

Geological Sequestration -Radwaste- Long-term tectonic stability

1. Introduction

High level radioactive waste should be isolated from the human environment for some 100,000 years. One of the major questions of geologic disposal of high level radioactive waste is how we predict that changes in the geologic environment would not damage the confinement of radioactive waste over the next 100,000 years or longer. The Japanese Islands are composed of island arcs along boundaries among four major plates: Eurasia, North America, Pacific, and the Philippine Sea plates. Island arcs are tectonically mobile due to direct effects of plate interactions. High level radioactive waste disposal requires the confirmation of extremely long tectonic stability. However, radioactive waste will become harmless in some limited future due to the decay of radionuclides.

Japan has very little reserves of conventional energy resources. The fear of global warming would also limit the use of fossil fuels. Japan's energy policy includes reprocessing of spent nuclear fuel and utilization of the plutonium and recovered uranium in atomic power plants. High-level radioactive waste (HLW) in liquid form, produced at reprocessing plants, is to be vitrified into a stable form, stored 30 to 50 years for cooling, and finally disposed of in geologic formations deeper than several hundred meters. Japan's current research on high level radioactive waste disposal emphasizes the generic validation of the geologic disposal concept in the Japanese islands,

analysis of multi-barrier systems, disposal technology, and a general survey of Japan's geologic environment for a forthcoming site selection process that is expected in the early 21st century.

Research and development for the safe disposal and storage of radioactive waste in Japan is carried out by several organizations; Japan Nuclear Cycle Development Institute (JNC, former PNC), Japan Atomic Energy Research Institute (JAERI), Radioactive Waste Management Center (RWMC), Geological Survey of Japan (GSJ), Central Research Institute of Electric Power Industry (CRIEPI), and other organizations. Total planning and supervision is under the authority of the Atomic Energy Commission (AEC), Nuclear Safety Commission (NSC), Agency of Natural Resources and Energy (ANRE) of the Ministry of International Trade and Industry (MITI), and the Science and Technology Agency (STA).

The Geological Survey of Japan investigates scientific bases of geological sequestration of radwaste as the national research institute of comprehensive geosciences. Current major research areas related to radwaste sequestration include the geological predictions of long-term tectonic stability, groundwater flow, and geochemical interaction of waste-rock-water systems with a special emphasis on natural analogue studies. New research such as geological databases and three dimensional mapping of underground environments are emerging important research themes.

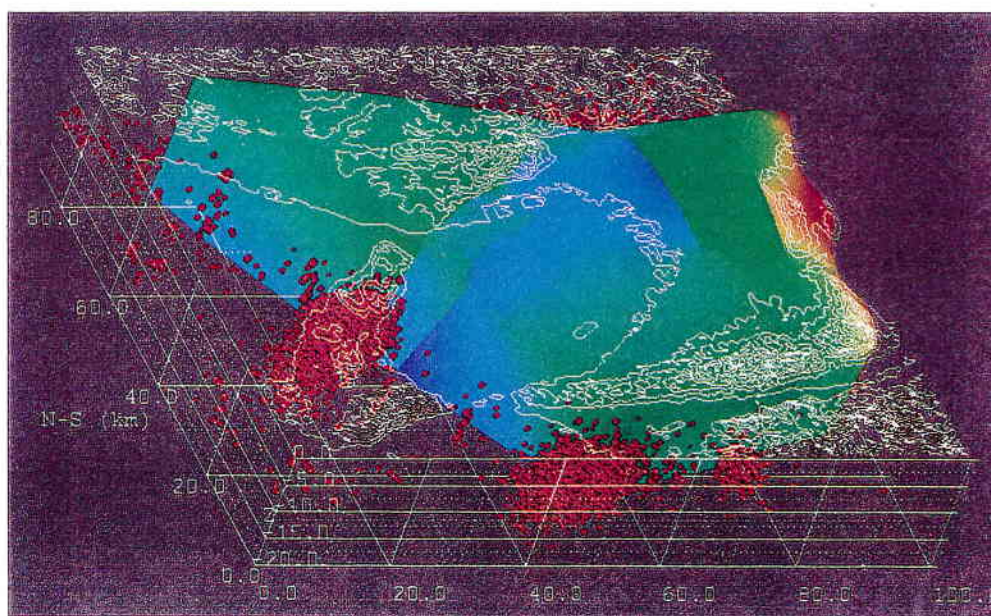


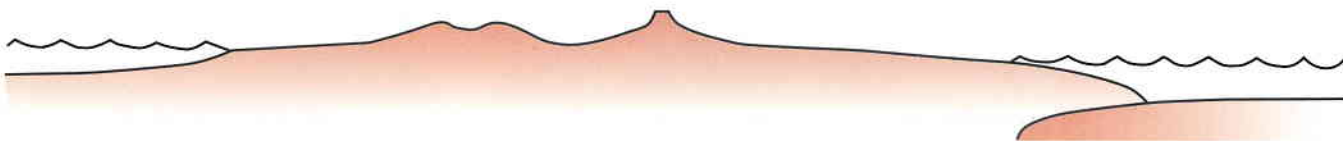
Figure 1. In a numerical simulation, subsidence (blue areas) and uplift (green, yellow and red areas) are divided by active faults that induce earthquakes (red balls) near the Osaka - Kobe region (Courtesy RWMC).



