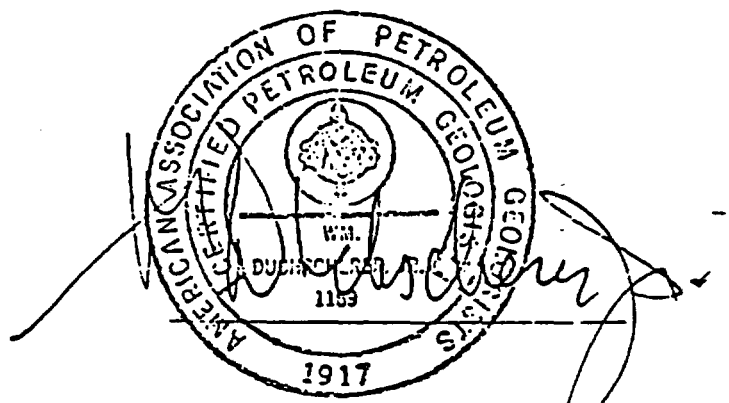
REPORT COVERING THE POSSIBILITY OF A METHANE ACCUMULATION UNDER THE REFERENCE REPOSITORY LOCATION HANFORD SITE

FOR: BWIP

By: William Duchscherer, Jr.



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INTRODUCTION

It is my understanding that it is the interest of the U.S. Department of Energy (DOE) to consider the UMTANUM Basalt flow of the Grande Roande Basalt underlying the Hanford, Washington site as one candidate repository horizon for nuclear waste storage. The Reference Repository Location on the Hanford site is hereafter referred to as the RRL.

Initial BWIP geologic and hydrologic studies have served to determine that the use of the UMTANUM Basalt as one candidate repository horizon for waste materials is very good. However, a recent core hole, RRL-2, encountered methane (CH_4) in the flow top of the UMTANUM Basalt at a depth of about 3650' in the RRL.

It is not my purpose on such a short notice and examination of BWIP data to delve into all the minute details of the structural-stratigraphic geology, cores, logs, and other geochemical-geophysical work that has previously been performed so well. Therefore, I shall address the six (6) topics covered during my visit with the BWIP staff at Richland.

These topics were as follows:

1) Origin of gas.
2) Extent of the gas reservoir (?)
3) Possible safety problems associated with

the repository (RRL) construction.

4) Potential for development of energy resource.

5) Additional data to be collected by BWIP to address these concerns.

6) Calculation of gas saturation.

ORIGIN OF GAS

The BWIP staff has collected a considerable amount of ^{13}C data from drilled core holes located across the Hanford site.

Carbon-isotopes distributions, i.e., $\delta^{13}C$ values, can be of diagnostic value for the determination of the origin of gases. In particular, the question as to whether a particular gas comprising mostly methane (CH_4) is related to an immature source (diagenetic stage) or to a very mature source (metagenesis stage) may be solved in this way. The preponderance of negative $\delta^{13}C$ values would indicate, when referring to the standard Peedee Belemnite chart, that the methane being encountered at Hanford falls within the range of biogenic methane or a very early thermogenic origin. These values were all in the $\delta^{13}C$ (-50 to -70 0/00) range.

It has been our experience that such negative values of

^{13}C indicate enrichment in ^{12}C relative to the Peedee Belemnite standard and positive values indicate depletion in ^{12}C or enrichment in ^{13}C. This most always is the case over hydrocarbon deposits that we have surveyed.

Also noted was the occurence of high sulfur values where there are low methane values or vice versa. This would be expected if certain microbial life systems existed in the subsurface.

In summary, as to the origin of the gas, I conclude that the negative values of $\delta^{13}C$ and the contrasting variation of sulfur and methane, i.e., low-sulfer/high-methane or high-sulfer/low-methane is pointing to an accumulation of methane in the basalts and possibly from an immature source (diagenetic stage).

EXTENT OF THE GAS RESERVOIR

The extensive geophysical investigations conducted across the Hanford site are just that -- "physical" investigations which indicate structural and possible stratigraphic conditions. In a sense, these have enabled a "vertical" picture of the subsurface at Hanford.

