NATURAL ANALOG RESEARCH

AT THE

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

William M. Murphy and English C. Pearcy

Presented to the Nuclear Waste Technical Review Board

Reno, Nevada
April 16, 1991

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Project: Geochemical Analog of Contaminant Transport in Unsaturated Rock

Objective: Design and Conduct an Analog Study Relevant to Yucca Mountain to Evaluate the Use of Analogs in Site Characterization and Model Validation

Sponsor: Nuclear Regulatory Commission Office of Nuclear Regulatory Research

NRC Program Manager: Linda Kovach
CNWRA Project Manager: John L. Russell
Principal Investigators: William M. Murphy and English C. Pearcy

Project Status: Literature Review Completed
Site Selection Investigations Initiated

Project Forecast: Selection of Site(s)
Formulation of Site-Specific Research Objectives and Design
Collection and Interpretation of Data

OBSERVATIONS ON NATURAL ANALOG STUDIES

A repository for high-level nuclear wastes requires knowledge and confidence in a system over a time scale exceeding that of human civilization. Only geologic systems permit direct study of chemical isolation and transport phenomena over the required time and space scales.

The concept of a geologic repository is based on natural analog reasoning. Many geologic systems are proven to have been stable for millions or billions of years. Analogous systems could safely isolate nuclear wastes.

Geology can also provide useful analogs of unfavorable systems. For example, the genesis of ore deposits illustrates massive elemental migration and concentration processes.

Natural analog research can be conducted at small and specialized scales as well as large and interdisciplinary scales.

Key uses of natural analog studies are the identification and evaluation of large space- and time-scale processes and mechanisms, and the validation of qualitative and quantitative models of repository performance.

Natural analog studies suffer basic limitations including the incomplete geologic record, difficult assessment of initial and boundary conditions, partial or imperfect analogy, and nonunique interpretations.

COMPARISONS OF A YUCCA MOUNTAIN REPOSITORY AND POSSIBLE GEOCHEMICAL ANALOG SITES

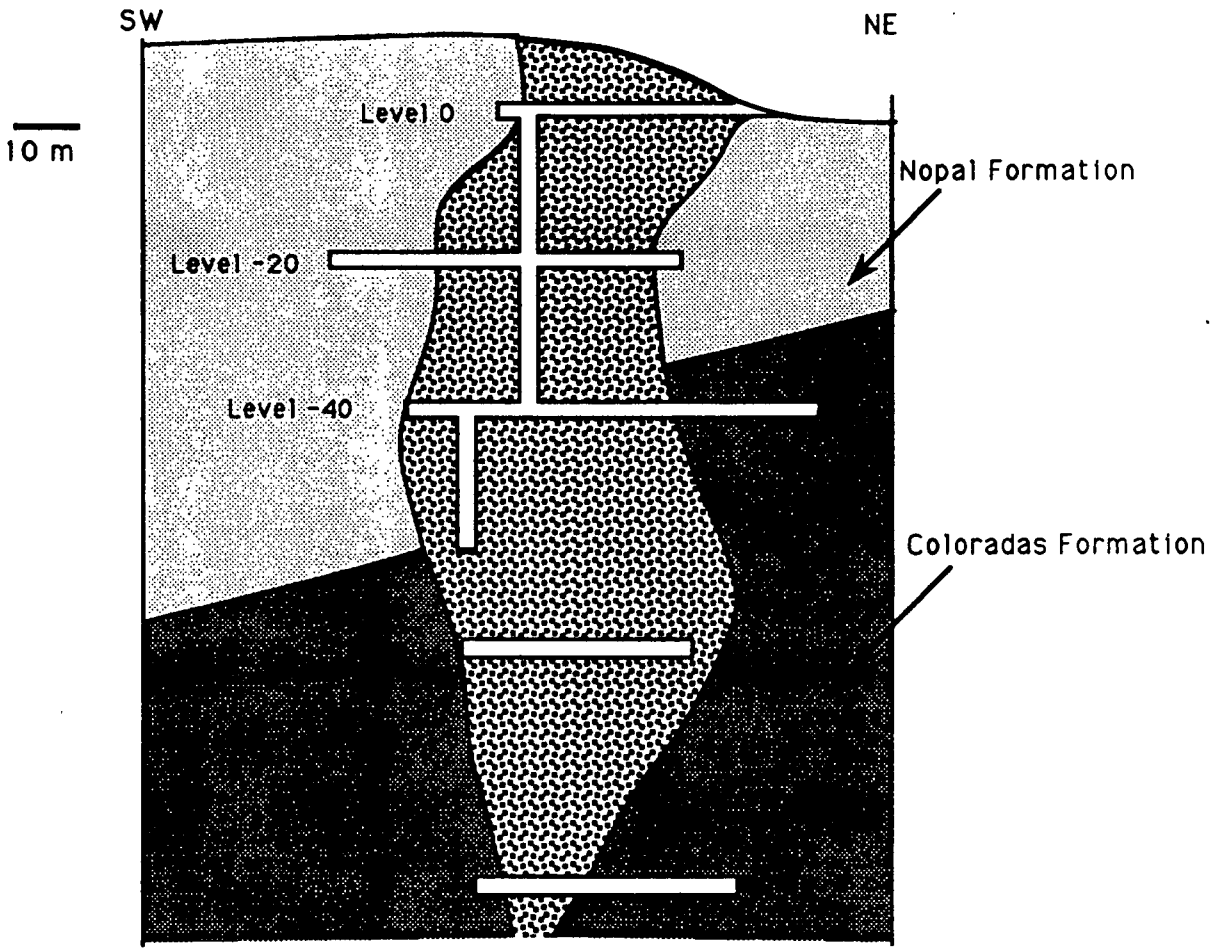
SITE	ROCK TYPE	ALTERATION MINERALOGY	HYDROLOGY; CLIMATE	TIME SCALE (years)	CONTAMINANT OR ANALOG	PROCESS
Yucca Mountain Waste Repository	Silicic Tuff	Clinoptilolite, Smectite	Unsaturated; Semi-arid	10^3-10^4	Spent fuel/ Vitrified Waste	Contaminant Transport
Peña Blanca Uranium Deposits	Silicic Tuff	Kaolinite, Smectite, Heulandite	Unsaturated; Semi-arid	10^6-10^7	Uraninite	Oxidation of Uraninite, Migration of U
Akrotiri Archaeological Site	Silicic Tuff/ Paleosol	Clinoptilolite, Smectite	Unsaturated; Semi-arid	3.6×10^3	Metallic or other Artifacts	Trace Element Migration

