

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT**

**PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT: POÇOS DE CALDAS PROJECT
STUDY AREA**

PRESENTER: MICHAEL E. SHEA

**PRESENTER'S TITLE
AND ORGANIZATION: PRESIDENT
TERRACON INC.
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**PRESENTER'S
TELEPHONE NUMBER: (312) 324-6813**

**RENO, NEVADA
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POÇOS DE CALDAS PROJECT

LOCATION: OSAMU UTSUMI URANIUM MINE & MORRO DO FERRO THORIUM/REE DEPOSIT, POÇOS DE CALDAS CALDERA, MINAS GERAIS, BRASIL

DURATION: 1985–1991
(FIELD DATA COLLECTION: 1986–1989)

MANAGING PARTICIPANT: SWEDISH NUCLEAR FUEL & WASTE MANAGEMENT COMPANY (SKB)

ORGANIZATION: MULTINATIONAL AGREEMENT

PARTICIPANTS:

BRASIL:	CNEN
	NUCLEBRAS
SWEDEN:	SKB
SWITZERLAND:	NAGRA
U.K.:	UKDOE
U.S.A.:	U.S. DOE

POÇOS DE CALDAS PROJECT

DOE INVOLVEMENT

- **TECHNICAL AND PROGRAMMATIC PLANNING FROM INCEPTION**
- **PROJECT MANAGEMENT ON BOTH THE STEERING AND TECHNICAL COMMITTEES**
- **ACTIVE RESEARCH**

POÇOS DE CALDAS PROJECT

THE POÇOS DE CALDAS CALDERA

- **80 MILLION YEAR OLD VOLCANIC/PLUTONIC COMPLEX WITHIN A 35 KM DIAMETER SUBSIDENCE CALDERA**
- **CONTAINS BOTH AN OPEN-PIT URANIUM MINE (OSAMU UTSUMI) AND REPORTEDLY, THE MOST RADIOACTIVE LOCATION AT THE EARTH'S SURFACE (MORRO DO FERRO THORIUM/REE DEPOSIT)**

POÇOS DE CALDAS PROJECT

PRINCIPAL OBJECTIVES

- ASSIST IN VALIDATION OF HYDROCHEMICAL MODELS, CODES, AND DATABASES USED TO EVALUATE ROCK/WATER INTERACTIONS AND THE SOLUBILITIES AND SPECIATIONS OF ELEMENTS.
- DETERMINE INTERACTIONS OF NATURAL GROUNDWATER, COLLOIDS, RADIONUCLIDES, AND MINERAL SURFACES WITH RESPECT TO RADIONUCLIDE TRANSPORT PROCESSES AND COLLOID STABILITY
- PRODUCE A MODEL OF GEOCHEMICAL TRANSPORT ACROSS REDOX FRONTS, WITH SPECIAL ATTENTION TO REDOX-SENSITIVE NATURAL SERIES RADIONUCLIDES
- MODEL MIGRATION OF REE/U-TH SERIES RADIONUCLIDE DURING HYDROTHERMAL ACTIVITY SIMILAR TO THAT ANTICIPATED IN THE NEAR-FIELD

POÇOS DE CALDAS PROJECT

PERFORMANCE ASSESSMENT IMPLICATIONS

- **SOME OBSERVED NATURAL PROCESSES/
INTERACTIONS NEED TO BE INCORPORATED
INTO PERFORMANCE ASSESSMENT MODELS**
 - **AMORPHOUS TO CRYSTALLINE PHASE TRANSITIONS**
 - **MICROBIOLOGICAL CHEMICAL REACTIONS**
 - **FLOW CHANNELING**
 - **MATRIX DIFFUSION**
 - **REDOX RETARDATION**

- **THERMODYNAMIC DATABASES NEED FURTHER
REFINEMENT**

POÇOS DE CALDAS PROJECT

PERFORMANCE ASSESSMENT IMPLICATIONS

(CONTINUED)