A geochemical soil survey using the Δ C method would enable a horizontal or areal picture of the methane concentrations over the Hanford site, the RRL in particular, which would serve to indicate any hydrocarbon accumulations that were present below the ground surface. To amplify on this, I suggest a review of published papers which illustrate this phenomena.

If an accumulation of methane underlies the RRL, I would expect a Δ C geochemical halo to outline its extent quite satisfactorily. The ΔC survey is normally performed on a close grid network of 8 soil samples per square mile on one-half mile traverses - thus enabling close control for interpretations.

POSSIBLE SAFETY PROBLEMS ASSOCIATED WITH REPOSITORY CONSTRUCTION

Mine safety considerations are out of my range of expertise. However, it goes without saying that any potential for gaseous inflow into an underground structure must be given careful examination. I suggest that this question be referred to the U. S. Bureau of Mines.

POTENTIAL FOR DEVELOPMENT OF ENERGY RESOURCES

This problem deals with the economic value of a methane

deposit underlying the Hanford site and the RRL in particular. Of course, any large accumulation of hydrocarbons has economic value. In the case of the minor amounts of methane at Hanford, the economic value would have to be determined.

Several major oil companies have drilled deep holes in the general area. They are keeping these wells and their associated data on a "tight" status. I suggest that Rockwell or the DOE obtain this information on a confidential basis to aid in directing your field studies. Obviously they have been targeting the sedimentary suites under the basalts. If gas is present in the sediments underlying the basalts, they could possibly be the source of the methane that was encountered in the recent core hole on the RRL and in the upper basalt formations.

I am not acquainted with the legal status of the ownership of the Hanford site acreage, but I can assure you that if an economic hydrocarbon deposit does exist under the RRL, there will be undue pressure brought by commercial interest for its exploitation. The time is now to ascertain this possibility!

ADDITIONAL DATA TO BE COLLECTED BY BWIP TO ADDRESS THESE CONSIDERATIONS

Additional data that, in my considered opinion, could be beneficial in evaluating the concentration of methane in the

rocks beneath the Hanford site are Landsat photo geology, biological studies of the bacteria cultures, helium emanometry surveys, low-altitude aeromagnetic profiling, and a Δ C geochemical survey.

To elaborate on the above, a growing body of evidence indicates that in near-surface rocks over a petroleum field, there can be found, as a result of vertical leakage, a variety of subtle to obvious chemical anomalies. This is predicted upon the fact that, in nature, there is no such thing as a perfect seal as all gaseous reservoirs leak - leaving their signatures in the near-surface rocks. In porous soils at or near the surface, bacteria intereact (as mentioned above) with seeping hydrocarbon and ultimately a variety of diagnostic diagenetic phenomena result. These phenomena include isotopically and chemically distinctive porefilling carbonate cements, reduction and dissolution of trace metals, and the direct uptake by plants of certain micronutrients. All these seepage mechanisms may be considered to be fossil evidence of hydrocarbon microseepage and can be detected by Landsat data and verified by a geochemical ΔC soil survey.

Landsat data could also possibly indicate tonal anomalies over the Hanford site which could be directly tied into hydrocarbon gases migrating into the near-surface soils. The methane leakage provides an enhanced evaporation of near-surface ground waters producing caliche-like evaporite concentrations of soluble soil salts. This phenomena leads to

"tonal" anomalies that are directly correlated to geochemical soil salt patterns providing a guide to the presence of hydrocarbons at depth.

If there has been hydrocarbon microseepage at Hanford into the near-surface soils, this can be readily detected by low-altitude aeromagnetic profiling. The basis being that continual seepage of hydrocarbons and/or associated compounds such as H_2S has produced a near-surface chemical reducing environment, resulting in the reduction of hematite to magnetite. A postulated sequence of reduction would be:

Hydrated ferric oxides $\longrightarrow$

Hematite $\longrightarrow$ Magnetite

Fe_2O_3 | $FE + 2Fe_2 + 3O_4$

Vertical profiling of these data would indicate areas of high magnetite and thus indicating areas of hydrocarbon reduction.

