News briefs

Radioactive waste and sorption in natural systems

All countries operating nuclear power plants devote substantial resources to developing safe and final solutions for the disposal of waste, particularly high-level radioactive waste. The solution currently preferred by specialists consists in the emplacement of wastes in a deep and stable geological setting (granite, clay, tuff, salt formations) that has remained virtually unchanged for millions of years. The aim is to ensure that such wastes will remain undisturbed for the few thousand years needed for their levels of radioactivity to decline to the point where they no longer represent a danger to both present and future generations.

As a general rule, the natural security afforded by the geological formation chosen is enhanced by means of additional precautionary measures: wastes are immobilised in an insoluble form, in blocks of glass for example, and then placed inside corrosion-resistant containers; spaces between waste packages are backfilled with highly pure, impermeable clay; and the repository may be strengthened by means of concrete structures. These successive barriers are mutually reinforcing and together ensure that wastes can be contained over the very long term.

The safety authorities responsible for licensing the construction of waste repositories require that the operator perform a detailed analysis of what might happen were an unforeseen series of events to occur and, in particular, if the integrity of the containment system were to be breached, for example by an earthquake opening up fractures in the rock formations and resulting in the gradual flooding of the repository with groundwater. There are two major processes that need to be taken into account in the event of water entering into contact with waste products, namely, the leaching of radioactive products and the subsequent transport of radionuclides by the water through the various barriers mentioned above (i.e. the container, the layer of clay surrounding the waste packages and the geological formation containing the repository) to the biosphere. The leaching of radioactive products into the water would be an extremely slow process since wastes are immobilised in a form that is, in principle, insoluble; the barriers that the products would subsequently have to penetrate would considerably delay the physical movement of contaminated water; and, in addition, these barriers would in many cases be capable of partly removing the contamination from the water. This decontamination capability is attributable to a number of processes, the most important of which is referred to by scientists as "sorption".

Sorption is a major factor in the assessment of the safety of a radioactive waste repository. It is therefore important to develop mathematical models capable of predicting the level of sorption, as well as the degree to which it might vary, in the event of leakage from a repository.

To be credible, a model must obey the laws of science and chemistry and must be based on a

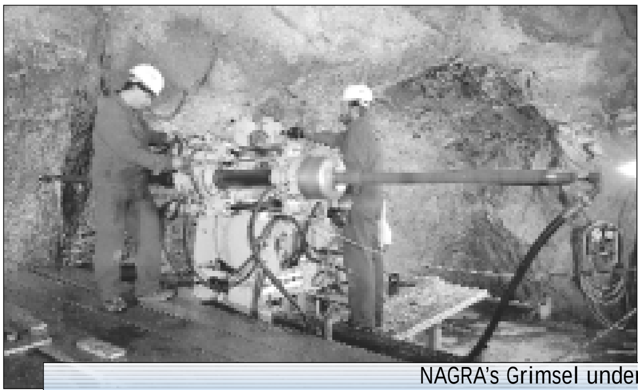
Geological and hydrogeological exploration of a mesozoic clay formation (opalinus clay) in Benken, Switzerland.

Comet Photo, NAGRA, Switzerland

large volume of experimental evidence. However, sorption is generally a complex phenomenon that cannot readily be investigated and that is influenced by a wide range of parameters. The precise conditions that prevail at great depths below the earth's surface are not easily reproducible in the laboratory, and identifying the chemical species present in the vicinity of the absorbing surface requires extensive investigative facilities. Measuring sorption is, therefore, a long and costly exercise. For many years scientists contented themselves with measuring the "overall" level of sorption in simple systems, the results of which were then extrapolated to the conditions actually prevailing in the environment.

The increased interest now being taken in ecological issues, and, in particular, the growing awareness of the scale of the problems posed by industrial pollution with regard to the management of drinking water supplies, have spawned a large number of university research programmes in recent years. Major progress has been made in basic research into sorption processes. Many of the results that have been obtained can be applied to the particular problems of concern to the nuclear industry. At present, scientists have a good understanding of the processes at work in simple chemical systems and scientifically verifiable models have been developed which can be used to produce credible extrapolations of experimental results and predict how sorption will vary in response to changes in the physical and chemical conditions in a given system.

The problem facing safety analysts in the case of radioactive waste repositories is the complexity of natural systems. Since scientists know how to model the sorption of a chemical compound by a single mineral, the next logical step is to consider natural rocks composed of several different minerals; that is to say, to develop a model for all the different types of complex systems that can occur in nature.




Comet Photo, NAGRA, Switzerland

NAGRA's Grimsel underground site in Switzerland,
used for geological and hydrogeological tests related to the disposal of radioactive waste.

Several modelling approaches, and even a number of models, have been proposed as part of an initial description of sorption in natural complex systems. In view of this diversity, it might well be thought that much work still remains to be done. Yet the successful results announced in the increasing number of papers presented at scientific conferences would seem to suggest that the modelling of sorption has now reached a certain degree of maturity. It should now be possible to work towards securing a broader international consensus on the most appropriate approaches for incorporating sorption into the long-term safety analysis of radioactive waste repositories.

Under the aegis of the NEA, which has substantial experience in this area, twelve organisations from ten NEA Member countries have decided to take part in an international comparative exercise. The aim is to attempt to demonstrate the predictive capabilities of various existing models by using them to interpret sorption measurements carried out on complex materials. Participants will be given a restricted amount of data to configure their models, which will then be run "blind" to predict the sorption in similar systems for which experimental results already exist. These predictions will then be compared with the measured data. Once the exercise has been completed a performance assessment will be made of the various modelling approaches proposed, in which the degree of accuracy of each approach will be compared with its intrinsic complexity, and the results published in a report.

The Sorption II project, which is self-financed by participants, was formally launched on 28 September 2000 at the inaugural meeting of its Management Board and is expected to run for two years. ■