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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

February 18, 1986
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Mr. Jeff Pohle
Division of Waste Management
Mail Stop SS-623
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: SALT

Dear Jeff:

I am enclosing a review of the following document:

1. Conti, R.D. and Senger, R.K., 1985, Hydrostratigraphy of the Wolfcamp Aquifer, Palo Duro Basin, Texas Panhandle: Texas Bureau of Economic Geology, Austin, TX, OF-WTWI-19885-38.

If you have any questions concerning this review, please call.

Sincerely,

Gerry Winter

Gerry V. Winter

GVW:sl

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WMGT DOCUMENT REVIEW SHEET

FILE #:

TEXAS BUREAU OF ECONOMIC GEOLOGY #: OF-WTWI-1985-38

DOCUMENT: Conti, R.D. and Senger, R.K., 1985, Hydrostratigraphy of the Wolfcamp Aquifer, Palo Duro Basin, Texas Panhandle: Texas Bureau of Economic Geology, Austin, TX.

REVIEWER: Williams & Associates, Inc.

DATE REVIEW COMPLETED: February 18, 1986

ABSTRACT OF REVIEW: APPROVED BY: Roy E. Williams

The report under review presents a methodology for delineating hydrostratigraphic units in the Palo Duro Basin. The methodology delineates the distribution of porosity (total porosity assumed equal to effective porosity) and permeability within the strata of the Wolfcamp Series that lies below the evaporite sequence that has been assumed to be an aquitard. The methodology uses data derived from drill cutting sample logs, core logs, porosity-log cross plots, and empirical porosity-permeability relationships for limestone, sandstone, and shelf margin and non-shelf margin dolomite.

Williams and Associates considers the product contained in this report to constitute progress toward the definition of hydrostratigraphic units in the Palo Duro Basin. The only major concerns that we have regarding the material contained within this report are the manner in which permeability is measured and the fact that total porosity is assumed to be equal to effective porosity. In addition this report differs from the other reports which assume the Wolfcampian Series to constitute a single hydrostratigraphic unit (aquifer). We also have several minor concerns regarding the limitations of the data base.

BRIEF SUMMARY OF DOCUMENT:

The report under review presents an estimate of the geographic distribution of the following hydrogeologic parameters: average porosity, average matrix permeability, and the product of permeability and thickness for non-shaly Wolfcamp sediments. Lithofacies correlations for the Brown Dolomite and the Wolfcampian Series strata were derived from analyses of sample logs, core logs, and porosity logs. The results of porosity distribution studies were incorporated with empirical porosity/permeability relationships for dolomite, limestone, and sandstone. Average permeability and the product of permeability and thickness trends were mapped.

The report states that sonic logs are sensitive to intergranular porosity but are insensitive to secondary porosity. Neutron logs are sensitive to hydrogen concentrated in fluids (water, oil, or gas). Density logs are sensitive to the electron density of the formation. The report states that the analyses of Wolfcamp lithology and porosity have demonstrated that the simultaneous analysis of neutron and density logs more accurately identify limestone and dolomite lithologies. The neutron-sonic crossplot (simultaneous plot of neutron and sonic geophysical log responses) is less accurate in identifying limestone and dolomite lithologies; the less accurate identification is due to an insensitivity to secondary porosity. The report states that "A one-to-one association between neutron-density crossplot-derived porosity and core-plug derived porosity ... also was found" (p. 3). Shaly intervals were distinguished from non-shaly strata by anomalously high neutron and density porosities.

Log responses were resolved on a three-foot interval. Published cross plot charts from Schlumberger (1979) were used for interpreting porosity and lithology from log data. Cross plot derived lithologies were compared with sample logs and core logs in nearby wells. The report notes that cross plotting results are influenced by mineralogy. The presence of silica (SiO_2) and shale are two mineralogies which affect cross plotting results significantly.

The dependence of permeability on porosity was evaluated based on permeability measured in laboratory analysis of core plugs. The log normal association between permeability and porosity is illustrated in figures included in the report under review. The report states that limestone and dolomite each show a two sloped increase in the log of permeability corresponding to a linear increase in porosity. The report states that "Shelf-margin dolomites are distinguished from non-shelf-margin dolomites by higher permeabilities associated with equivalent porosities" (p. 5). A high porosity/low permeability zone is found in an oolitic

sequence found in the northwestern part of the study area. The northwestern part of the study area is near the Oldham-Deaf Smith County line. The report states that the Granite Wash was characterized by a linear increase in the log of permeability which was associated with a linear increase in porosity. The distal Granite Wash sediments form a permeability-porosity relationship distinct from that of the proximal Granite Wash deposits. The report states that the proximal Granite Wash deposits have an exceedingly high permeability relative to porosity values from the same cores.