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2. Geologic prediction

The prediction of long-term tectonic stability and water-rock interactions are key issues for performance assessment of waste disposal, especially in an island arc region. Long-term geologic prediction is not necessarily more difficult than short-range prediction. Since it is usually difficult to pinpoint the exact time of occurrence, we may usually only suggest a broad range of possibility.

A systematic approach is necessary for the geologic prediction of long-term tectonic stability because prediction by a single method is not reliable enough for the safety assessment of waste disposal. Methods for geologic prediction are classified as follows:

- (1) Prediction by extrapolation: The most fundamental method for geologic prediction is effective especially in slow steady-state processes.
- (2) Prediction by analogy: Natural analogues provide reliable validation for long-term prediction.
- (3) Prediction by probability: Statistical research may be indispensable to the assessment of catastrophic events.
- (4) Prediction by experiment: Laboratory and in-situ experiments are essential to exact understanding.
- (5) Prediction by conceptual model: The plate tectonic model is useful for prediction of tectonic movements.
- (6) Prediction by numerical simulation model: Tectonic movement is predicted by a numerical model (Fig. 1).

(7) Prediction by safety assessment model: The safety assessment of complex disposal systems requires the development of synthetic models, scenario analyses, and consequence analyses.

3. Tectonic stability

Frequent earthquakes and numerous active faults clearly indicate severe deformation of the crust in and around Japan. Volcanic eruptions and abundant hot springs suggest intensive underground geothermal and magmatic activity in some regions.

The speed of ordinary geologic processes, however, is much slower than that of human activities. Tectonic movements faster than 1 mm/year occur only in a few restricted regions near plate boundaries, volcanic fronts, or major active faults. Volcanic activity takes place only on the continental side of the volcanic front. There are virtually no possibilities of igneous intrusions between the subduction zone and volcanic front in an island arc. Active faults and big earthquakes are rare and there is no volcanic activity in the thick rigid "fore-arc wedge" between the subduction zone and volcanic front. There exist tectonically stable blocks in island arcs between the subduction zones and volcanic front (Fig. 2).

The great regional variation of the geologic environment in the island arc will make forthcoming investigations for site selection very important for the safe disposal of radioactive waste.

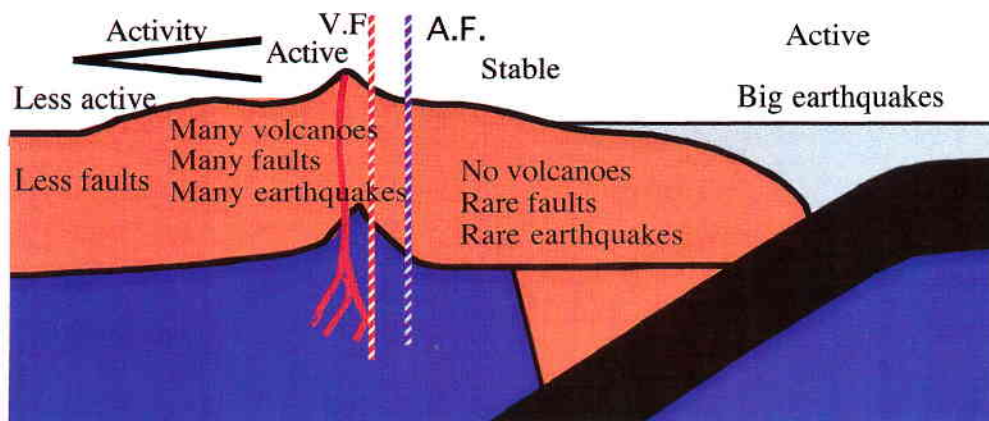


Figure 2. Tectonically stable zone in an island arc region. V.F. and A.F. denotes volcanic front and active fault front, respectively.

For more information contact:

Hitoshi KOIDE

Environmental Geology Department
Geological Survey of Japan

1-1-3 Higashi, Tsukuba, Ibaraki, 305-8567 Japan

phone: +81-298-54-3801

fax: +81-298-54-3801

e-mail: MXE02263@nifty.ne.jp

web site: <http://www.aist.go.jp/GSJ/>



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