BWIP biologists could study the soil over the RRL to determine if there exists the type of bacteria present that are living off methane. If so, the possibility of a hydrocarbon deposit at depth exists.

Helium emanometry can be employed across the RRL area by taking soil samples and analyzing the helium content. Helium being inert, stable, and slightly soluble in ground fluids, is a good geochemical indicator of hydrocarbons. The helium analyses are performed by mass spectrometry. The basis of this type of survey is that helium is produced by the decay of uranium and thorium in the earth and is migrated into hydrocarbon reservoirs where it accumulates and through microseeps can be detected in the near-surface soils.

A C geochemical survey may be the most exacting and definitive tool of all those additional data gathering systems mentioned above. The Δ-C method is extremely rapid with approximately 125 square miles being covered per month (1,000 samples). The cost is inexpensive compared to other methods. The basis of its theory is simple:

1) Methane arriving in the near-surface soils is oxidized yielding CO_2 in the carbonate cements.

2) By DTA at 500° C to 600° C, the clay fraction dehydrates yielding CO_2.

3) A gas analyzer measures this CO_2 and converts it into millivolts.

4) Frequency curves are plotted to arrive at a contour value.

5) Geochemical halos interpreted if methane was present in the soil from underlying hydrocarbon accumulations.

6) Geochemical halos outline the extent of underlying accumulations.

All these additional disciplines would help immeasurably in the determination of a methane accumulation with the Δ C method being the most economic and diagnostic.

CALCULATION OF GAS SATURATIONS FROM GEOPHYSICAL LOGS

It was noted that there have been a number of geophysical logs run in the core holes on the Hanford site. It is possible to calculate gas saturations from these logs as follows:

If water is the only liquid and Rw (water resistivity) is known, from Archie's equation, we have:

$$(1) \qquad Sw = \frac{1}{\emptyset} \cdot \sqrt{Rw/RT}$$

Where Sw = water saturation (%)

$\emptyset$ = porosity, obtained from neutron or density logs (%)

Rw = water resistivity

Rt = true resistivity from induction log

(2) and $\emptyset = \frac{Pma - Pb}{Pma - Pf}$

Where Pma = grain density of formation

Pb = bulk density obtained from density log

Pf = density of fluid, usually 1

Then, by appropriate substitution, equation (1) becomes:

(3) $$Sw = \frac{1}{\frac{Pma-Pb}{Pma-Pf}} \cdot \sqrt{\frac{Rw}{Rt}}$$

The water saturation may now be determined by using the porosity calculated from (2) and using equation (1).

From the basic equation,

(4) $$100\% = S_{water} + S_{gas} + S_{oil}$$

$$S_{oil} = 0$$

then, $S_{gas} = 100 - Sw$

I have also enclosed a chart which can be used to obtain S_{gas}.

It has been my experience that the logging company will make these calculations on the location if so requested. However, you have to furnish them with correct Rw and density values.

RECOMMENDATION

I have attempted to answer the questions raised and add what knowledge from experience I have to the overall picture.

My major recommendation is for BWIP to consider a geochemical Δ C soil survey over the RRL area. This, as referred to above, would give an areal or lateral extent to any major methane accumulations at depth. It would, however, not solve the whole problem as any geochemical halo found would almost certainly have to be drilled to determine the depth of origin.

Other recommendations would be to review and study the existing Landsat data, the aeromagnetic data, the gas analysis data for helium and have your biologists look into the bacteria cultures. Also, the geophysical log data run to-date could give some fair ideas as to existing gas saturations.

Internal Letter

Rockwell International

Date. September 8, 1982

No.

