CHAPTER 1

INTRODUCTION TO SECOND WORLD WIDE REVIEW OF GEOLOGICAL PROBLEMS IN RADIOACTIVE WASTE ISOLATION

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1.1 INTRODUCTION

The first world wide review of the geological problems in radioactive waste isolation was published by Lawrence Berkeley National Laboratory in 1991[1]. This review was a compilation of reports that had been submitted to a workshop held in conjunction with the 28th International Geological Congress that took place July 9-19, 1989 in Washington, D.C. Reports from 15 countries were presented at the workshop and four countries provided reports after the workshop, so that material from 19 different countries was included in the first review.

It was apparent from the widespread interest in this first review that the problem of providing a permanent and reliable method of isolating radioactive waste from the biosphere is a topic of great concern among the more advanced, as well as the developing, nations of the world. This is especially the case in connection with high-level waste (HLW) after its removal from nuclear power plants. The general concensus is that an adequate isolation can be accomplished by selecting an appropriate geologic setting and carefully designing the underground system with its engineered barriers.

There is the additional problem of isolating low- and intermediate level waste (LILW). Significant quantities of LILW are generated from various sources, and while they are not as long lived and do not pose the same level of difficulty as HLW, they constitute another, but important, problem for the nuclear industry.

Much new technology is being developed to solve the problems of waste isolation, and there is a continuing need to publish the results of new developments for the benefit of the international nuclear community. Thus, it was decided that after a five-year interval, it would be desirable to gather material on the latest developments and publish another review on the geological problems of radioactive waste isolation. As shown in Table 1.1, this second review contains reports from 26 countries.

1.2 SOME HIGHLIGHTS FROM THE SECOND REVIEW

1.2.1 Characterizing the Repository Site

Although no repository for HLW has yet been put in operation, significant progress has been made on this subject since the publication of the first review. To decide where to locate a repository for HLW requires a lengthy and detailed process of characterizing the rock mass in which the waste will be placed. Some countries have been working on this process for over ten years, and the wide variety of technologies that are described in this review reflects the fact that, in general, each country has its own internal constraints to satisfy. The process of site characterization can be significantly different depending on the particular type of rock that has been selected as a potential repository site.

The problem of locating a repository for LILW is not as difficult as for HLW, primarily because there is no heat release from the waste to cause temperature problems. Furthermore, a number of the reports in this review describe some well thought out procedures that have been developed to handle LILW. For example, in Slovenia[2], the siting process has been divided into four steps. In the first step, unsuited areas are omitted from consideration on the basis of certain exclusionary criteria. In the second step, the remaining acceptable areas are further reduced to potential sites according to land use, water resources, seismic and geological criteria. In the third step, several of the most suitable of the potential sites are chosen by comparing their locations on the basis of population, economic feasibility, transport, ecology, and public acceptance. In the final fourth step, a comprehensive analysis of the most suitable sites from the third stage is made by applying the criteria of the previous steps and an additional factor involving the corrosive nature of the soils, and then a detailed field investigation is carried out to confirm site suitability.

1.2.2 Maximum Repository Temperature

The problem of characterizing the potential repository site for HLW is complicated because of the heat generated by the decay process. If the HLW is not stored at the surface for a lengthy period so as to lose most of its thermal generating capacity, the heat released in the underground can raise repository temperatures well above ambient for thousands of years. In the immediate vicinity of the drift in which the canisters containing the waste have been placed, the temperature of the rock walls may reach as much as 200° C. This depends on the canister spacing and the thermal generating capacity of the waste. When one considers that the area of the repository may be several square kilometers in size, the mass of rock that will be thermally perturbed is significant, and as a result, the problems of understanding the factors that control the coupled behavior (thermal, hydraulic, chemical, mechanical) of such a rock mass are formidable.

