Gross Alpha Activities in Surface and Subsurface Soils, Rocks, and Water in the Central Pajarito Plateau: *Geological and Geochemical Considerations*

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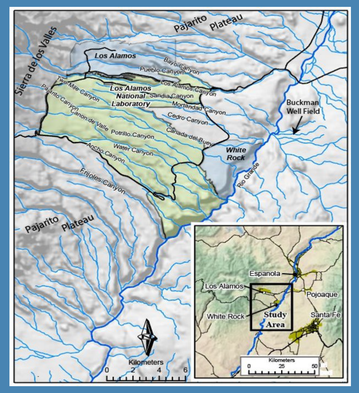
Background | A soil Surveillance program has been conducted at Los Alamos National Laboratory (LANL) and adjacent areas in the Pajarito Plateau since the early 1970s to monitor potential health concerns related to natural and anthropogenic radioactivity. Key findings are: (1) higher concentrations of anthropogenic radionuclides and radioactivity in soils are related to LANL operations; (2) these concentrations have been decreasing with time; and (3) the reduction has been approaching natural background levels, beginning in 1996; and is due to weathering, radioactive decay, and reduction in operations and better safety and engineering controls at LANL (Fresquez et al., 1998 and references therein).

In the 1990s, more investigations were conducted to determine background elemental concentrations of inorganic chemicals and radionuclides in soils and rocks, mostly within the LANL site (McDonald et al., 1996; Ryti et al., 1998). Results were used to identify potentially contaminated areas, to develop cleanup strategies, and to understand contaminant migration.

Objective | Prior investigations mostly focused on soils; unlike recent and ongoing studies in soils, rocks, and waters from surface and subsurface settings. Comparative assessment of radioactivity data from soils, rocks, and water was conducted to determine the sources, concentrations, and distributions of the major alpha emitters and gross alpha activities and assess potential environmental concerns.

Gross alpha activity (GAA) reported here, is a measure of the total amount of radioactivity in soils, water, and rocks mostly produced from the radioactive decays of alpha-emitting elements (e.g., K-40, Th, and U).

Radionuclide and Gross Alpha Activity in Soils, Rocks, and Waters in the Pajarito Plateau

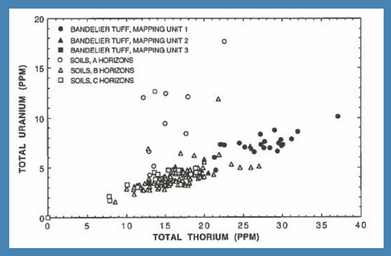


Geographically, areas with background-and-higher concentrations of radionuclides and GAA occur in developed (e.g., urbanized) areas such as the LANL site and the towns of Los Alamos and White Rock and in adjacent undeveloped terrain (e.g., natural setting with minimal human impact) of the eastern Jemez volcanic field, respectively (Figure 1).

Figure 1. Location map, showing developed (i.e., LANL and towns of Los Alamos and White Rock) and undeveloped (e.g., Sierra de los Valles) areas of the Pajarito Plateau upstream from the LANL site.

Geologically, the central Pajarito Plateau contains discontinuous soil deposits and diverse volcanic rocks and sediments (e.g., Bandelier Tuff, Cerros del Rio basalts, Tschicoma Formation dacite lavas and Puye Formation) that are characterized by variable concentrations of natural radionuclides and GAA (Figure 2).

Figure 2. Simplified geological map of the Jemez volcanic field and adjacent areas. The blue box marks the central Pajarito Plateau, consisting of the Bandelier Tuff (yellow), Cerros del Rio Basalts (cross hatched orange), Tschicoma Formation dacites (orange), and older sediments and lavas (Magenta).



Distributions of radionuclide concentrations in soils, rocks, and waters in surface settings

A. Soils and Bandelier Tuff units

Soils on the Pajarito Plateau are mostly derived from the weathering of Bandelier Tuff units as indicated by the general similarity of the radionuclide contents. Unit 1 is naturally enriched in uranium (U), whereas some of the higher thorium (Th) and U concentrations in A and B soil horizons are attributed to anthropogenic contaminations (Figure 3).

Figure 3. Total thorium (Th) and uranium (U) concentrations in soils and the Bandelier Tuff (McDonald et. al., 1996).

B. Bandelier Tuff, Tschicoma Formation dacite lavas, and Cerros del Rio Basalts

Differences in U and Th contents within the Bandelier Tuff units reflect geochemical zonation in the magma chamber (Figure 4).

Th and U concentrations in basaltic rocks are low; higher in Tschicoma Formation dacite lavas, and significantly higher in Bandelier Tuff units (Figure 4). The GAA values are consistent with the Th and U contents.

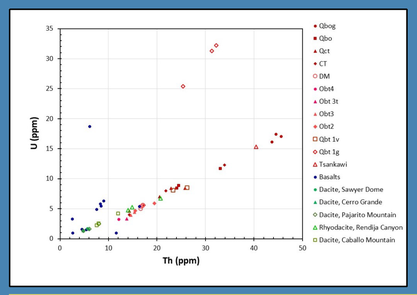


Figure 4. Total Th and U concentrations in Bandelier Tuff units (Qbt, Qct, Tsankawi, Qbo, and Qbog), Tschicoma Formation dacites, and Cerros del Rio Basalts from outcrops.

