Martis Valley Groundwater Recharge

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Dissolved Noble Gas Concentrations provide insight into groundwater recharge in the Martis Valley alpine basin.

Introduction

Groundwater Recharge :

- How? Excess Air
- When? Tritium/ Helium
- Where? Recharge Temperature

- **How will Martis Valley's water supply be affected by increasing demand and climate change?**
- **We investigate groundwater recharge to assess its vulnerability to seasonal and climate variability.**

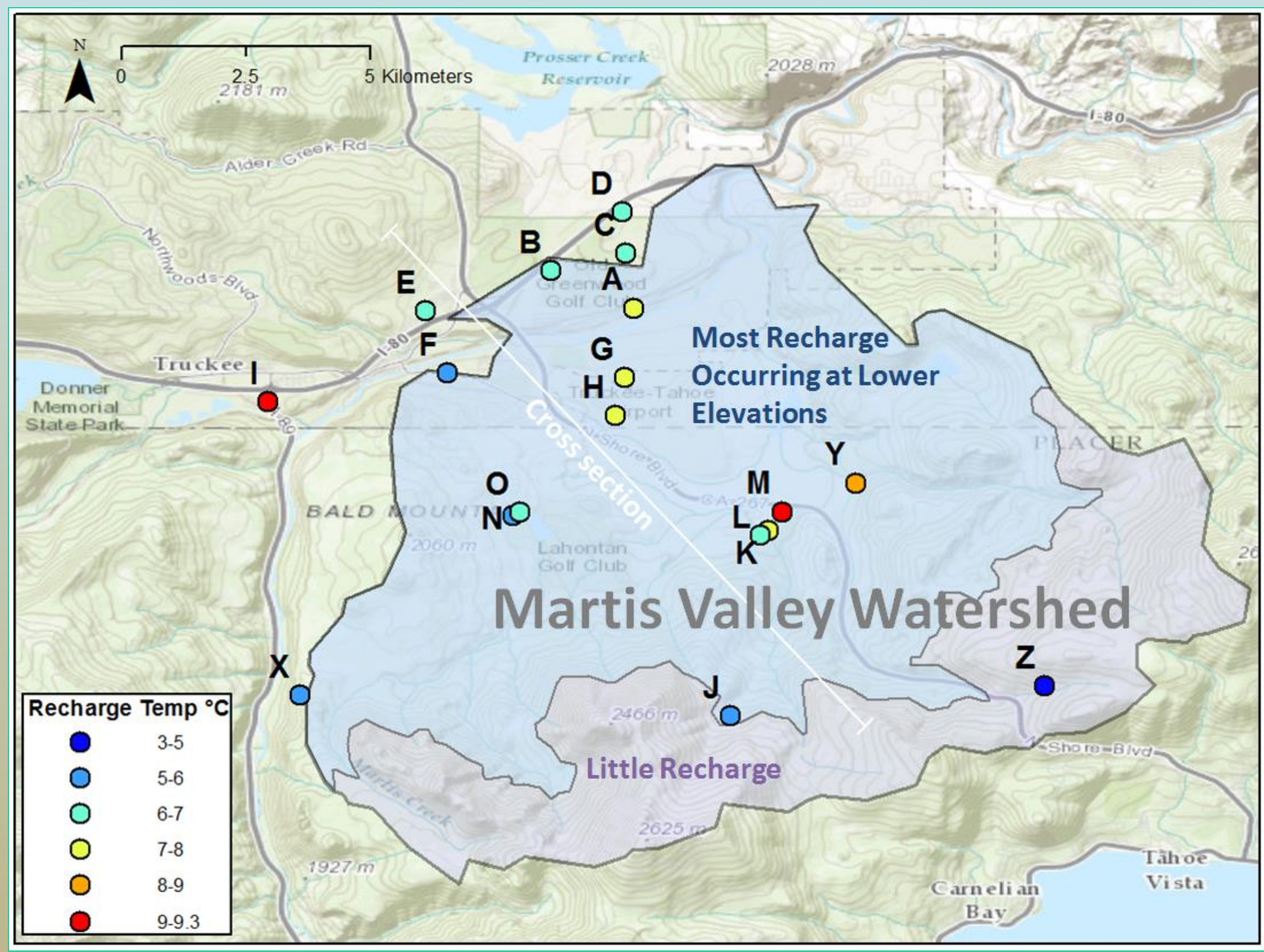


Figure 1: Martis Valley Watershed, Well A-O locations with recharge temperatures.

