

# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

## TRIP REPORT

**SUBJECT:** Natural Analogues: Their Application to Repository Safety Assessment and Stakeholder Communication. NAnet International Workshop (06002.01.141.017)

**DATE/PLACE:** May 11-13, 2004  
Château de Cadarache, France

**AUTHOR:** David A. Pickett

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### Dates of Travel and Countries/Organizations Visited

May 11–13, 2004  
Château de Cadarache, St-Paul-lez-Durance, France

### Author, Title, and Agency Affiliation

David A. Pickett, Senior Research Scientist  
Center for Nuclear Waste Regulatory Analyses (CNWRA)

### Background/Purpose

The purpose of this trip was to present an invited talk at the workshop “Natural Analogues in the Design, Decision and Demonstration of Radioactive Waste Disposal - NANet International Workshop.” NANet (natural analogue network) is a European Commission-funded project that, in the words of the workshop announcement, “has the objective of adding value to existing information on natural analogues by identifying new and improved ways for increasing their use in radioactive waste disposal projects, most notably by the performance assessment and communication experts in waste management and regulatory agencies.” The workshop was a key activity for the project, which will be completed at the end of 2004. NANet draws on partners from waste disposal companies, regulatory agencies, and consultancies in eight European countries. The central activity of NANet has been to critically review and assemble information in the field of natural analogs to nuclear waste disposal.

The talk was titled “Natural Analogs and the Yucca Mountain Review Plan: NRC Perspective,” and was previously given by me at a September 2003 workshop sponsored by the Electric Power Research Institute. The presentation explains the role of natural analogs in 10 CFR 63 and in the NRC plan for reviewing a license application for the potential high-level waste repository at Yucca Mountain. The organizers were interested in including a regulatory perspective in the workshop, and had seen the September 2003 presentation.

### Abstract: Summary of Pertinent Points/Issues

Several European countries, as well as Japan, were represented at the workshop, but there was also a strong United States contingent. The Nuclear Waste Technical Review Board sent a board member (R. Parizek) and staff member (D. Diodato), and four Department of Energy contractors attended (two of whom made presentations). The United States perspective was of particular interest, given the scheduled submittal of a potential license application this year. The

workshop consisted of one day of formal talks and a small number of posters, followed by a second day devoted to eight-member discussion groups that addressed questions posed by the NAnet coordinator. Conclusions reached by the groups focused on the need for the natural analog community to continue emphasizing applications more than academic investigation, and the importance of tailoring natural analog information more precisely on the different target audiences and various stages of repository investigation and development. Attendance at this workshop allowed presentation of the NRC perspective on the use of analogs to both United States and international audiences. In addition, feedback at this meeting from multiple international nuclear waste programs provided current perspectives on the usefulness and limitations of natural analogs.

### Discussion

Bill Miller (Enviros Consulting, United Kingdom) introduced the workshop by describing the NAnet project. He stated that a large amount of useful scientific information had been produced by past natural analog studies, but that there was no consensus on how analogs should be employed in repository programs, the studies were not well integrated with laboratory and modeling efforts, and application to performance assessment was limited. NAnet is focused on helping "take stock" of natural analog information in light of the maturity of repository programs, recent focus on multiple lines of reasoning, and recognition of the need to communicate with stakeholders. The project has produced summaries of natural analog studies that follow a standard review template and has fed that information into matrices that help organize available analog data and results along the lines of waste types, repository conditions, and processes affecting waste isolation. The end product toward which NAnet is striving is a database of analog sites with detailed information and references, as well as critical reviews that may help guide their application.

Maria Jose Gimeno (University of Zaragoza, Spain) described a Spanish project that has produced a detailed, comprehensive catalog of analog sites and their uses in repository safety assessments. Though the project has necessarily focused on analogs that are relevant for the Spanish disposal concept, it has produced a database structure that most attendees agreed should be useful to NAnet as a template. The uses of analog information in performance assessments in the Spanish program include: support for screening features, events, and processes, helping develop conceptual models, and supporting parameters.