TO: (Name, Organization, Internal Address)
R. A. Deju

FROM: (Name, Organization, Internal Address, Phone)
G. S. Hunt

Subject: Consultant Report from Roger L. King, U. S. Bureau of Mines

Roger L. King and Dave Hyman of the Methane Control Group, U.S. Bureau of Mines, met with Basalt Waste Isolation Project (BWIP) staff members on August 4-5, 1982 to discuss the occurrence of methane in Columbia River basalt groundwaters. During that time, Mr. King and Mr. Hyman examined our sample collection equipment, reviewed the BWIP gas data base and discussed the fine points outlined in their attached report.

In his letter, Mr. King points out that sampling techniques and equipment currently used at Hanford are similar to those employed in Bureau of Mines' investigations. He also recommended evaluating gas emissions as a function of reservoir dewatering. This type of test can be performed in horizontal boreholes drilled from the Exploratory Shaft. Mr. King also indicated that the Bureau of Mines would be willing to provide technical assistance to BWIP on a long term basis through a cooperative agreement. This could include assistance on many facets of the mining phase of repository construction as well as future work related to methane gas.

If you have any questions regarding our meeting with Mr. King and Mr. Hyman, please contact me.

G. S. Hunt, Manager
Site Department

GSH/RWB/bac

Att.

cc: S. M. Baker
R. J. Bielefeld
H. W. Brandt
J. D. Davis
H. B. Dietz
R. E. Gephart
D. L. Graham
F. A. Spane
D. A. Turner
Rec. Ret. (2) L311

United States Department of the Interior

BUREAU OF MINES

PITTSBURGH RESEARCH CENTER
COCHRANS MILL ROAD
POST OFFICE BOX 18070
PITTSBURGH, PENNSYLVANIA 15236

August 25, 1982

Mr. Donald J. Brown
Rockwell Hanford Operations
Energy Systems Group
Post Office Box 800
Richland, Washington 99352

Dear Mr. Brown:

It was a pleasure meeting with you and your competent staff during Dave Hyman's and my visit with you recently. As we promised, here is the letter report we said we would send reflecting our opinion of your present program to ascertain the extent of methane in the Columbia River basalts and suggestions for additional research. The report is formated according to the 5-point agenda used during our meeting.

1. Origin of the Gas: Two possible origins have been identified - hydrocarbon derivatives of organic material in sedimentary interbeds and gases transported, possibly in solution with groundwater, from deep (below the Grande Ronde basalts) source rocks. The stratigraphy below the basalts is not currently known in the study area. Carbon isotope compositions can give an indication of the nature of the origin of gases but multiple diverse origins can "dilute" lighter biogenic methane with heavier thermally cracked methane. At present there is insufficient evidence to uniquely identify a methane source. Nitrogen in natural gas can indicate the thermal alteration of organic material but it is also associated with crystalline rock bodies and red beds. A paper Dave Hyman found recently may be of interest to you in this endeavor, and I have enclosed it for your review (Attachment 1).

2. Extent of the Gas Reservoir: The main areas shown to have a relatively high horizontal permeability are the flow tops of the flows whose lateral extent and variability is not mapped. The resolution due to low borehole density essentially precludes this. Tracer studies in conjunction with geohydrology studies would aid in mapping the extent of the reservoir(s).

3. Possible Safety Problems Associated with Repository Construction: Gas related regulations for noncoal mines as enforced by MSHA are found in the Code of Federal Regulations 30 Part 57 (Attachment 2). Noncombustible gases such as nitrogen can act as asphyxiants in the context of marginal ventilation and should be considered. Combustible gases, primarily methane can be maintained below explosive and legal limits through ventilation and degasification techniques when gas emission and reservoir characteristics are known.

4. Potential for Development of Energy Resources: The Columbia Basalt Plateau had a history of gas production during the early 1900's. The proposed 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories" addresses the need to characterize the resource potential of the site vicinity. Appropriate State of Washington agencies such as the Department of Natural Resources, Geology and Earth Resources Division, Olympia, Washington, 98504, should be of assistance to this end. Future gasfield production and/or increased irrigation well water production could impact the site hydrology and may require examination and perhaps modeling.