Methods

Field: *(Winter '11, Summer'12, Fall'12)*

- Collection of tritium and noble gas samples in pinch-clamped copper tubes

Lab:

- Sample degased in vacuum
- Abundant gases removed with getters
- Noble Gases cryogenically separated
- Measured by static mass spectrometry

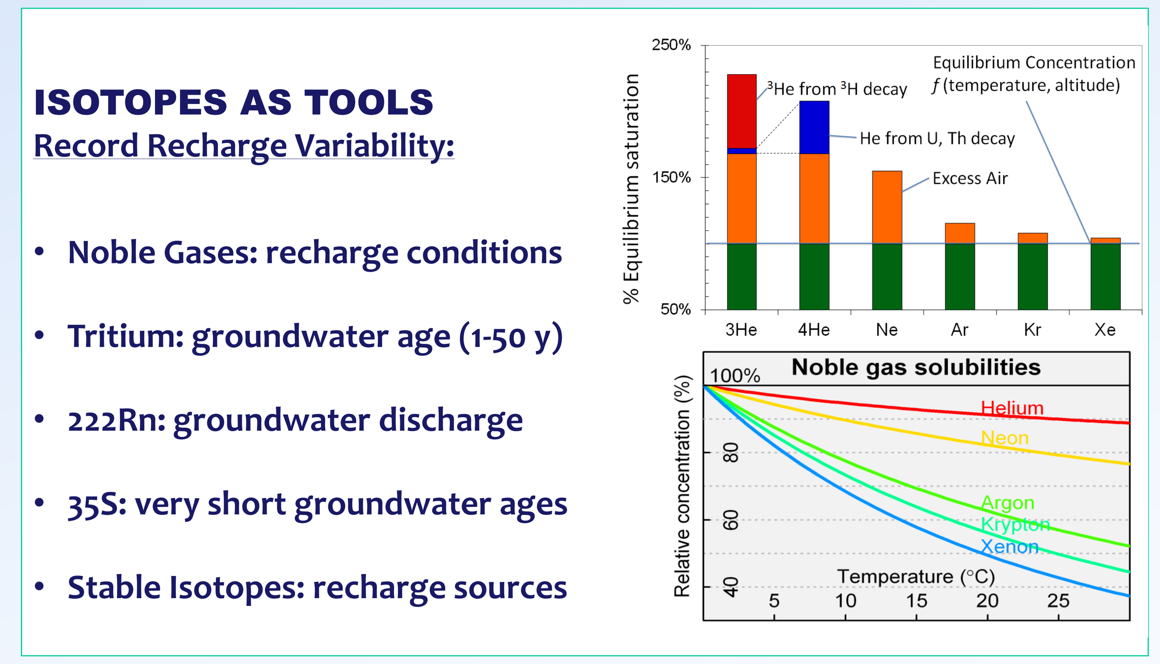


Figure 2: Noble gas concentrations vary with temperature and the addition of excess air.

Figure 3 : Sampling a monitoring well.