The German natural analog program, focused particularly on repository processes, was the subject of a talk by Matthias Beushausen (Federal Office for Radiation Protection, Germany). Because a final site for high-level waste disposal has not yet been selected, the German program may offer an opportunity to formalize the use of natural analogs at an early stage.

Dora Yoshida (University of Nagoya, Japan) then discussed the Japanese analog program, which, in the absence of a designated disposal site, focuses on long-term stability of the geological environment in a tectonically active country and on public communication. An area of strong scientific emphasis has been on the development of fracture systems in crystalline rock, due to their potential for providing radionuclide transport pathways.

DOE natural analog activities were summarized by Pat Dobson (Lawrence Berkeley National Laboratory), who first broadly covered how DOE has used analogs to support analyses of each component of the proposed Yucca Mountain repository. This summary should soon be

available in a revision to the DOE Natural Analogue Synthesis Report. Dobson then discussed in some detail the current project at the Nopal I uranium deposit, Peña Blanca, Mexico – the site of past NRC-sponsored studies by the CNWRA. Interesting preliminary results of drilling and coring at the site include observation of a gamma activity peak at the water table in all three wells, suggestive of secondary accumulation of uranium released from the ore deposit. In addition, evidence for drilling-related uranium mobilization is being evaluated. Chemical and isotopic analyses of water and core samples are underway. Notable planned activities include: (i) imposed seepage through the ore body in the unsaturated zone involving tracer studies, (ii) detailed analysis of colloids (notably hematite, goethite, and clays), (iii) cross-well tracer tests, and (iv) testing and validating performance assessment models for unsaturated and saturated zone flow and radionuclide transport.

After my presentation (see “Background/Purpose” section and attachment), Jonathan Pearce (British Geological Survey, United Kingdom) reported on an application of natural analogs outside the nuclear waste disposal arena. A European Commission-sponsored project named NASCENT (for “Natural Analogues for the Storage of CO<sub>2</sub> in the Geological Environment”) was established to conduct studies on natural occurrences that would help in understanding the potential risks of CO<sub>2</sub> sequestration. For example, analogs have supported physical and chemical models of extensive CO<sub>2</sub>-rock interaction that could compromise a CO<sub>2</sub> disposal site. Also, observations of natural CO<sub>2</sub> leakage from the subsurface have shed light on potential human hazards such as rapid sinkhole formation due to CO<sub>2</sub> migration. The talk was intended to illustrate how application of natural analogs has proven useful in other areas.

Another talk from the DOE Yucca Mountain repository program followed. John Stuckless (United States Geological Survey) demonstrated the use of natural and anthropogenic analogs in public education by presenting a series of qualitative analogs that, he asserted, showed the ability of an unsaturated-zone repository to remain dry and stable. Examples came from a wide variety of geologic and hydrologic settings.

Les Knight (Nirex, United Kingdom) ended the oral presentation session with a talk titled “An Alternative View of Natural Analogues.” The main point of the presentation was that natural analog studies are an extension of the concepts of uniformitarianism and reasoning-by-analogy that are ubiquitous in geologic studies of all types – including site characterization. Therefore, natural analogs are used much more commonly than thought; even when studies are not explicitly defined as under the “natural analog” heading.

The second day of the workshop was devoted to meetings of five working groups of seven or eight members each, followed by a discussion of group findings. I was co-chair of a group chaired by John Smellie (Conterra, Sweden) with members Karel Kunc (Radioactive Waste Repository Authority, Czech Republic), Pedro Hernan (Empresa Nacional de Residuos Radiactivos, Spain), Phil Richardson (Enviros, United Kingdom), Kari Rasilainen (VTT Technical Research Center, Finland), and Pat Dobson. The group discussed 14 questions posed by the organizers. The first question asked concerned the NAnet definition of an analog; our group decided on the following wording:

An analogue is a natural, archaeological, anthropogenic, or industrial system with some definable similarity with one or more components of a radioactive waste repository, its surrounding environment, and processes that control its evolution.