The report makes three basic assumptions for the purposes of determining the geographic distribution of the hydrogeologic parameters of porosity and permeability. These assumptions are "All non-shaly porosity is intergranular and interconnected or effective." In addition, "Discreet lithologic packages of porous zones can be treated as pure dolomite, limestone, or sandstone for purpose of establishing porosity-permeability relationships" is assumed also. The third assumption is: "Permeability parallel to bedding is isotropic with respect to its compass orientation" (p. 6-7).

Lithologic columns were constructed for 27 wells for the Wolfcamp strata. A "Thickness-weighted average porosity for non-shaly intervals in the Brown Dolomite and subjacent Wolfcamp strata, was calculated for each well ...." "Comprehensive hydrostratigraphic characterization of each Wolfcamp lithologic unit entails assessing the geographic distribution of geologic parameters (for non-shaly intervals), thickness-weighted-average porosity (ϕ_{avg}), thickness-weighted-average permeability (k_{avg}), and permeability-thickness production (k x h)." The report states that the Brown Dolomite and subjacent strata in the Wolfcamp Series were treated as individual units. The arithmetic mean was used to determine the thickness-weighted-average porosity. The arithmetic mean also was used to determine the thickness-weighted-average permeability. The report points out that the permeability-thickness product (k x h) approaches transmissivity; transmissivity is dependent upon the intrinsic matrix permeability, fluid density, and viscosity.

The report presents a figure to illustrate the net thickness trends for shale. The report presents a sequence of figures for the Brown Dolomite and the Wolfcamp strata which is subjacent to the Brown Dolomite. The sequence of figures includes the distribution of thickness-weighted-average porosity, average permeability and permeability-thickness product. The axes of increased porosity are comparable between the Brown Dolomite and the Wolfcamp strata. The preferred orientation for increased porosity is north-northwest to south-southeast. Trends of greatest permeability are oriented north-south to northwest-southeast for both the Brown Dolomite and Wolfcamp strata.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The information contained in the report under review is important to the Waste Management Program because of the stratigraphic relationship of the Brown Dolomite and Wolfcamp Series strata to the younger Permian salt aquitard sequence. This report is important also because it demonstrates also that the Wolfcamp Series can be broken into more than one hydrostratigraphic unit. This report is the first TBEG report that reaches this conclusion. The predominant vertical head gradient in the section suggests downward leakage from the Permian salt aquitard to the Wolfcamp strata. The apparent relatively high porosity and high permeability of portions of the Wolfcamp sediments also are important to the program because the Wolfcamp sediments may constitute the preferred hydrogeologic conduit along which radionuclides could be transported to the accessible environment.

This report is important also because it presents a new methodology for site characterization wherein borehole geophysics and laboratory data are correlated with field data (sample logs, albeit somewhat limited) to try and define hydrostratigraphic units in the Wolfcamp Series. The definition of hydrostratigraphic units is important to the program for the purposes of developing the conceptual models of flow, appropriate testing plans, and the assessment of ground water travel times in the basin.

The "Deep-Basin Brine Aquifer" is referred to in several reports reviewed to date. These reports (Senger and Fogg, 1984; Kaiser, 1985; Orr and Senger, 1984; Senger, 1984) refer to the Wolfcamp Series as an aquifer. We do not believe that the Wolfcamp Series should be referred to as an aquifer. Our review of OF-WTWI-1984-44 presents our views on this use of the term aquifer.

PROBLEMS, DEFICIENCIES, OR LIMITATIONS OF REPORT:

The report states that the results of this study may be used to predict the location of potentially favorable reservoir parameters. The report states that future drilling targets for hydrocarbon resources may be ascertained from the results of this study. We believe the most important aspect of this study is its relevance to the disposal of high level radioactive waste and not the determination of reservoir properties for hydrocarbon production. The results of this study may be very useful for the determination of site characterization plans. The issues considered by the Nuclear Regulatory Commission and the

Department of Energy both are oriented toward determining the most probable groundwater flow paths and the determining of groundwater travel time. The results of this study can be used to orient the field program for quantifying the parameters which are required for determining flow path and ground water travel time. The report is the first report we have reviewed that divides the Wolfcamp Series into more than one hydrostratigraphic unit. Previous reports (cited above) treat the Wolfcamp Series as a single aquifer.