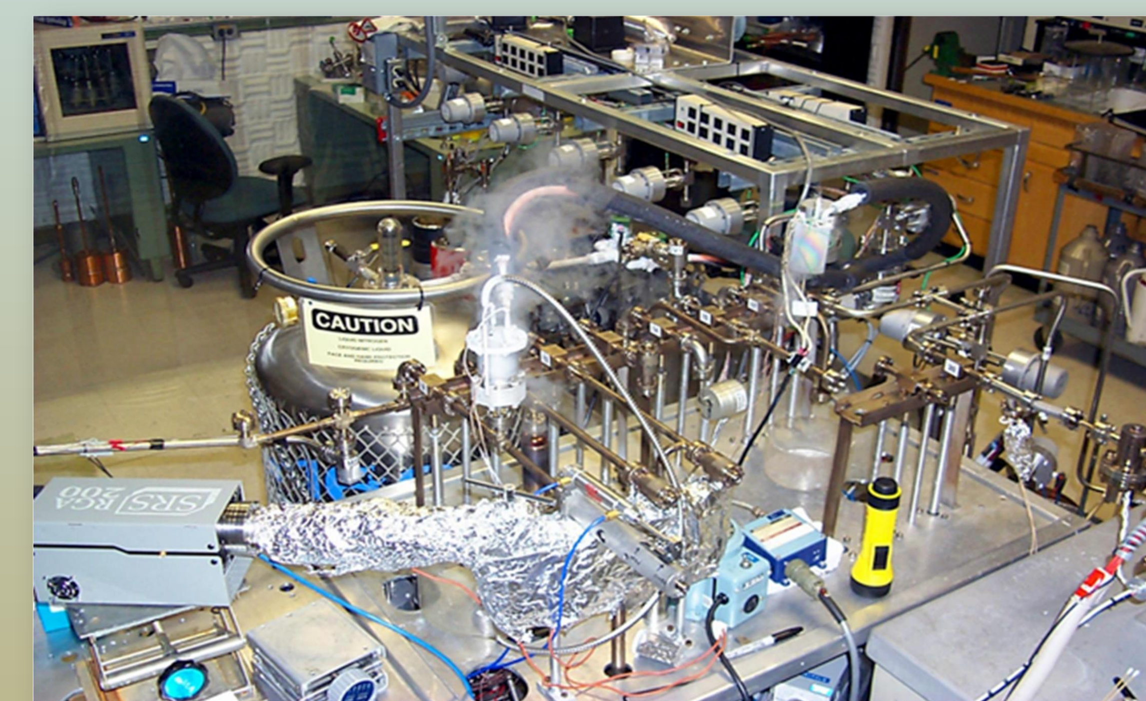


Figure 4 : LLNL Noble Gas Mass Spectrometer

Results 1

Recharge temperature can be used to estimate:

- Flow depth
- Recharge Elevation

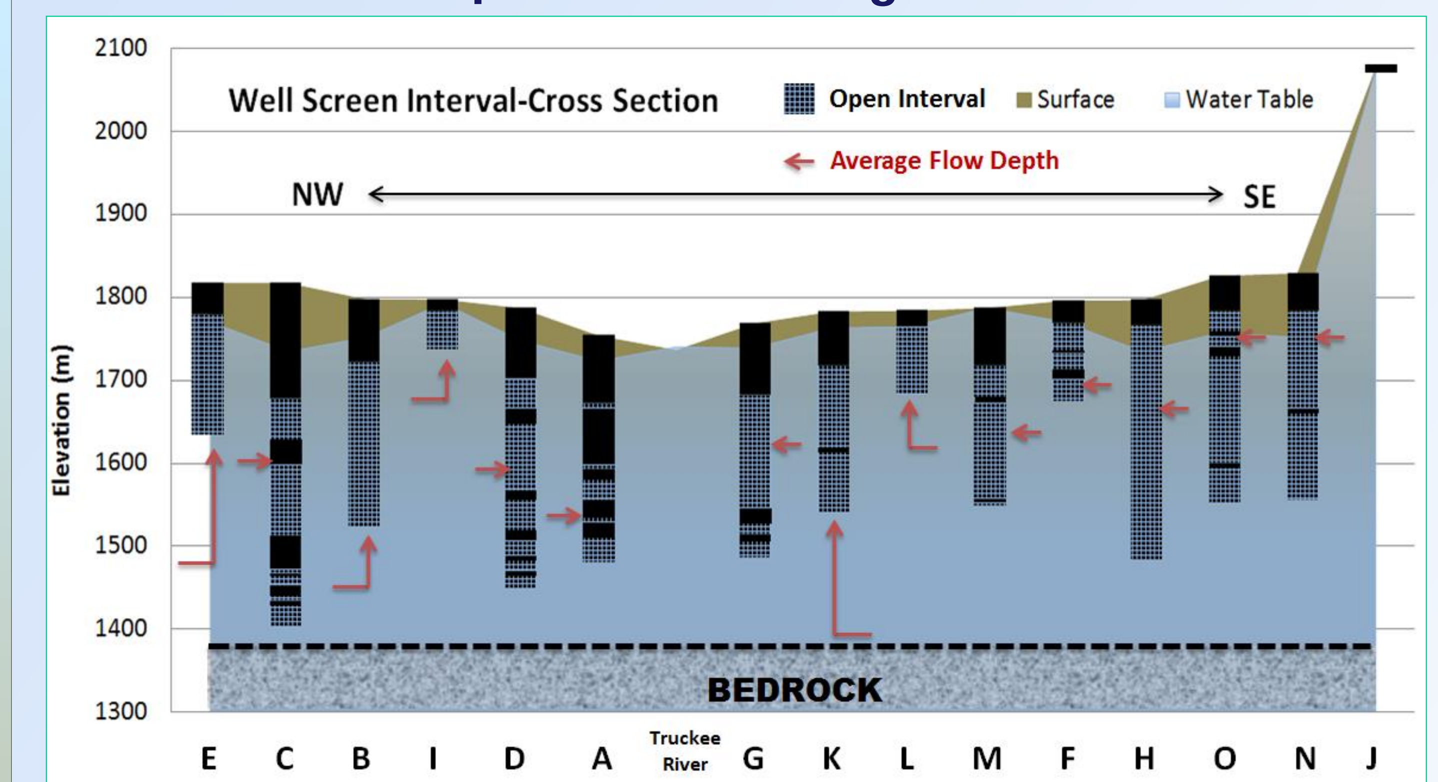
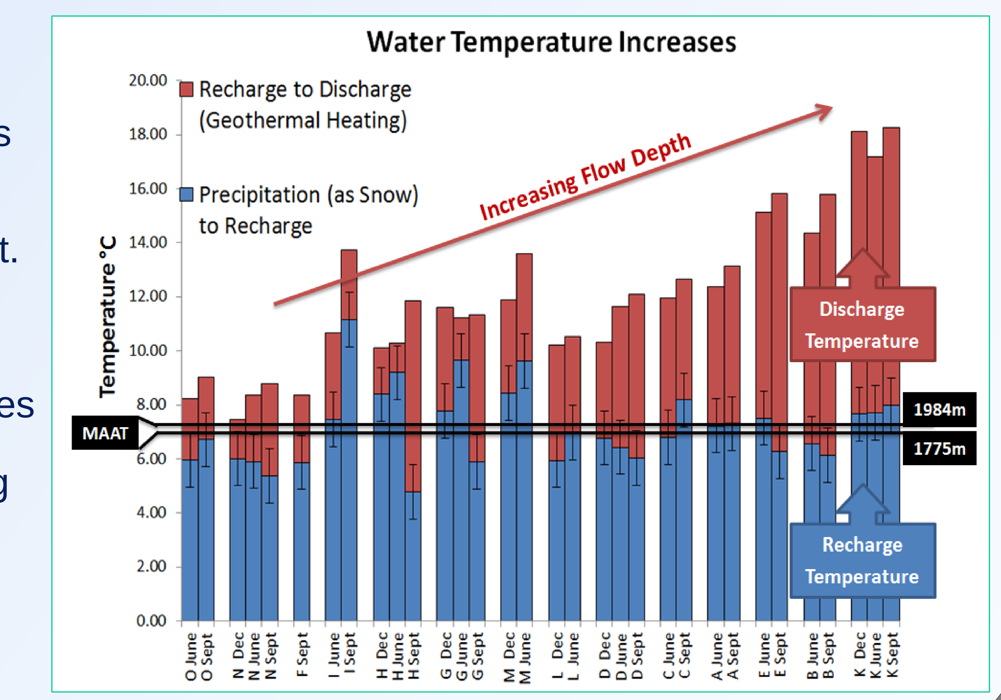


Figure 5 : Long well screens and multiple well screen intervals in Martis Valley's production wells produce a groundwater sample with varying sources and a mixed age. The average flow depth is the average depth the water reached in order to increase its recharge temperature to its discharge temperature using a geothermal gradient of 25° C/km.