As a result, it will be noted in this review that most countries have been following the lead of the early workers in Europe, who have adopted the practice of storing the spent, as well as reprocessed, fuel in surface cooling ponds for 40 to 50 years. This will dissipate the great bulk of the heat load, so that after emplacement in the repository, maximum rock temperatures will not exceed 100° C. This procedure has been adopted by practically all countries except United States where the cooling period may be no more than 10 years. Currently, the United States is investigating a potential site at Yucca Mountain in the State of Nevada where the rock is a fractured tuff. If a repository is eventually built at this site, the current conceptual repository design would produce maximum emplacement drift wall temperatures of approximately 155° C at about 40 to 60 years after emplacement.[3]

1.2.3 Rock Types Under Consideration

Another point of interest is the variety of rock types that are under consideration in the different countries where a repository may be built. In the first review, whch was mainly concerned with HLW, granitic rocks were the primary rock type under consideration, but it is evident in Table 1.1 that a much wider range of rock types is now being evaluated. In those countries where detailed investigations have been carried out since the first review, excellent summaries are presented of the new technologies that have been developed for several different rock types.

1.2.4 International Waste Management Systems

The establishment of international waste management

Table 1.1. List of countries and rock types being investigated where radioactive waste repositories may be locat-

Country	Rock Type for HLW	Rock Type for LILW	Country	Rock Type for HLW	Rock Type for LILW
Belarus	clay, salt	clay, salt	Japan	(1)	
Belgium	clay	clay	Korea		andesite
Bulgaria	granitic, marls		Netherlands	salt	
Canada	granitic		Poland	(1)	(1)
China	granitic		Slovakia	(1)	(1)
Croatia		(1)	Slovenia	marl	
Czech	granitic		Spain	(1)	(2)
Finland	granitic		Sweden	granitic	
France	(1)	(2)	Switzerland	clay, granitic	marl
Germany	salt	iron ore, salt	Taiwan		(1)
Hungary	claystone		Ukraine	granitic, salt	
India	granitic		United Kingdom	volcanics	
Indonesia	basalt		United States	tuff	

Note: (1) Not yet determined; (2) Surface facility.

systems has been suggested in the past and a number of studies has been undertaken[4,5,6,7] to address the inherent difficulties associated with the disposal of limited amounts of HLW exclusively within national borders. Such a system would be set up to accept and manage radioactive waste from countries with small nuclear energy programs and relatively small volumes of HLW. Bredell and Fuchs[8] and Lin[9] have recently discussed the feasibility of such systems, from technical, economical, institutional and ethical viewpoints.

The feasibility of an international waste management system is not discussed in detail in any report of this second review, but as one reads of the activities in the smaller counties (e.g., Switzerland[10], Taiwan[11], Ukraine[12]) it is clear that each one is becoming aware of a difficult situation in developing a viable program to handle the problems of isolating HLW. Asomewhat different aspect of the need for an international facility may develop in Indonesia[13] because this archipelago is one of the regions of the world with active volcanisim.

The need to consider international waste management systems has been discussed in a recent editorial by Issler[14], who raises some important arguments. From the economic standpoint, countries with relatively small nuclear energy programs and relatively small volumes of HLW are faced with solutions that are essentially uneconomic. A large proportion of the disposal costs is independent of waste volume, particularly those related to concept development, site selection and characterization and, to a large extent, construction and operation of the facility. The costs of site characterization can be very large. For example, the cost of the total effort to characterize the HLW site at Yucca Mountain in the United States is currently about $2.5 billion[15]. This is atypical of costs in Europe, but it serves as an upper bound to illustrate the magnitude of costs associated with this complex problem.

From the practical standpoint, it may be very difficult for small countries to find a HLW repository site that is satisfactory geologically and, at the same time, can satisfy planning restrictions. On the other hand, the geological situation in a particular country may not be favorable, and the country has no choice except to store the waste for an indefinite period. In this respect, regional repositories could provide a safer solution. And from the technical standpoint, the more advanced countries can help others that are disadvantaged by lack of infrastructure, restricted financial means, insufficient technical capacity, or lack of relevant know-how.

Issler has a very good point that puts the situation in context. The United States is planning only one or two repositories for its HLW. Europe, which is comparable in geographic area, has 18 of the 26 countries on Table 1.1, that need disposal facilities. Should 18 national repositories for HLW be constructed, or do not the economic and geologic considerations indicate that two or three regional facilities would suffice? It is understandable that acceptance of international solutions, particularly in the host countries, will be difficult to achieve, but the option of international waste management systems should be kept open and needs careful consideration.

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