The report has made use of geophysical logs to an extent which has not been conducted at the other sites to date. The use of geophysical logs in this manner should be investigated further. We wish to point out that these indirect methods of determining hydrogeologic parameters are subject to interpretation and definite data limitations. This fact is not pointed out in the report under review. Specifically, the determinations of porosity based on geophysical logs are limited to the volume of material which the log has encompassed within its range of sensitivity. The small volume of influence limits the capability of the geophysical logs to detect secondary porosity on a scale that might be detected by other means of in-situ hydrogeologic testing such as tracer tests. The apparent cross correlation of porosity derived from borehole geophysical logs and porosity determined from laboratory analyses of core plugs is limited by the inherent problems associated with laboratory tests. The core represents a very small volume of the formation sampled; the core has had its internal stresses released as it was extracted. The reinstitution of stresses is problematical with respect to measurements of porosity and permeability. Permeability is determined by an empirical relationship developed from core data; permeability measurements are subject to the same constraints noted for porosity.

Permeability data are derived from core analyses. These permeability values are not compared or correlated to in-situ measurements of permeability. Permeability values derived from testing core are believed to be lower than in-situ measurements of permeability. Values of permeability obtained by in-situ testing can be categorized by the method of testing; small scale single well tests usually yield lower values of permeability than large scale multiple well tests or values derived by inverse modeling (Bredehoeft et al, 1983). The differences in values obtained by different methods of testing are believed to be due to the volume of material that is stressed during testing. Core samples constitute the smallest volume of material tested. In-situ tests stress varying volumes of material depending upon the type of test conducted and the duration of the test. Inverse modeling usually incorporates the largest volume of material. Secondary porosity-permeability features are more apt to be incorporated into the volume of material tested as the size of

the volume increases. The values of permeability measured by testing will increase as these secondary permeability features are incorporated in the test volume.

The report points out another problem associated with the analysis of geophysical logs. Mineralogy (silica and shale) can affect the interpretation of the log data. The mineralogy introduces another uncertainty into the analysis of log data.

The assumptions of the report should be reiterated because they severely constrain the results of the study. The first assumption states that total porosity is equal to the interconnected porosity (effective porosity). The second assumption assumes that each of the lithologic zones is homogeneous. The third assumption assumes isotropic conditions. The limitations are common to analytical solutions and are commonly encountered in most methods of analysis.

The report states, as noted in the brief summary, that the permeability-thickness product approaches transmissivity but is not equal to transmissivity. The report uses intrinsic permeability which does not reflect fluid density and fluid viscosity. Incorporation of these two parameters into the product would produce values of transmissivity. The report does not plot true transmissivity as noted in the brief summary. This point should be kept in mind when reviewing the data. The values of fluid density and fluid viscosity are not noted in the report under review. It would be useful for the data to be included in order for the reviewers to be able to make an independent assessment of the permeability-thickness product maps.

REFERENCES CITED:

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Hanford struggling with nuclear weapons waste

By JOHN K. WILEY
Associated Press

RICHLAND — Permanent disposal of highly radioactive defense wastes has been pending for 40 years, "but it's certainly something you need to get started next year," says a Hanford waste management official.

Jerry D. White, director of the U.S. Department of Energy's defense waste management program at the Hanford nuclear reservation, said cleanup of the radioactive liquids and solids stored there is expected to take at least 30 years.

Tight budgets and policy changes in the interim could stretch that to 50 years or more, he said.

Although new storage tanks are designed to last that long, efforts toward permanent disposal need to begin now, White said.

"It's nothing you need to do (completely) next year, but it's certainly something you need to get started next year," he said.

Most of the wastes, left over from more than 40 years of weapons production, are stored near the center of the nuclear reservation in reinforced concrete tanks lined with carbon steel.The Energy Department is preparing a draft environmental impact statement outlining its plans for permanent disposal of the wastes.

Hanford stores 62 percent of the nation's high-level defense wastes, byproducts of the manufacturing of nuclear weapons.