Many of the questions addressed the NAnet compilation of analog sites, with the group making specific recommendations regarding comprehensiveness and the structure and level of technical sophistication of the matrices by which sites are organized and described. Among other items of consensus within our group were:

- Natural analog studies should remain a separate area within repository programs, but should inform, and be informed by, site characterization and laboratory studies.
- It is not practical to quantify the usefulness of an analog, because successful applications are not necessarily quantitative.
- Any single process studied at an analog site should not be analyzed in isolation from the specific regional setting.
- The Spanish effort at initiating development of an analog database should be adopted by NAnet.
- The lack of recognition of natural analogs in performance assessment has many root causes, and can best be bridged by greater integration of performance assessment groups into the planning, execution, and interpretation of natural analog studies. Better integration would have the dual benefits of (i) raising awareness of the role that natural analogs have had, and can have, in model development, and (ii) ensuring that the natural analog community responds to the real needs of performance assessment.

Each group presented its findings in the final plenary session of the workshop. Many common themes emerged similar to those listed above. Among other groups' notable findings were:

- The natural analog "message" should be tailored to each of three audiences: technical workers, decision-makers, and the general public.
- The best use of analogs in the licensing stage of repository development could be in model validation.
- Earth scientists need to resist the tendency to downplay their degree of certainty.
- Natural analog workers need to pay more attention to methods for effectively communicating with the public.

The reference to public communication in the final bullet emphasizes how the regulator's perspective on natural analogs differs from the approach of many of the attendees. NRC concerns itself not with how well the analog message is communicated, but with the technical correctness of application. Nevertheless, the communication tools discussed at the workshop (e.g., analog site databases) should aid regulators in gaining access to relevant information in evaluating a licensee's safety case.

Miller stated that an informal proceedings document will be prepared, and the group discussion findings will be incorporated into the final NAnet report. He predicted that the shift in focus of the natural analog community from more academic studies to applications will gain momentum in coming years.

#### **Pending Actions/Planned Next Steps for NRC**

None.

**Points for Commission Consideration/Items of Interest**

None.

**Attachments**

"Pickett NAnet Analogs.ppt": David Pickett presentation "Natural Analogs and the Yucca Mountain Review Plan: NRC Perspective," in Microsoft PowerPoint format.

**"On the Margins"**

The United States natural analog community was recognized at the meeting as among the more active in recent years, and there was a great deal of interest in how analogs will figure into the potential Yucca Mountain repository licensing process.

**SIGNATURES:**

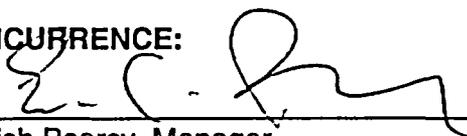


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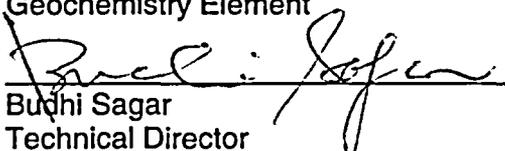
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# Natural Analogs and the Yucca Mountain Review Plan: NRC Perspective

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Presented at Workshop on "Natural Analogues in the Design, Decision,  
and Demonstration of Radioactive Waste Disposal"  
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S O U T H W E S T R E S E A R C H I N S T I T U T E

Center for Nuclear Waste  
Regulatory Analyses

# Natural Analogs in Code of Federal Regulations, Title 10, Part 63

- No specific requirements
- Natural analog studies are mentioned as potential elements of supporting information for models assessing performance, e.g., 63.21(c)(15), describing the Safety Analysis Report:
  - “Analyses and models that will be used to assess performance of the geologic repository must be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies.”