- **CURRENT APPROACH TO CALCULATING SOLUBILITY LIMITS APPEARS TO BE ROBUST**

- **PERFORMANCE ASSESSMENT MODELS TEND TO BE CONSERVATIVE AND MAY BE OVERLY PESSIMISTIC**
 - IRREVERSIBLE VS. REVERSIBLE SORPTION
 - COLLOID TRANSPORT

- **HYPOTHETICAL REPOSITORY CIRCULATION SYSTEM IS REMARKABLY SIMILAR TO THAT AT THE MINE**

POÇOS DE CALDAS PROJECT— LESSONS LEARNED

- **HETEROGENEITIES IN THE PHYSICAL AND CHEMICAL PROPERTIES OF THE ROCKS AND WATERS OCCUR AT ALL SCALES AND WERE NOT ALWAYS POSSIBLE TO CHARACTERIZE ADEQUATELY**
- **ROBUST MODELS WERE REQUIRED TO INTERPRET THE SPARSE AND HETEROGENEOUS DATA. A SIMILAR APPROACH WILL LIKELY BE NEEDED TO CHARACTERIZE A REPOSITORY SITE**
- **LARGE-SCALE, RAPID TRANSPORT OF RADIONUCLIDES HAS NOT OCCURRED AT POÇOS DE CALDAS**
- **DATA COLLECTION CANNOT BE RUSHED, NO MATTER HOW MANY RESOURCES ARE AVAILABLE AT THE OUTSET**
- **IT IS PARTICULARLY IMPORTANT THAT HYDROCHEMICAL SPECIATION DATA BE COLLECTED IN-SITU**

POÇOS DE CALDAS PROJECT— LESSONS LEARNED

(CONTINUED)

- **ANY STUDY SITE WILL BE MORE COMPLEX, ILL-DEFINED, AND PERTURBED THAN EXPECTED**
- **IT IS NOT ALWAYS POSSIBLE TO CONSTRAIN A PROCESS ADEQUATELY IN ORDER TO STUDY AND INTERPRET IT**
- **REFINEMENTS TO HYDROCHEMICAL TRACE ELEMENT MODELS ARE TRANSFERABLE**
- **ANALOGUE STUDIES PROVIDE EXPERIENCE FOR CONDUCTING PERFORMANCE ASSESSMENTS**
- **MODELERS AND INVESTIGATORS MUST COORDINATE DATA REQUIREMENTS AT THE OUTSET. SOME DATA NEEDS MAY BE IMPRACTICAL OR IMPOSSIBLE TO FULFILL**

POÇOS DE CALDAS PROJECT

BENEFITS TO DOE/YMP

PROVIDED DATA FOR PARAMETERS INCLUDING

- **RETARDATION FACTORS**
- **DISPERSION COEFFICIENTS**
- **MATRIX DIFFUSION COEFFICIENTS**
- **SORPTIVE AND TRANSPORT PROPERTIES**
- **HYDROTHERMAL EFFECTS ON PERMEABILITY**
- **MINERAL STABILITY**

POÇOS DE CALDAS PROJECT

CONCLUSIONS THAT ADDRESSED CRP'S BASIC CONCERNS

- **DATA COLLECTED AT POÇOS DE CALDAS WERE SUCCESSFULLY USED TO VALIDATE NUMERICAL MODELS AND TO CONFIRM OR CORRECT LABORATORY MEASUREMENTS**
 - **CORRECTIONS WERE MADE TO THERMODYNAMIC VALUES**
 - **AMORPHOUS TO CRYSTALLINE PHASE TRANSITION**
- **DURING THE POÇOS DE CALDAS STUDY, INVESTIGATORS IDENTIFIED MATERIALS AND PROCESSES THAT HAD NOT PREVIOUSLY BEEN IDENTIFIED AS RELATED TO RADIONUCLIDE MIGRATION AND NEEDED TO BE INCORPORATED IN MODELS**
 - **MINERAL PHASE NOT INCLUDED IN THERMODYNAMIC DATABASE**