5. Additional Data to be Collected by BWIP to Address these Concerns: In many states water and/or petroleum-gas well drillers are required to file a log of their drilling activities (usually as a condition of licensing) and in addition there are private concerns that sell well log information. This subsurface data could aid in identifying potential gas source rock(s) and in addition provide extent-of-reservoir(s) information.

Extending the scope of current hydrologic testing to examining a 2-phase system and including tests to determine gas emissions as a function of dewatering a reservoir (as can occur during shaft and/or repository development) will go a long way to determine reservoir characteristics (porosity, permeability of gas and water, relative permeability of gas to water, etc). The utilization of a 2-phase (gas and water) model calibrated to the individual reservoir(s) by field tests would be a useful tool in assessing gas emissions into the pressure sink of an underground excavation. Your present measuring system for this data appeared adequate, however, if you desired to acquire commercially available equipment, we could suggest the following vendors from whom we acquire such equipment:

Water Separators

1. Kimray, Incorporated
52 N.W. 42nd Street
Oklahoma City, OK 73118
Telephone: (405) 525-6601

2. Sarco Company, Inc.
John L. Harvey Company
West 7 Trent Avenue
Spokane, WA 99201
Telephone: (509) 624-3002

Venturi's

1. Barco Venturi Flow Measurement System
Toucey Associates
3349 Industrial Boulevard
Bethel Park, PA 15102
Telephone: (412) 831-8363

2. Aeroquip Corporation
300 South East Avenue
Jackson, MI 49203

Holding Tanks

To enclosed specifications (Attachment 3)

I have also enclosed for your perusal a package of information regarding the capabilities and present research being conducted by the Bureau of Mines at the Pittsburgh Research Center. If you think you may want additional technical assistance on a long-term basis, we could establish a cooperative agreement. I have enclosed a copy of a typical agreement with this letter (Attachment 4). Please let me know if you have any desire to do so.

Sincerely yours,

Roger L. King

Roger L. King
Research Supervisor
Methane Control

Enclosures

cc: Mr. Robert Bryce

Bob. I have enclosures - however they are lengthy and did not seem to add much. 30 CFR 57 is probably in the library Sec 57.27 - 57.26

Other Enclosures are as follows:

1. Memorandum of agreement between BOM and the Gas Research Inst
2. Articles in Environmental Sci Tech. Vol 16 No 7, 198
a. Characterization of Organic Contaminants in Env. Samples Associated with Mt. St. Hellens 1980 Volcanic Erupt

WMEG AND WMGT DOCUMENT REVIEW SHEET*

FILE NUMBER: 3413.2

DOCUMENT: Quarterly Report, Rock Mass Sealing, June 1, 1983 - August 31, 1983, Contract No. NRC-04-78-271

REVIEWER: J. Rhoderick JR

DATE REVIEW COMPLETED: 1/3/84

DATE APPROVED: 1/4/84

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

Although high-level waste repositories will be located at sites with highly favorable isolation characteristics, two aspects that could create a concern with respect to radionuclide release, for any site, are manmade penetrations of the rock mass within or near a repository, and damaged rock zones with reduced isolation capabilities. The objective of this research project is to provide an experimental performance assessment of existing technology for sealing boreholes. This assessment will provide a factual database on the feasibility of successfully using presently available technology to reduce waterflow (and hence radionuclide migration) through boreholes near a high-level waste repository.

BRIEF SUMMARY OF DOCUMENTS:

This is a summary report of work performed during the period June 1, 1983 - August 31, 1983. This work is ongoing and has been reported and commented on extensively by the staff in the past. The ongoing work includes: experimental work at two field sites, laboratory dynamic testing of plugs, excavation induced damage to wall rock of boreholes, assessment of bentonite plugs, elevated temperature experiments, and investigations on the influence of size on the performance of the plugs.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

N/A

ACTION TAKEN:

N/A

ACTION RECOMMENDED:

N/A

Distribution:
WM file: 3413.2
WMEG r/f
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MJBell
JTGreeves
SMNeuder
HJMiller
JOBunting
PSJustus
MRKnapp
LBHigginbotham

*If an item is not applicable to a particular review, write N/A next to the item.