The Pangea Concept for an International Radioactive Waste Repository

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SUMMARY

Pangea Resources Australia Pty. Ltd. is engaged in a study to investigate the feasibility of constructing and operating an international radioactive waste repository in Australia. Western Australian in particular has a unique combination of geology, topography and climate which makes it eminently suitable for a deep geological repository for the safe and permanent disposal of radioactive waste. Australia also has the political, social, legal and financial systems, together with the technical capability to make it acceptable as a host nation for an international repository. The establishment of an international repository in Australia would benefit the whole world as well as Australia.

1. INTRODUCTION

The Pangea concept can provide an integrated global radioactive waste management service. At the core of the concept is an international radioactive waste repository that can accept spent fuel for direct disposal, appropriately conditioned high level and intermediate level waste, and appropriately conditioned nuclear materials from global disarmament activities.

The site of the repository would be selected primarily on technical grounds to provide the highest levels of safety and the greatest ease in demonstrating safety. Pangea has developed a new approach for site selection in defining a series of "high isolation" site attributes, which then enable such potential sites to be readily selected, investigated, characterised and analysed for safety.

This paper reviews the origins of the Pangea concept, describes the high isolation approach to site selection, the Pangea integrated waste management system, together with its potential economic impact on Australia.

2. THE ORIGINS OF THE PANGEA CONCEPT

At this time neither the federal government nor the state government of Western Australia has endorsed the Pangea concept for an international repository in Western Australia. Pangea is currently engaged in a feasibility study in Western Australia and is not seeking any government endorsement or approval. Rather, within the context of examining the feasibility of the concept, Pangea seeks the opportunity to engage both governments in a reasoned and objective dialogue to examine the merits and benefits of the concept. Pangea also seeks to stimulate and to engage in an open and informed discussion with the public and those groups who have a direct interest in the Pangea proposal. In addition Pangea is informing other governments on the Pangea concept and the global benefits of an international repository for the safe and permanent disposal of high level nuclear waste and spent fuel.

The Pangea concept can be traced to the SYNROC Study Group, which began its activities in late December 1988. This was a vehicle set up by the Australian government to study the commercial potential for SYNROC in a global context. This work progressed towards a conceptual plan for a reprocessing facility located in Australia with a deep geological disposal facility to take the resultant immobilised high level waste, and to provide the option of direct spent fuel disposal. Pangea with a different set of supporting organisations - has built on some components of the SYNROC Study Group conclusions and combined these with new concepts.

Pangea is currently funded by BNFL, NAGRA and EHL. These organisations bring to the Pangea project the technical skills and the experience needed for all the components of the project, such as transport of nuclear materials, site selection and characterisation, performance assessment and safety analysis, repository design and project management. The current group of supporters and Pangea are

acutely aware that this project can succeed only with the support of the Australian people and the participation of Australian industry. It is a declared objective of Pangea to include Australian investors and to interact closely with Australian industry.

Recently it became obvious that a new nuclear waste disposal initiative was justified because many national waste repository programs were suffering delays, cost overruns, and, in some unfortunate cases, significant loss of investment due to failed attempts to site a geological repository. The unexpected complexity of making a safety case in highly complex geological conditions was a key factor contributing to these problems. Pangea believes that both scientific and public support would be more easily obtained if assertions of safety were based on simple and robust geological systems.

A further aspect of large and growing importance was the recognition that, with the end of the cold war, an enormous effort would be required to attain the crucial goal of total nuclear disarmament. To reach that goal there will be necessary to dispose safely and permanently of appropriately conditioned surplus nuclear materials as the world progresses towards nuclear disarmament. Most of the weapons grade material is likely to be converted to fuel for use in power reactors and an international repository for disposal of the resulting spent fuel would certainly expand the range of disarmament options available.

The Pangea concept was therefore developed with a strong focus on the long-term safety of the repository and on the security of weapons sourced nuclear materials. The safety aspect led to the development of the "high-isolation" concept for repositories which is described in the following section. The focus of the project is a deep repository located in suitable, very simple and stable geology, with flat topography with a stable arid climate. The security aspect is enhanced with a host country which has a history of strong support for non-proliferation, which has a stable democratic society, and which is trusted by the other nations of the world.

3. THE HIGH-ISOLATION APPROACH TO SITE SELECTION

The basic feasibility of geological disposal is accepted within the nuclear waste management community and the achievability of safe and permanent safe disposal has been asserted by many international experts and organisations. All states with nuclear power and related activities have active programs for repository development. No insuperable technical problems are foreseen for developing geological repositories by those directly responsible, or by the majority of the scientific and technical community. In the wider public and political circles, however, the perceptions are often different. Waste disposal programs are not widely regarded as being on a straightforward route towards successful implementation. In recent years there has been growing debate on other approaches such as long-term surface storage or advanced transmutation schemes – although neither of these can be regarded as a real alternative to deep geological disposal.

The single most important reason for this situation is the lack of public confidence in the ability of scientists to predict repository performance with sufficient reliability over the long time scales of relevance. Methodologies have been developed to at least scope the bounding behavior of disposal systems. However, safety assessments for deep geological repositories have become enormously complex. Within the technical area, the issue which has undoubtedly led to the most debate is the characterization of the geological environment at a potential repository site. The geological media being investigated and characterised are mostly complex and heterogeneous on the scales of relevance, and this has turned out to be a much more challenging task than was appreciated in early years.