Figure 6 : Recharge temperatures in Martis Valley are higher than expected for direct infiltration of snowmelt. Most recharge temperatures fall between the mean annual air temperatures at 1775m and 1984m elevations, suggesting most recharge is occurring within a soil zone between these elevations.



Results 2

- **Many samples contained high excess helium.**
- **Excess helium was found to be terrigenic He, containing a mix of radiogenic He and mantle He.**

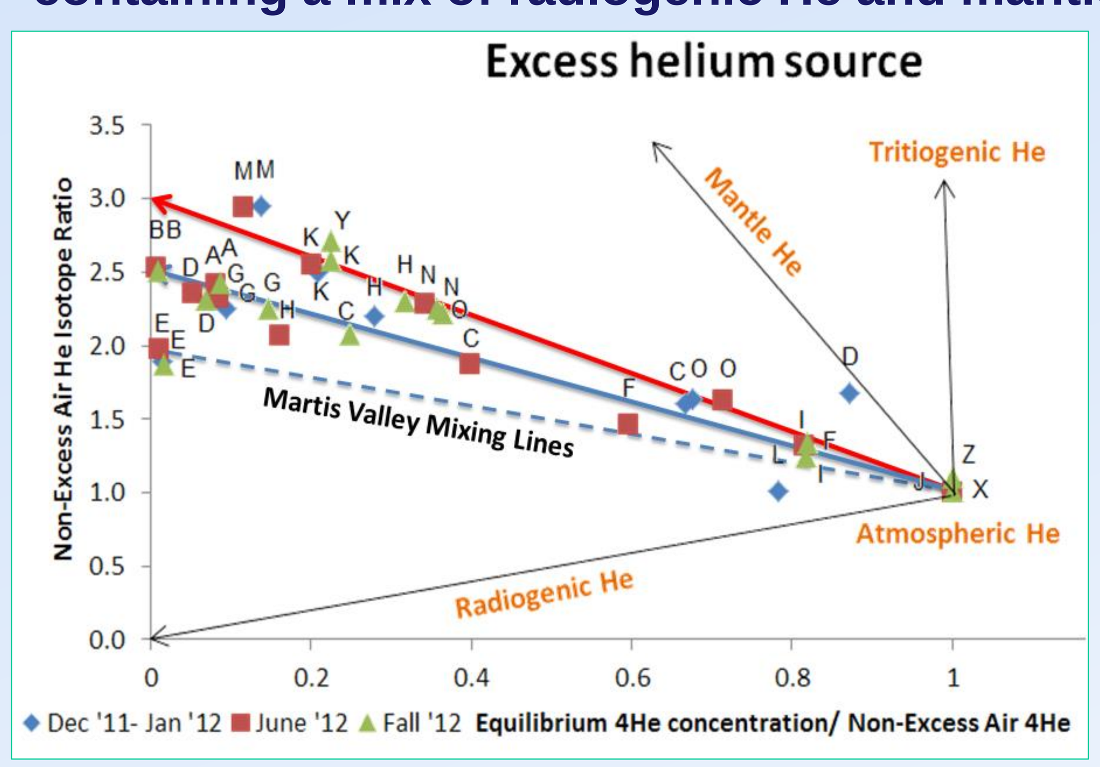


Figure 7 : The proportions of excess helium mixtures vary spatially. Wells in southern Martis Valley, containing 29-48% mantle helium, plot along the red mixing line. Wells in northern and northeastern Martis Valley contain less mantle helium and plot along the blue and dashed-blue mixing lines..