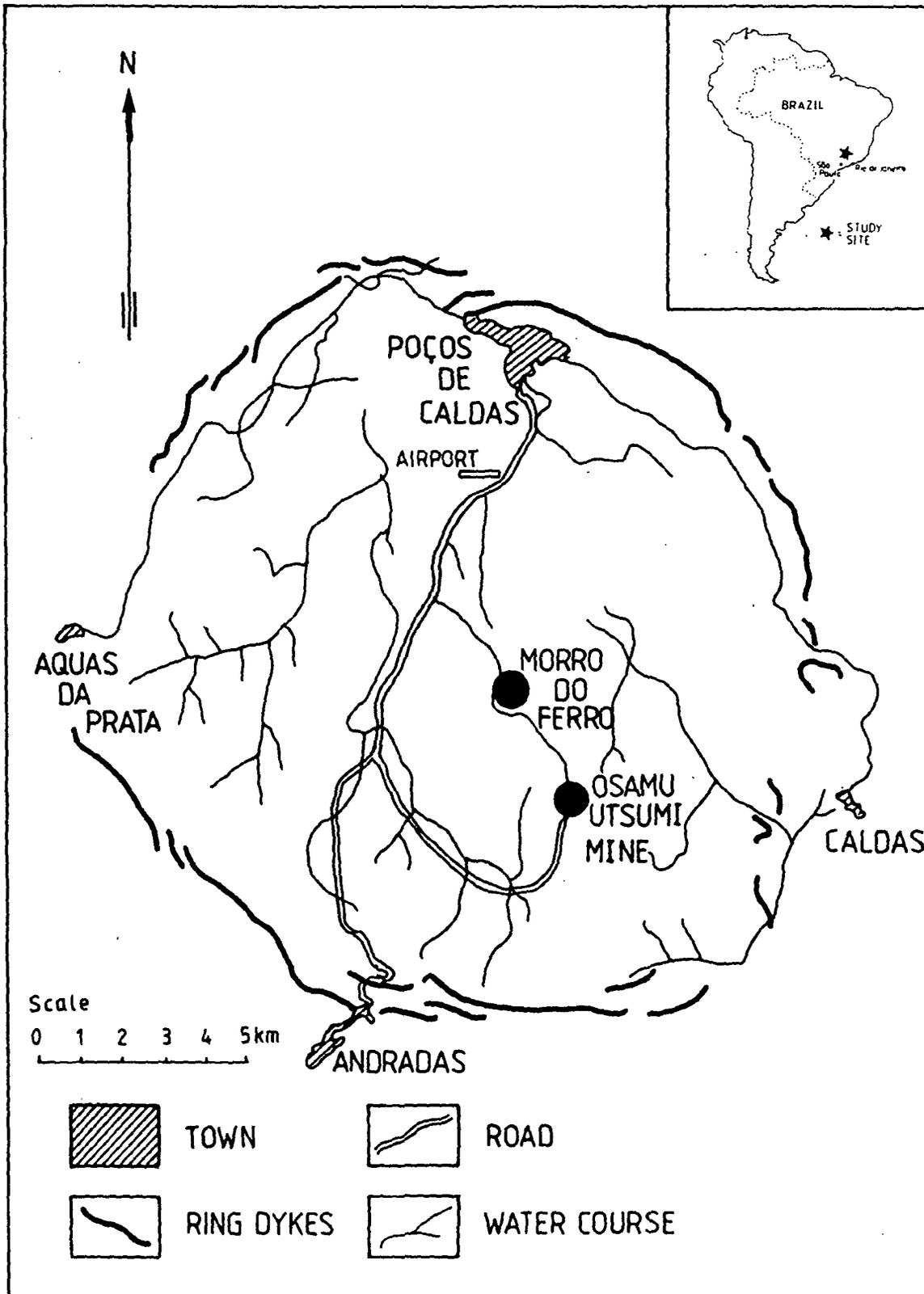


Figure 2.1. Location of the Osamu Utsumi mine and Morro do Ferro study sites.