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SOLUTION (IN SITU LEACH) MINING OF URANIUM: AN OVERVIEW*

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In situ solution mining is an alternative to current uranium mining methods. Basically, the in situ method involves (1) the injection, via wells, of a leach solution into a uranium-bearing ore body, (2) dissolution of the contained uranium, and (3) removal of the uranium-bearing solution to the surface via production wells. Uranium is then extracted from the leach solution in a recovery plant through an ion-exchange process. The leach solution is renewed to the original concentration and recirculated through the ore body. Development of this new technology is paralleling renewed activity in the uranium mining industry.

Resurgence of activity within the uranium mining industry has been caused by the demand for uranium to fuel nuclear reactors used to generate electrical energy. This has contributed to a significant increase in the market price of uranium within the last several years. As both the price and demand for uranium remain high, smaller deposits and lower grade ores become economically viable as production sources. With these conditions, in situ mining has become an alternative to the conventional open pit and underground uranium mining methods.

Most of the known uranium deposits in the western United States occur in sandstones of fluvial origin. These sandstones were formed by ancient river systems and many of their former surface characteristics are evident in the present subsurface environment. Perhaps the most oustanding characteristic of these paleochannels is their variability.

Sandstone units occur as thin beds, thick lenses, or sinuous bodies. Sediment size (sands, silts, clays) can change rapidly in vertical and lateral directions. Specific characteristics of these deposits are of particular importance for in situ solution mining since the ore body is a basic part of the process circuit. The mineralogic and hydrologic properties of the ore body are pertinent factors in both the engineering design and environmental monitoring of an oper[illegible]

A uranium ore deposit must meet several criteria before it can be mined using the in situ technique. Generally, the ore deposits should: (1) be located in a saturated zone, (2) be confined by impervious layers, (3) have adequate permeability, and (4) be amenable to chemical leaching. It has been estimated that up to 50 percent of the known ore-bearing sandstone in the western U.S. can be mined using this solution mining method.[1]

Application of the in situ method to extract uranium is a recent development. One of the first attempts to use the method was undertaken by Utah Construction and Mining Company in the Shirley Basin of Wyoming during the 1960's. The solution mining operation was subsequently abandoned and the ore deposit was mined via an open pit.[1] In the early 1970's a number of pilot-scale facilities were constructed by various companies in Texas and Wyoming. The success of these test operations is evidenced by the scaling-up to commercial production facilities at a number of the sites. Currently, there are seven commercial solution mining operations with production capacities ranging from 70 to 450 metric tons of yellowcake per year. An estimated 20 to 25 pilot-test sites are in operation and most of these are expected to expand in the future.

In order for the solution mining method to be a viable mining alternative, the economics per pound of yellowcake produced must be comparable with the conventional uranium mining methods. Precise data is unavailable; a report from one company involved with both open pit and solution mining indicates that solution mining has an economic advantage.[2] In situ mining is particularly attractive because of the comparatively low front end capitol cost. While economic returns may be higher with the in situ method, the uncertainty in estimating resource recovery and production rates at the current level of technology may preclude any certain economic advantage. In addition, all economic analyses have excluded the cost of restoring the affected aquifer; mitigation of this environmental impact may be a significant factor.

Due to the nature of the operation, the extracting of any mineral resource results in a real impact on the environment. A conventional uranium mining (open pit) and milling operation will result in (1) temporary change in land use, (2) alteration of local topography, (3) removal of large quantities of groundwater from the mine, (4) the creation of a large tailings pile and (5) release of quantities of chemicals and radioactive materials to the atmosphere. When compared with a conventional operation, in situ leaching appears to offer a significant environmental advantage.

Surface disturbance is minimal since little excavation is required. The removal of vegetation cover and soil compaction with resulting erosion and sedimentation from well field operations are the primary surface impacts.

Since reclamation of the disturbed areas should be accomplished quite readily, the period encompassing the temporary change in land use should also be reduced.

Groundwater impacts and the disposal of liquid wastes are the primary environmental aspects associated with in situ leaching. These problems, however, are considerably smaller than those associated with a conventional uranium mining and milling operation. Assuming an ore grade of 0.1%, an estimated maximum of 16 tons of solid waste per ton of produced yellowcake would be generated by a solution mining operation compared to 1000 tons of radioactive waste (tailings) using conventional milling methods. Furthermore, the tailings from the conventional operation contain all of the radium-226 and other daughter products associated with the ore deposit whereas less than 5% of the radium in the ore deposit is brought to the surface during in situ leaching. The disposition of solid wastes from solution mining operations must be carefully planned to prevent the proliferation of numerous, small waste disposal sites which might negate the advantage gained from smaller quantities of radioactive materials reaching the surface environment.

Groundwater impacts, including withdrawal and contamination, are a primary concern with in situ leaching. Most of the withdrawal of groundwater occurs during the removal of residual leach solution and any dissolved contaminants after leaching has been completed. The quantity of groundwater required is dependent upon a number of factors including: (1) the restoration method, (2) type of leach solution, (3) character of the ore-bearing aquifer, (4) size of the well field, and (5) required groundwater quality.

However, it should be pointed out that since an ore deposit has to be dewatered, considerable quantities of groundwater must also be removed during conventional mining operations. Including aquifer restoration, it is estimated that solution mining would remove from one-half to one-third of the amount of water withdrawn by conventional mining methods.

Potential groundwater contamination is the primary impact associated with in situ leaching. Groundwater contamination can result from migrating leach solution (excursions) or incomplete restoration. Contamination from excursions is expected to be negligible because of the required monitor wells and well-field control capabilities.

The most widely used restoration technique involves the displacement of groundwater. This method, groundwater sweeping, involves the pumping of contaminated groundwater from the leached area which then causes uncontaminated surrounding groundwater to flow through the mined-out zone. The surrounding groundwater eventually displaces the contaminated groundwater thereby effecting restoration. The nature of both the contaminants and the surrounding groundwater influence the effectiveness of this restoration technique and a large number of displacements may be required to reduce the concentrations of some contaminants. This can require an extended period of time and considerable quantities of groundwater and has resulted in the search for other restoration methods. Presently, chemical treatment methods and groundwater recycle are being tested. While pilot leach sites have been satisfactorily restored, restoration has not yet been demonstrated for a commercial scale operation.

At the present, only carbonate-oxidant systems are being used in commercial operations. Tests on acid-oxidant systems are presently being conducted by one company in Wyoming. Cursory examination of the acid-oxidant system does not disclose any environmental advantages or disadvantages over the carbonate-oxidants system.

Two draft environmental impact statements have been completed for proposed commercial scale operations in Wyoming.[3,4] The state and Federal agency comments on these statements are being received and their attitudes on solution mining as a viable alternative will be discussed.

In situ leaching has been successfully demonstrated as a method for extracting uranium. However, it should be recognized that this technique is still in a developmental stage. There are as many variations of the technique as there are operators and each ore deposit can present a new set of challenges. Similarly, the environmental effects of the in situ method have not yet been fully defined. Investigations of the environmental effects must parallel the technological development of this method. Only then will in situ leaching become a fully acceptable alternative to conventional methods for mining uranium both in terms of economic costs and environmental impacts.

References

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