- **Terrigenic excess ^{4}He is used to determine mixing between younger and older tritium dead groundwater.**
- **Many wells contained mixed groundwater due to long well screen intervals.**

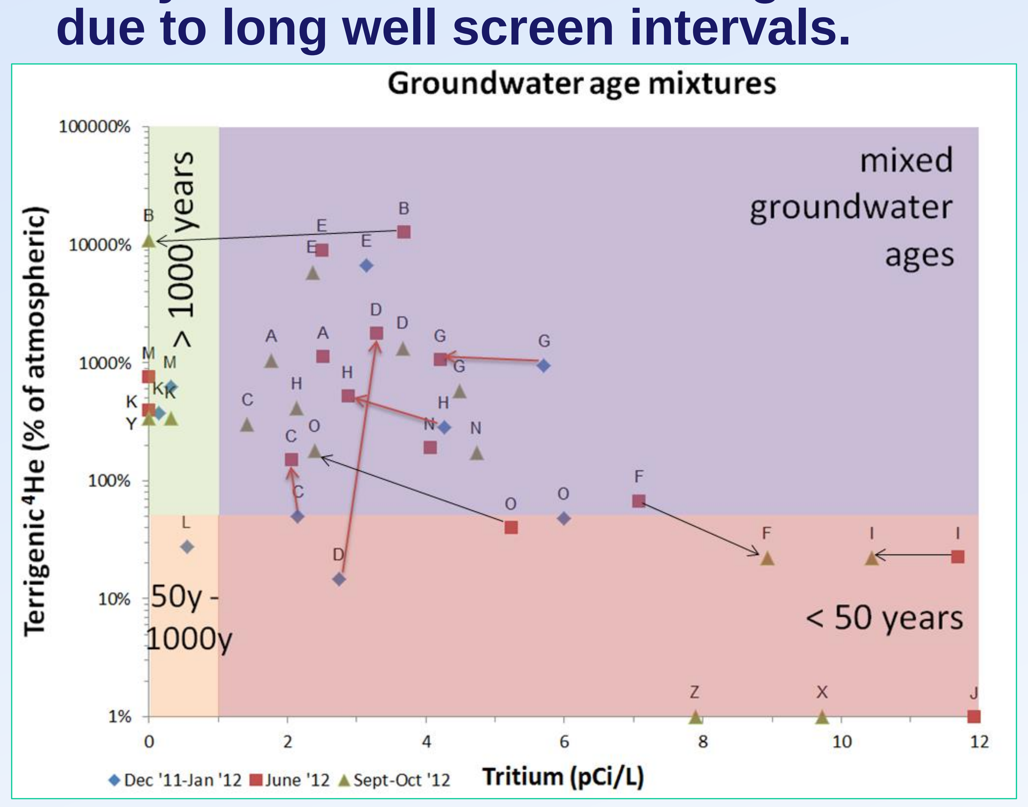


Figure 8: Martis Valley's production wells alternate seasonally drawing more heavily on aquifers with younger (high tritium, low terrigenic 4He) and older (low tritium, high terrigenic 4He) components of groundwater. Black and red arrows point out significant changes in groundwater composition from winter to summer and from summer to fall sampling events.

- **The Polaris Fault was identified as a significant source of mantle helium.**
- **Mantle helium (high terrigenic ^{3}He/^{4}He) can be used as a tracer of groundwater flow.**