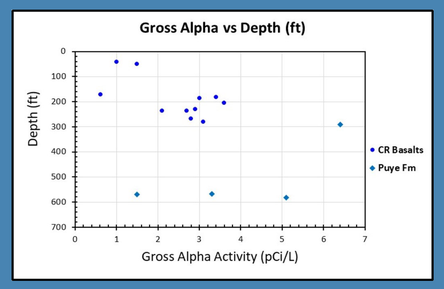
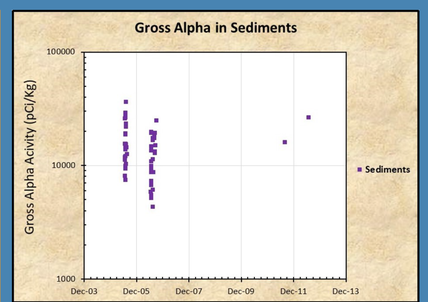


Figure 5. GAA of Cerros del Rio basalts and Puye Formation sediments from well R-9 are consistent with the low values shown in Figure 4 (Broxton et al., 2001).

C. Gross alpha activity in surface waters and sediments



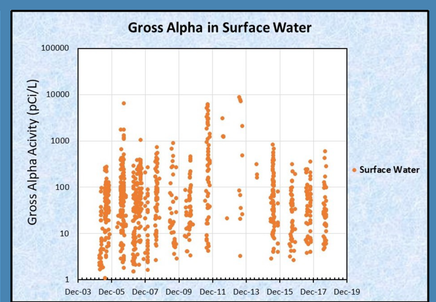


Figure 6. GAA in surface sediments collected between 2003 and 2013, show variable concentrations due to anthropogenic contamination.

Figure 7. Variations in GAA in surface waters collected between 2003 and 2018 are related to contamination.

GAA concentrations of the surface sediments and waters, mostly collected from the LANL site are variable consistent with bedrock contents of radionuclides and anthropogenic contaminations (Figures. 6 and 7).

D. Distributions of radionuclide concentrations and GAA data in subsurface rocks and waters

a. Mortandad Canyon

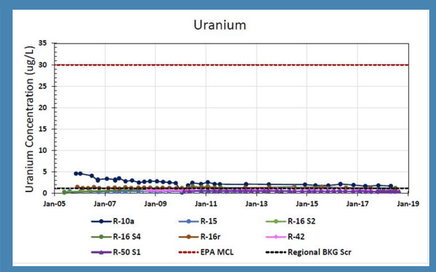
Figure 8. U and Th concentrations in groundwater from several wells in Mortandad Canyon are very low and similar to the dacite lavas (Figure 4) .

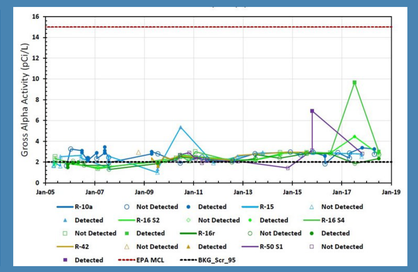
Figure 9. GAA in groundwater from several wells in Mortandad Canyon are very low compared with surface waters in Figure 7.

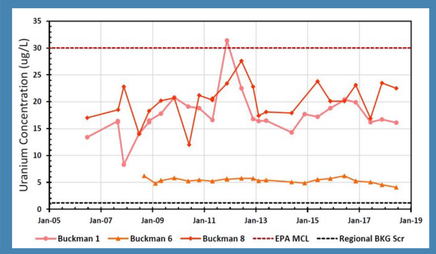
b. Buckman well fields

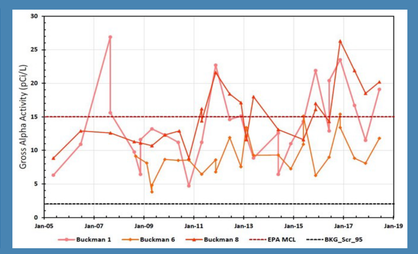
Figure 10. Buckman well field groundwater (Figure 1) has higher U concentration compared with groundwater from Mortandad Canyon in Figure 8.

Figure 11. Higher GAA are noted in groundwater consistent with higher U concentrations in Buckman well fields.









The regional groundwater in the Buckman and the Mortandad Canyon well fields occur in similar geological formations and are located at close proximity on opposite sides of the Rio Grande (see Figure 1). Both well fields have different recharge areas

Conclusion

Preliminary results from surface waters and sediments indicate that elevated radionuclide concentrations and GAA from within the LANL site are attributed to anthropogenic contamination.

In contrast, radionuclide contents and GAA in subsurface waters and sediments from Mortandad Canyon wells are low and are generally consistent with values from the Tschicoma Formation dacite lavas.

Low uranium concentrations and GAA in groundwater from Mortandad Canyon wells are attributed lavas with low U contents in recharge areas of the Jemez Mountains. In contrast, the elevated U contents and GAA in the Buckman well fields are related to the recharge areas of U-rich granitic and sedimentary rocks shed from the Sangre de Cristo Mountains.

References

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