APPLICATION OF COMMERCIAL EXPLORATION TECHNIQUES TO SITE SELECTION AND CHARACTERIZATION

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ABSTRACT

Since 1976 the U.S. Department of Energy has conducted intensive geologic studies of the Hanford Nuclear Reservation in south-central Washington. With passage of the Nuclear Waste Policy Act of 1982 the process of search for a geologically suitable waste repository site became more structured, and it has been subject to outside review by the state, affected Indian tribes and other federal agencies, notably the Nuclear Regulatory Commission and the U.S. Geological Survey. This paper contrasts the USDOE approach with that of the mining and petroleum industries, highlighting fundamental differences in philosophy and techniques. It is proposed that the principle of "condemnation", which is fundamental in commercial exploration methods, could greatly benefit the USDOE siting program, which by comparison has been slow, costly and not very productive.

EXPLORATION PHILOSOPHY AND THE CONDEMNATION PRINCIPLE

Few graduate schools fully prepare geologists and geophysicists for responsible assignments in mineral and petroleum exploration. Beginners need conditioning under experienced managers in order to appreciate certain harsh realities of the extractive industries. Among these are (1) that a depleted mine or well has only a negative value, so that money must be spent continually to find and develop new reserves, but exploration costs directly reduce profits; and (2) that "dry holes" cost about as much as discoveries, so that the payoff from a discovery has to be far greater than its direct cost just in order to break even. In recent years the high cost of borrowed money has forced exploration managers to become extremely conservative and tight-fisted, saving their big money for nothing less than a virtual sure winner.

After learning basic skills in the field and the company's proprietary methods, a promising young geologist may be given some money to develop a play or prospect. Now on his own, he determines to bring in a major discovery - there are few greater thrills in one's career, quite apart from the material rewards.

Unfortunately this leads to the universal syndrome miners call "falling in love with the prospect". The field man pleads for just a little more time, only a little more money . . . and is frustrated when he is turned down and reassigned. In a given case he could be right, of course, but his exploration manager fully appreciates that the ratio of commercial wells to "dusters" is about 1 in 16, and that in mining only about 1 in 100 prospects or geophysical anomalies is even drilled, with only a small fraction of those drilled becoming operating mines.

What the exploration manager does is known as "condemnation". That is, he looks for evidence that will condemn the prospect, freeing his money and people to search somewhere else. This loss-cutting philosophy is universal in the exploration departments of all successful companies. It takes time for the individual to understand and practice it, however, which can lead to heated debate between the manager and his staff. A good exploration manager is constantly questioning, doubting and discounting all but unequivocally favorable information; if he does not, he will soon be out of business.

The Hanford Philosophy

The job of a company is to make money. The job of USDOE at Hanford, or elsewhere, is to find a repository site which can be licensed by NRC. While the company is looking for a commercial accumulation of petroleum or minerals, USDOE is looking for the absence of disqualifying features.

How does one proceed objectively to search for something he earnestly hopes is not there? This question has not been resolved within the repository community. But the system of rewards between a commercial operation and USDOE can be compared, along with the practical constraints.

Objectivity in the search for petroleum or minerals is enforced by the condemnation principle, and the constraint is defined in terms of the money available. Rewards for success are defined by profits and professional recognition.

Objectivity in the search for a repository site is harder to achieve, because there are lesser, and in principle no money constraints; Congress has set up the Nuclear Waste Fund through dedication of a portion of utility bills and told USDOE that if more is needed, it can be gotten. And the system of rewards is backwards - the discovery of a disqualifying geologic condition can clearly lead to the loss of work for USDOE's contractors and loss of jobs for their employees. Disqualification would create monstrous difficulties for USDOE as well; at Hanford and the Nevada site, both on controlled federal nuclear reservations, the avoidance of bitter (and probably losing) fights over condemnation of private land was a dominant factor in their selection as two of the three repository candidates.

Thus it is a credit to USDOE and its contractors that great efforts are made to work objectively, to obtain credible and quality-controlled data and to present the results in a carefully-documented academic format to outside reviewers. While these efforts are not universally successful, the fact that outside review by the states and NRC is a requirement in law means that any mistakes or omissions will eventually surface; the states have a further concern: that the site not be merely "good enough", but technically superior.

In some geotechnical areas the work is taking too long and costing too much. The work methods employed at Hanford, in at least the geological studies, are inefficient and not integrated, nor do they attack problems in a systems context.

GEOTECHNICAL STUDIES AT HANFORD

Enough is known about the Hanford site to state the critical "systems" question: can the longer-lived radionuclides in high-level wastes be safely contained at depth for long enough to meet the requirements of Title 40, Part 191 of the Code of Federal Regulations? This, by the way, is quite different from asking if they can be contained for long enough to pose little public health hazard; 40 CFR 191 is conservative.

