomite, and 4) the unweathered B shaly dolomite, an aquitard. Obviously this interpretation requires different treatment in quantitative analysis than did previous interpretations. It would especially influence predictions of proper and economic well depth and placement.

The Illinois State Geological Survey has used the concept of hydrostratigraphic units informally for the past five years[1,2]) and plans to continue this informal usage. These units serve a need long recognized by most hydrogeologists. Careful description and definition of them furnish the hydrologist and water supply engineer with a much clearer concept of the relation of the geologic framework to the hydrologic cycle and the place of geology in hydrologic and water resource problems. As a specialized category within the framework of the present stratigraphic code[3]) hydrostratigraphic units would allow the geologist to express clearly and more precisely the similarities, parallels, and contrasts between them and other units now recognized by the code.

References

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3) American Commission on Stratigraphic Nomenclature, 1961, Code of Stratigraphic Nomenclature, Am. Assoc. Petroleum Geologists Bull. **45** (1961) 645–665