# Natural Analogs in the Yucca Mountain Review Plan (YMRP Rev 2; NUREG-1804)

- Restricted to sections on post-closure performance assessment.
- One type of information source that may be used (i) by DOE to support models and parameters or (ii) by NRC staff to evaluate DOE models and parameters.
- Scenario analysis and event probability, e.g.,
  - Review Method on FEPs screening (§ 2.2.1.2.1.2): “Consider information from site and regional characterization, natural analog studies, and the repository design, during this evaluation.”
  - Acceptance Criterion on probability models (§ 2.2.1.2.2.3): “Probability models are justified through comparison with output from detailed process-level models and/or empirical observations (e.g., laboratory testing, field measurements, or natural analogs, including Yucca Mountain site data).”



# Natural Analogs in the YMRP (cont.)

- Model Abstractions: mentioned in all 14 sections, typically under data and model justification, data uncertainty, model uncertainty, and model support, e.g.,
  - Degradation of Engineered Barriers (§ 2.2.1.3.1.2), Review Method on Data Uncertainty: “Confirm that the U.S. Department of Energy has used parameters...that are based on laboratory experiments, field measurements, natural analog or industrial analog research, and process-level modeling studies, conducted under conditions relevant to the range of environmental conditions in the emplacement drifts located in the unsaturated zone at Yucca Mountain.”



# Natural Analogs in the YMRP (cont.)

- Radionuclide Transport in the Unsaturated Zone (§ 2.2.1.3.7.3), Acceptance Criterion on Data Sufficiency: “Data...used in the total system performance assessment abstraction are based on appropriate techniques. These techniques may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies.”
- Volcanic Disruption of Waste Packages (§ 2.2.1.3.10.2), Review Method on Model Uncertainty: “Examine the model parameters, considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies, and evaluate their consistency.”



# Natural Analogs in the YMRP (cont.)

- Item 20 in Appendix B, Acceptance Review Checklist:
  - “An explanation of measures used to support models for performance assessments. These models should be supported using an appropriate combination of methods such as field tests, in situ tests, laboratory tests representative of field conditions, monitoring data, and natural analog studies.
    - Accept for Review
    - Accept, but Request for Additional Information Prepared
    - Reject, Inadequate to Support Detailed Review”



# NRC Natural Analog Activities

- Peña Blanca – as a geochemical analog
  - Alteration
  - Fracture transport
  - Recent mobility
  - Basis for two optional source terms in Total-system Performance Assessment (TPA)
  - Potential implications of uranium isotope fractionation, decay-series disequilibrium



# NRC Natural Analog Activities (cont.)

- Igneous Activity
  - Active basaltic eruptions for tephra dispersal processes: Cerro Negro, Nicaragua; Tolbachik, Russia
  - Historically active volcanoes for eruption processes: Tolbachik, Russia; Sunset Crater, AZ; Heimaey, Iceland; Parícutin, Mexico
  - Eroded volcanoes for subsurface characteristics: San Rafael, UT; Fortification Hill, NV
  - Volcanic fields for evolutionary patterns: Reveille Range-Lunar Crater, NV; Big Pine, CA; Cima, CA; San Francisco Volcanic Field, AZ



# NRC Natural Analog Activities (cont.)

- Container Life
  - Literature review of meteoritic iron plus a small number of naturally occurring alloys
  - Experimental and literature study of josephinite – natural iron-nickel alloy (55-75 percent Ni)
  - Archeological analogs
- Unsaturated Flow
  - Bishop Tuff, California (analog silicic tuff, e.g., infiltration, fracture- and fault-related permeability effects)
- Seismicity
  - Bishop Tuff (normal fault system development)



# Summary

- No regulatory requirements
- YMRP suggests natural analogs as one component of support for models and parameters
- NRC analog studies are diverse and focused on key technical issues



# Acknowledgment

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