Pangea, using the knowledge and experience gathered over decades of involvement in site investigation, characterisation and performance assessment in many repository programmes, has developed a new approach. Unrestricted by political boundaries, Pangea considered the necessary attributes for a repository site which would not only make it extremely safe but also so simple that the safety case could be readily demonstrated to the public as well as the experts. A set of attributes for such a site was developed, based on consideration of the features, processes and events taken into account in state of the art safety analyses of repositories. These characteristics which can be identified as essential or as favourable can be summarised as follows:

- Stable geology (needed because of the long isolation times aimed at)
- Flat topography (reduces driving forces for groundwater movement)
- Near-horizontal sedimentary strata (simpler to investigate and extrapolate)
- Stable, arid climate with negligible erosion (eases problem of extrapolation)
- Low permeability (host rock formation reduces groundwater movements)
- Old and saline groundwater (indicates extremely slow groundwater movement; non-potable)
- Stratified salinity (counteracts thermal buoyancy effects)

- Reducing geochemical conditions (reduces solubilities of radionuclides)
- Absence of complex karst systems (avoids complex hydrogeologic modelling)
- Low population density (reduces intrusion risks)
- No significant resource conflicts (reduces intrusion risks)

In principle, the safety assessment for a high-isolation site with the above attributes will not differ from safety assessments for other repository programs. In practice, the high isolation concept is aimed at easing the burden of demonstrating safety by choosing a system with as many positive safety characteristics as is feasible. The objective is to choose a site and a repository design that are of intrinsic high quality with respect to safety and are also amenable to a reliable assessment of safety. The safety case for a high-isolation site may be different from that for more conventional sites because of the low energy natural system, which has extremely low driving forces for any processes which could lead to nuclide release and transport away from the repository. This would make it easier to model groundwater flow scenarios of the types that are central to most conventional safety assessments. Direct evidence of extremely long residence times (e.g. by age dating, salinity profiling) will be an important indicator of stability. The safety case for a high isolation site may however need to focus more upon potential effects on the natural system due to disturbances introduced by the repository itself.

A survey of the world aimed at identifying large, flat, historically-arid areas with stable and simple geological formations quickly lead to a group of areas which were part of the original Pangaea super-continent. This land mass started to break apart some 200 million years ago, with Australia separating from Antarctica about 80 million years ago. Remaining in the continents of the Southern Hemisphere are areas which have not been subjected to large tectonic forces nor to the influences of repeated glaciation. The largest contiguous stretch Pangea geology is in the desert basins of Western and South Australia.

In addition to the natural attributes of high-isolation sites, further selection criteria were applied, based on the technological capabilities, the non-proliferation credentials, the societal stability, the political and legal system, and the economic status of potential host countries. As a result, the feasibility study is focused on Western Australia where extensive regions appear to satisfy the appropriate geological, climatic and environmental criteria.

4. THE PANGEA INTEGRATED SYSTEM AND ITS ECONOMIC IMPACT

The total waste management and disposal system foreseen by Pangea includes the conditioning, packaging and transport of spent fuel or wastes within the client country, international transport in a fleet of special purpose ships to a dedicated port in Australia, rail transport to the repository site, a surface buffer storage and final disposal in the repository 500 to 1000 m below the surface. The reference project provides for disposing of an inventory corresponding to around 75'000 tonnes of spent fuel, plus high level and intermediate level waste, over a 40 year operating life. However, there are no fundamental reasons for either limit. At the current feasibility study stage, designs are at the conceptual level and costs are partly by analogy with existing and planned facilities elsewhere.

Broadbrush estimates, give the following picture of costs and benefits. The total investment in the Pangea project will be about $10.5 billion. The annual costs associated with the operation of the repository, together with the transport and handling of the cargo from the waste generators to the repository will be in the order of $0.8 billion. It is estimated that about 23,000 jobs will be created during the construction of the sea terminal, rail link and repository and in the manufacture of transport casks, disposal packages and ships. The operation of the facilities is likely to provide long-term employment for about 2000 people. Many of the positions created will be in areas of high technology, engineering and science. In addition, there will be employment in the necessary service industries. The revenues generated over the 40 year operating life of the Pangea project are estimated to be about $200 billion, with about $90 billion returned to governments in royalties and taxes. Finally, the economic boost of the project to Australia will provide further opportunities for employment. The economic impulse to the Australian economy has been estimated by Access Economics to be of the order of 1% of the Gross National Product of Australia over the 40 year reference operating life.

5. CONCLUSION

The Pangea concept for an international radioactive waste repository can provide a unique Australian solution to a global problem the safe and permanent disposal of radioactive waste. Australia has a combination of geology, topography and climate which satisfy the criteria of a high isolation site and make it highly suitable for hosting a deep geological repository. In addition Australia has the political, legal, financial and social systems which would make it acceptable to other nations as a host country for such a repository.

Consequently, the establish ment of an international radioactive waste repository in Australia, with its unique combination of natural and social attributes, can benefit the whole world as well as Australia.