White said the 1,500-page document, expected to be released in March, details four possible solutions, including:

- Processing the wastes by draining or mining them from the tanks, sealing them in glass, and placing them in steel canisters in a proposed "deep geologic" repository. This would take care of 98 percent of the defense wastes at Hanford, he said.
- Stabilizing the wastes in place, by covering all storage and dump sites with protective barriers.
- A "reference alternative" that calls for processing of readily retrieved high-hazard wastes for storage in repositories and stabilizing difficult-to-retrieve wastes in place.
- Do nothing. This option would simply continue the practice of storing the defense wastes in the double-walled tanks and monitoring them for leaks.

White said he doesn't think the last option will be the one that is finally chosen, mainly because of public concerns over the safety of the tanks, some of which already have begun to leak.

"I don't think it is acceptable, but it's an option," he said.

The option of digging up and storing all the wastes in a repository would involve considerable risks, especially to workers, he said.

"There is always some risk involved" in handling radioactive materials, White said. "But trying to dig up all the defense wastes (for burial in a repository) is like taking someone with a slight head cold and putting them in intensive care."

What is chosen likely will be a combination of burying some of the more dangerous wastes in underground repositories and stabilizing some of the less harmful ones in place, he said.

Whatever options are chosen, White said he hopes the project begins with the most serious problems: the single-walled tanks.

"The end process of the EIS is a record of decision," he said. "When we get to that end, we hope to get a decision early on for the single-walled tanks."

There are about 58 million gallons of defense wastes stored in 149 single-walled and 20 double-walled tanks in the 200 area near Hanford's chemical reprocessing plants, said Bill Heine, Rockwell's waste program manager.

Rockwell, chief contractor on the reservation, manages the "tank farm" where defense wastes are stored.

The single-walled tanks, some of them 40 years old, no longer are in active service, the Energy Department said. A number of the tanks have begun leaking, and a program to "stabilize" the wastes by pumping out and evaporating the liquids is expected to be completed in the 1990s.

However, radioactive solids called "salt cake," mud-like sludges and slurry materials, still remain in the single-walled tanks.

Unlike the proposed civilian nuclear waste repository — which would bring spent fuel rods for storage from reactors across the nation — the defense wastes already are at Hanford and must be dealt with, said White.

The proposed civilian high-level waste repository is a side issue in the disposal of defense wastes.

DOE plans massive public education plan on waste site

Associated Press

RICHLAND — The Department of Energy would rather be criticized for a $1.5 million public education program on highly radioactive defense wastes than miss the chance to explain disposal options, says a top Hanford waste management official.

The Energy Department's program has been criticized by citizen activist groups, such as Greenpeace and the Washington Public Interest Research Group.

Richard Wilde, Rockwell Hanford's environmental impact coordinator, said the series of open houses and public workshops in Washington and Oregon are intended to broaden public knowledge and solicit public comment on defense wastes at Hanford.

Wilde shrugs off criticism of the program's costs and motives.

"I would rather be subjected to that criticism ... as long as everybody who wants to gets involved" in the public comment process, he said.

Karen Wheeless, spokeswoman for the Energy Department's Richland office, said the $1.5 million allocation is to fund a six- to eight-month program that includes the open houses, public workshops, public hearings and hearings before various congressional and state agencies.

The first draft of the Hanford defense waste environmental impact statement is expected to be issued in March.

The period for comment on the defense waste EIS is 120 days, Wilde said, noting that the normal comment period is 90 days.

One of the groups expected to have something to say is the Hanford Education Action League.

"We have been concerned about (defense wastes) for a long time," said the Rev. William Houff of Spokane, the group's president.

"We consider it a more serious issue than the (proposed civilian nuclear waste) repository, one that is enormously greater because it is already in process," he said.

Defense wastes have been stored on the Hanford nuclear reservation since the mid 1940s.

Because the wastes already are stored there, decisions on how to permanently dispose of them will be easier to make, Wilde said.

"We're going at this in a very positive way," Wilde said. "We're taking an existing situation and making it better."

Even the Washington State Nuclear Waste Board concluded "many people feel that moving the defense waste currently stored at Hanford into a permanent disposal facility will be an improvement over the way defense wastes are now stored."

But the board, in an information paper issued in January, also concludes that "the main objective of the state's review program is to be sure that (the defense waste EIS proposals) are technically sound and that all potential options are thoroughly analyzed."

The planned open houses and workshops were scheduled to answer the public's questions about possible health risks, Wilde said.

"The EIS is complicated because we are trying to tackle everything at once," said Wilde of the 1,500-page document. The technical nature of the subject "makes it hard to understand and makes it hard to explain to the public."

Some of the open houses will be held before the document is released, while the workshops will be held after the EIS is issued, said Wheeless.