The main geotechnical question then becomes: are there groundwater pathways through the layered basalts and interbeds which could introduce contaminants into the shallow aquifers and the Columbia River? These pathways could be diffuse, consisting of the pervasive intraflow fracture network, or they could be discrete, along faults, shears, and interbeds. Testing for diffuse pathways is difficult, slow and expensive, but that is where much of the effort is being expended. Under close scrutiny by state and federal agencies, USDOE is proceeding with this and parallel studies in geochemistry, rock mechanics and hydrologic modeling - all documented, quality controlled and carefully reviewed internally before release. There is also a program in regional and local tectonic analysis, involving fault mapping and geophysics, but it is slow-paced.

The state has criticized USDOE for not moving more quickly and energetically in the search for faulting and shears near the repository site. The point has been made that not all the geological and geophysical information available in the open literature and in proprietary (syndicated) studies for the petroleum industry is being used. The state's reasoning is that if there is a disqualifying fault or related pathway, the cheapest and best thing that could happen is to find it quickly and abandon the site. If it is found not to exist, then the other, more expensive and laborious studies can proceed, but the condemnation principal applies just as surely as if the exploration target is a valuable resource.

USDOE's responses have varied. In the case of one syndicated geophysical study, its cost (about $40,000) is noted as a constraint, but in most other cases USDOE proposes to examine these issues for consideration during Site Characterization, a statutory phase under the Nuclear Waste Policy Act, estimated at roughly 5 years and $1 billion at each of the three repository sites. At present USDOE and its contractors are preparing a Site Characterization Plan, anticipated for issue in 1987. These responses are perfectly appropriate under current USDOE ground rules, but are vastly different from industry practice.

HOW AN EXPLORATION MANAGER WOULD LOOK AT HANFORD

Many years of surface geologic mapping around and on the Columbia Plateau provide a framework for structural analysis, but the repository site itself has a thick alluvial cover. Drilling to and through the basalts is costly, in excess of $1 million per deep hole. Looking for vertical or high angle faults with vertical holes is not likely to provide much satisfaction.

An industry-trained geologist would begin by asking himself some questions. For example, what are the targets? In money, the target is a saving of $1 billion, less the cost of condemnation studies. Geologically, faults and shears capable of groundwater transport are the targets, with the understanding that not all such structures are inherent pathways. But if they are pathways, they may well be disqualifiers.

The geologist would assemble all available data to see what others have done, and how well they did it. He would find seismic (epicenter) maps since 1969, from the Hanford instrument network; medium-resolution USGS aeromagnetic and gravity maps of the surrounding region; an unevaluated state map of satellite photolineaments published in 1975; and of greatest interest, a 1978 Weston Geophysical high-resolution aeromagnetic map of some 15,000 sq miles, centered on Hanford, which was used in NRC licensing of a nearby nuclear power plant.

All these data would be assembled on a common scale and map projection, along with the field-mapped geology, as a stack of mylar transparencies. While aeromagnetic mapping proves nothing directly, the inferred geology can be checked against actual field mapping; in this case it would be evident that the degree of correlation between mapped faults and aeromagnetic linears is extremely high. That is, faults mapped in outcrops were also detected magnetically, and they can be extended into areas of alluvial cover with some confidence. The seismic and photolineament data would be found to complete a logical and consistent picture.

The picture would suggest that the Hanford repository site lies within a 5 by 6 mile rectangle bounded by four faults. The inferred precision of location would be about 1/4 mile. Considering the billion-dollar target, the geologist would propose a drilling program on the order of $10 million, deviating the holes at depth to intersect the suspect faults normal to their strike and at an angle greater than 30 degrees. The work would take up to a year with one rig; considering the widespread availability of rigs and expert drillers, he would recommend two in parallel to economize staff time.

A "discovery" in this exploration project would result in major dollar savings, plus clearing the way to focus resources on a better candidate site. "No discovery" would lend needed technical credence to other site studies at Hanford. Either way, it would appear advantageous to USDOE's national program to drill these anomalies before committing hundreds of millions of dollars to less focused studies.

DISCUSSION AND CONCLUSIONS

Expending $10 million on unproven or inferential geologic hypotheses is nothing new in industry practice. The condemnation principle often requires it. Since USDOE does not support the scenario described, it seems that either there is an institutional obstacle that needs articulation, or else the present

system of rewards in not working in the best interest of the general public.

In December 1984, a national panel examined management alternatives for the civilian nuclear waste program, recommending a federally-chartered corporation along with two other alternatives it thought superior to the status quo. Somewhere in this matrix there should be an approach which rewards sound, but otherwise disinterested application of science and engineering to the search for a safe repository site. The conclusions of this paper are that:

- In both theory and application, the industry approach, based on the condemnation principle, is superior to the classic technocratic procedures of USDOE, and
- There should be a deliberate and thoughtful review of management and program design alternatives which would encourage efficiency in site studies through adoption of more industry practices in the early stages of screening and exploration; the academic approach is unsuited to the task as it wastes time and resources.

It should be apparent that application of better site selection and characterization methods will have the highest payoff as more sites are available for consideration. Experience gained in the past four years suggests that identification and characterization of candidate sites should be started again from the beginning on a nationwide basis. If scientists and citizens believe the site search is being conducted objectively and non-politically, USDOE may well be able to make up the time lost so far, and to avoid years of costly and nonproductive litigation which are on the horizon today.