Radiation in the Environment

- The arrow pointing to an extension of the radiation plume or an effect of geology?
- When it's your home this distinction becomes important.
- Currently to differentiate there must be an aerial gamma ray survey of the area before the disaster occurred.

Figure 1a: NNSA aerial gamma ray survey of Fukushima Daiichi

- Radiation occurs naturally in bedrock and soil.
- Gamma rays are released from the decay of the radioactive isotopes K, U, and Th.
- Gamma rays interact with the soil and rock, and can only make it through about 30 cm of material.
- Energy of gamma rays is specific to each isotope, allowing identification.

Figure 1b: Decay chain from unstable Uranium-238 to stable Lead-206

Aerial Gamma Ray Surveys

- Measures K, U, Th concentration in rock and soil.
- Fly areas with 200-400 m spacing.
- Low flying.
- Scintillation detectors.
- Collect: ground radiation as well as background.
- Cosmic.
- Equipment.
- Atmospheric.

Figure 2: NS Tec Helicopter with gamma ray detectors attached

Collecting Existing Geochemical Data

Navajo Mines Geochemical Data

Figure 3: On the left is an aerial gamma ray survey of our area in north central Arizona known as the Navajo Mines area, on the right is a satellite image of the same area. The yellow arrow indicates the similarity between the blue shape in the aerial gamma ray survey and the basin flow, thus a relationship between geology and radiation.

Figure 4: Displays data collected within the Navajo Mines area from national databases such as the USGS, IEDA, and GeoROC; uranium mining companies as DIRE Exploration; and scientific literature. Red points are uranium mines, blue points are soil chemistry, and purple points are geochemical data. Pastel basemap is a USGS geologic map.

Figure 5: Example rock (blue) and soil (purple) unit reports for PkI (limestone, Harrisburg Member, Kaibab Fm) and QaI (Holocene alluvial fan deposits), includes histograms and statistics of U, K, Th concentration. This is how values were assigned to geologic units with multiple data points.

Rock Unit Geochemistry

Figure 6: Both have a sliding scale from blue representing low exposure rate to red representing high exposure rate.

Pink Arrow: Shows alluvial fan that is cooler than the bed rock around it in both the model and survey.

Black Circle: Displays that in both map and model the west has overall higher exposure rates than the east.

Red Arrow: Shows another set of alluvial fans that are cooler than the bedrock around them in both the model and map.

Purple Arrow: Displays discrepancy between the model and the map. In the model, the outside of the Black Point basin flow is cooler (blue) than the inside (green). In the model the outside (orange) is hotter than the inside (yellow).

Model Creation and Comparison

- Data was collected from national databases, private companies, scientific literature and field work.
- Rock Unit Reports are used to constrain the U, K, Th content of each unit.
- A model is created by converting concentrations of U, K, and Th for each rock and soil unit into a ground exposure rate: D = 1.32 K + 0.548 U + 0.272 Th.
- Compare the original aerial gamma ray survey to the model.
- Improve the method and learn the constraints.

Future Work & Acknowledgements

Future work will include creating a part model containing rock and soil data using Monte Carlo N-Particle Transport Code, examining remote sensing data, creating a contoured model using iGas, and field work, with a goal to improve the overall model.

I would like to thank NS Tec for funding this project, DIRE Exploration for providing additional data, and Bruce Dickson for providing invaluable insight and data.

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