New Mexico Environment Department, 18Ground Water Quality Bureau, 18DOE Oversight Bureau, and 18Hazardous Waste Bureau

Abstract

Los Alamos National Laboratory (LANL) has conducted multidisciplinary research on uranium since the mid-1940s. Treated and non-treated industrial aqueous discharges, many containing potentially natural uranium with α²³⁵U/α²³⁸U atom ratio = 137 ± 813, have been discharged to Arroyo, Pueblo, Los Alamos, and Mortandad Canyons. These discharges provide reactivity to dissolve actinides and produce intermediate actinide groundwaters and background subsurface in the region. The Environmental Protection Agency drinking water standard for total uranium and the New Mexico Water Quality Control Commission standard for dissolved uranium is 0.126 µg/L (0.032 µmol/L). Upper tolerance limits have been calculated by the New Mexico Environment Department and LANL for numerous soils/rocks naturally present in the regional aquifer. These include total dissolved uranium (5.336 nM, 0.00137 mg/L), dissolved oxygen (0.253 mM, 8.10 mg/L), nitrate (N) (1000 nM, 0.0036 mg/L), chloride (1.061 mM, 3.6 mg/L), perchlorate (4.324 nM, 0.00043 mg/L), and sulfate (0.061 mM, 0.584 mg/L). Background concentrations of dissolved uranium in the regional aquifer increase with average groundwater age, especially east of the Rio Grande. Concentrations of dissolved uranium above background are 5 to 10 times above background. In several regional aquifer monitoring wells installed in Pueblo, Los Alamos, and Mortandad Canyons. Concentrations of nitrate, perchlorate, and/or Tritium collected with adhesion uranium(VI) species are elevated above background in the regional aquifer at several monitoring wells. Thermochromic calculations suggest that univalent actinide carbonate complexes, including UO₂(CO₃)₂⁻, UO₂(CO₃)₄⁻, Ce(UO₂)₂(CO₃)₄⁻ and UO₂(CO₃)₄⁻, dominate in the regional aquifer. These uranyl complexes are mobile only within oxidizing and enriched uranium waters (plotted in the regional aquifer at Los Alamos). Concentrations of natural radionuclides, including dissolved hydrogen sulfide, dissolved ferrous iron, dissolved organic carbon, and solid organic matter are not sufficient to enhance reduction of uranium(VI) to uranium(IV) aqueous complexes (UO₂²⁺ and UO₂(OH)²⁻). The regional aquifer is undersaturated with respect to uranium oxide (UO, urania) and colloids. In studies of concentrations of dissolved uranium(VI) in the upper sections of the regional aquifer are initially controlled by partial dissolution of soluble volcanic glass followed by specific adsorption of uranium(VI) complexes onto hydrous ferric oxide and exchange of uranyl cation with calcium on smectite surfaces. Upper sections of the regional aquifer beneath the Pajarito Plateau are enriched in actinide and groundwater shows variable saturation with respect to uranophane (Ca(UO₂)(H₂O)(SiO₄)₃·H₂O) and are oversaturated with respect to hausmannite (Ca(UO₂)(H₂O)(SiO₄)₅·H₂O) depending on pH and calcium and silica activities.

Sources of Natural and Anthropogenic Uranium

Natural – Whole rock concentrations of uranium range from 1 to 2 mg/kg for the Pajarito Plateau. Uranium-bearing solids, at pH 7, have varying solubility in aqueous phase (10⁻²⁰⁻¹⁰⁻³ M). The resolvable and SiO₂ (10⁻¹⁰⁻¹⁰⁻³ M) is the least soluble. Natural total dissolved uranium concentrations in the regional aquifer range from 10⁻⁶ to 10⁻¹⁰ M (0.12 to 1.37 mg/L) beneath the Pajarito Plateau. Analytical methods for uranium include hydride generation, chronix and halides are 15⁻¹⁰⁻¹⁰⁻³ M and 10⁻¹⁰⁻¹⁰⁻⁳ M, respectively. Antipathogenic – Natural, enriched, and depleted uranium is used for research purposes in LANL.

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Purpose and Scope

Evaluate natural and anthropogenic sources of uranium in the regional aquifer at Los Alamos National Laboratory. Topics of interest for uranium include:

- Appalachian
- Groundwater age
- Adsorption
- Mineral equilibrium

Analytical Methods for Uranium

Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) Methods (Gallaher et al. 1994) Lowest method detection limit is 5.29E⁻¹⁰ M (0.001 ng/L). Depending on sample matrix, Quantitation limit is 2.1E⁻⁰ M (0.001 µg/L). Thermal ionization Mass spectrometry

Hydrography of the Pajarito Plateau

Hydrogeological Conceptual Model For Part of the Expansos Basin (west of the Rio Grande), New Mexico

Hydrochemistry of the Pajarito Plateau and Española Basin

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Summary and Conclusions

Determining natural and anthropogenic sources of uranium within the Pajarito Plateau requires knowledge of groundwater age and geochemical processes controlling fate and transport of this actinide in groundwater.

Background concentrations of natural uranium increase with average groundwater age in the Expansos Basin (near and east of the Rio Grande). Presence of perchlorate, nitrate, and/or nitrate is useful in determining the source of uranium in groundwater at LANL.

Background concentrations of dissolved uranium vary from 5.0E⁻⁰ to 5.7E⁻⁰ µg/L (0.12 to 1.37 µg/L) in regional aquifer groundwater beneath the Pajarito Plateau, NM.

Uranium(VI) transport to the regional water table at Los Alamos, New Mexico has occurred at several locations. Dissolved concentrations of anthropogenic uranium are less than 6.3E⁻⁰ to 5.0E⁻¹ µg/L (10⁻⁶ to 10⁻⁵ M). Much higher concentrations of natural uranium are observed east of the Rio Grande in portions of the Expansos Basin and are hydrologically isolated from the Pajarito Plateau.

Operated by the Los Alamos National Security, LLC for the DOE/NNSA

Acknowledgment:

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