THE PEÑA BLANCA URANIUM DISTRICT

Location:	**Northern Mexico, 50 km North of Chihuahua, 250 km South of El Paso, Texas**
Physiography:	**Uplifted Block in the Basin and Range Province**
Climate:	**Semi-arid; Average Rainfall 24 cm/year; Average Temperature 19°C**
Geology:	**Faulted Silicic Tuffs 35 to 44 Million Years Old Overlie Cretaceous Limestones and Paleozoic Clastic Sedimentary Rocks**
Hydrology:	**Regional Aquifer Approximately 200 m Below the Surface; Intermittent, Discontinuous, Topographically Controlled, Perched Water Table at Shallow Depths**
Mineralization:	**Numerous Uranium Deposits Consisting Dominantly of Uranyl Silicates Associated with Zones of Faulting and Hydrothermal Alteration; Occasional Primary(?) Reduced Uranium Minerals**

THE NOPAL I MINE AT PEÑA BLANCA

Geology:	**High-Grade Mineralization Localized in a Vertical, Roughly Cylindrical Breccia Zone Associated with Intersecting Faults Near the Contact of the Nopal and Coloradas Formations**
Uranium:	**Uraninite or Pitchblende in Irregular Pods; Uranyl Silicates (Especially Uranophane and Weeksite) in Altered Tuffs on Fracture Surfaces and Replacing Primary Silicate Minerals**
Alteration:	**Primary Silicates (Mainly Alkali Feldspars) Hydrothermally Altered to Clays (Especially Kaolinite) with the Degree of Alteration Diminishing Radially Away From the Breccia Zone; Pitchblende Altered to Uranyl Silicates**
Exposure:	**Located on a Steep Hillside; Exploration and Mining Operations Generated Several Shafts and Adits over a Vertical Interval of About 100 m; Surface Excavations Expose Large Vertical and Horizontal Cross Sections Through the Breccia Zone**
Access:	**Property Controlled by the Mexican *Consejo Recursos Minerales* (Mineral Exploration Agency); No Current or Planned Mining Activity; Shafts and Adits are Unmaintained; Exploration Core and Mined Ore are Preserved**



Nopal I Uranium Deposit

(drawing based on information from Aniel (1983) and URAMEX (1980))

Additional slides

Geologic map of the Chihuahua and Sierra Peña Blanca area

Topographic and geographic map of the Peña Blanca uranium district

Overview of the Nopal I mine, looking north

Mineralized breccia at the entry of the 0 level adit at Nopal I

Rock sample of the Nopal Formation

Rock sample of pitchblende and uranyl silicate assemblage from Nopal I

Rock sample of highly altered mineralization from Nopal I

View east from the crest of the Sierra Peña Blanca Range