Article 480–Geophysical Well Logging

Adopted by the CGA Board of Directors on January 16, 1994

BACKGROUND

Geophysical well logs are commonly required or desired by State and local regulatory agencies, engineers, geologists and private individuals. Yet no standards or guidelines exist as to how such logging will be conducted or what interpretation can be made. Applications in the oil industry or in other States are often inappropriate for groundwater conditions found in California. In addition, there are widespread misconceptions about the use of geophysical logs for well evaluation concerning the determination of water quality, specific chemical content, quantity of production and other well properties.

DISCUSSION

A geophysical well log measures physical and chemical properties of formations and fluids in or around the vicinity of the well, and results in a series of curves plotted on a graph showing changes in the properties with depth. Geophysical equipment, types of logs available and log interpretation are highly technical and will not be covered in detail here. Standard textbooks, manuals and forthcoming ASTM Standards can be referred to for information on well logging technology.

The guidelines emphasize standards of practice that Contractors and other users of geophysical logs should be aware of to assure that valid data are being collected, and that the data are of suitable quality for project requirements. Any subsequent interpretations of the log data can then be based on documented conditions at the time the log was run. Often, the greatest value of logging is realized long after the initial well construction, when logs are referred to in future phases, such as well rehabilitation, etc.

It should also be noted that it is not the intent of the guidelines to "mandate" standard procedures or increase logging costs unreasonably, or create specifications which would favor one technology over another, or favor the use of logs provided by one service company over those of another.

RECOMMENDATIONS

The California Groundwater Association recommends the following practices for conducting geophysical well logging in water wells and other borings that are related to groundwater:

TOOLS

Types: Many different geophysical tools measure a variety of formation or well properties directly or indirectly, and many tools will run a number of logs at the same time. Common tools that are used in routine water well work in California are:

- Spontaneous Potential (SP)
- Single Point Resistivity
- Multi-electrode Resistivity
- Natural Gamma
- Caliper
- Fluid Conductivity and Temperature
- Flow Meter

Calibration/Standardization: Tool calibration should be within reasonable limits that match the requirements of the well logging project. Calibration of the tools may be carried out in the shop before logging or at the location. For example, calibration of caliper tool is accomplished by checking the response of the tool by placing rings of known diameter over the caliper arms. Calibration is important in that it shows evidence of repeatability and consistency of the measurements.

FIELD OPERATIONS AND PROTOCOL

Logging Contract: Items to be considered in a logging contract should, at a minimum, include the following:

- logs to be run
- equipment and quality control
- calibration/standardization requirements

- responsibility for log interpretation
- responsibility for lost tools

With respect to lost tools, most well logging service companies have a specific clause in their "Terms and Conditions" section of the contract addressing the responsibility for tools lost or lodged in the hole. It is the responsibility of the person ordering the services to understand the terms and conditions pertaining to the operation of the service company selected, before the logging operation(s) begins.

Occasionally, bore hole conditions prevent the passage of the logging tool. Forcing the tool may cause it to become lodged in the hole. If in the logging equipment operator's opinion there is a hazard that the tool may become stuck, then it will be necessary to condition and/or redrill the hole, if the logging is to proceed. Log Heading: The log heading should identify the well and contain all the information that is required to evaluate the log response, including the depth of the top and bottom of the interval logged, mud resistivity, scale changes, etc.

INTERPRETATION

Data Factors: The data recorded for all logs is affected by the condition of the bore hole, fluid in the hole and/or formation, geologic conditions, extraneous circumstances, and other often unknown factors existing at the specific location and time the log was run. The data recorded for any specific point at any specific time are the result of all conditions at that point at that time. It is often not possible to define all existing conditions. A number of conditions may change as time progresses. Following are just a few examples of unknown conditions that can affect interpretation of log data:

- Drilling fluid intrusion into the formation pushing the formation water away from the hole
- Vertical change in the water level or chemistry in the bore hole
- Specific minerals present in the formation but not recognized
- Variable size of the bore hole
- Formation or structure changes near the bore hole
- Extraneous electric currents from railroads or underground power lines or pipelines
- Chemical reactions within the bore hole or formation

General Limitations: Geophysical logging can be accomplished by a variety of types of logs as previously discussed, and no one method is suitable for all applications. Methods deemed appropriate for use at a specific location at a specific time may not apply to a nearby site, even in an apparently similar hydrogeologic environment, or in the same location at a different time.

Interpretation of the geophysical log is based on the information and knowledge available combined with the skill and experience of the interpreter. Such knowledge is obtained from the geophysical log(s), driller's log, and samples, combined with whatever "local knowledge" is available. Geophysical logging is not a replacement for lithologic samples, as these are necessary for proper log analysis. As noted previously, logs do not have a unique response. For example, in a natural gamma log, anomalies caused by shale formation cannot be separated from those caused by granite, without sample control. Similarly, in an electrical log, diminishing resistivity through a sand interval can be caused by changes in grain size, poorer water quality, or a combination of both.

Assuming that a geophysical log is run to acceptable standards for the project at hand and that the interpreter takes into account all available information, then a reasonable interpretation by a skilled person should be obtainable. Often, alternative interpretations are possible with even the best of existing data, and the best use of judgment and experience. Thus, the well site representative or well owner must realize that an interpretation is only "an interpretation" and that there cannot be any warranties or guarantees of such things as anticipated yield, water quality, etc., in a completed well.

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