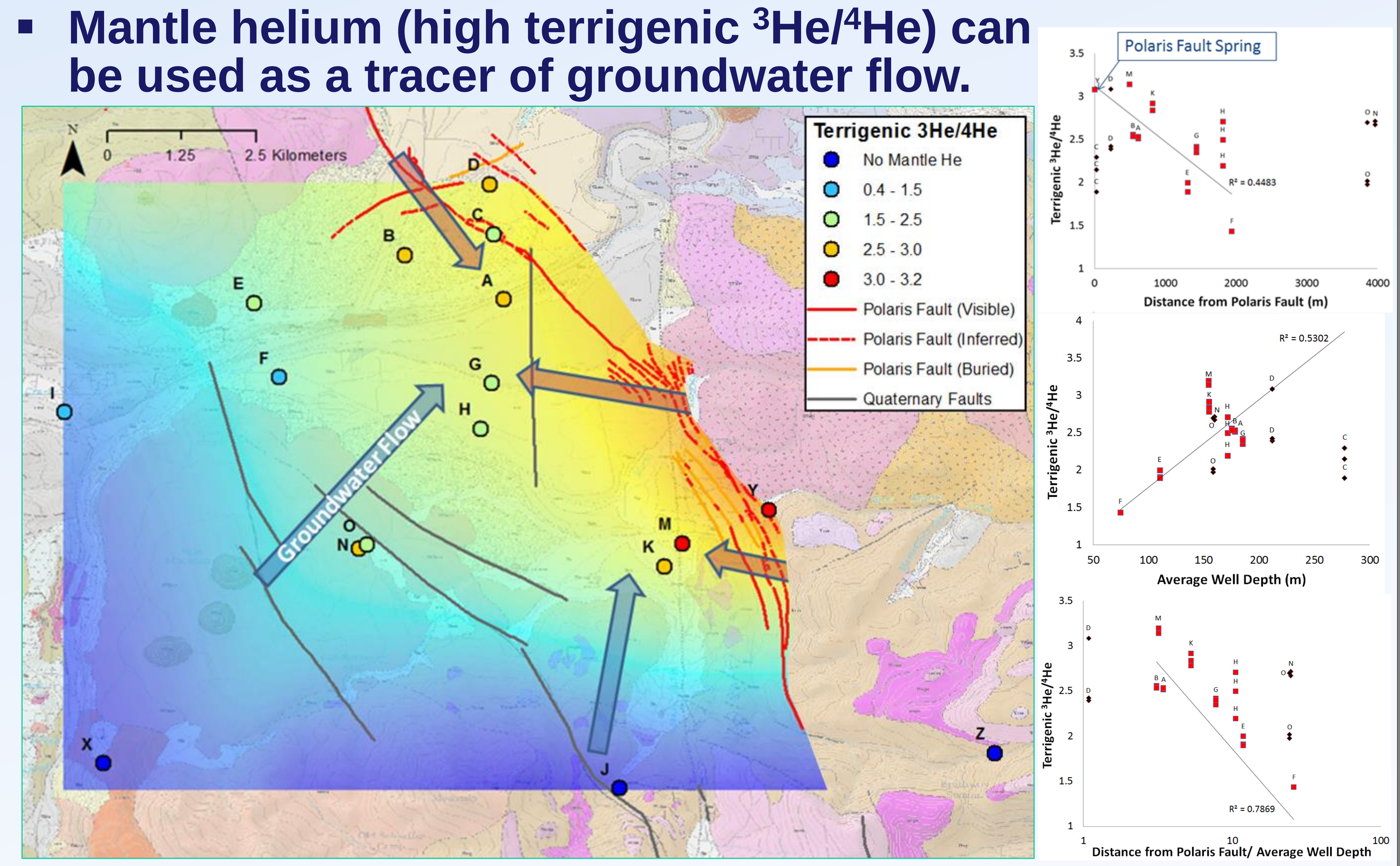


Figure 8: Groundwater in Martis Valley that recharged in areas on the map shown in red will contain high levels of mantle helium once it reaches the valley floor, as this water will likely pass through the Polaris Fault. Groundwater that recharged in blue areas will contain little mantle helium. Red and blue arrows show inferred groundwater flow directions from these two recharge areas

Conclusion

- **Long screen wells produce groundwater with a mixture of ages, from less than 50 years (containing tritium) to over 1000 years (containing terrigenic helium).**
- **Seasonal variations in recharge temperatures, tritium, and excess air suggest that the wells capture varying recharge conditions and groundwater ages throughout the year.**
- **Wells will shallow flow depths show significant seasonal variability, making them particularly vulnerable to effects from climate change.**
- **Mantle helium originating from the Polaris Fault can be used to trace groundwater flow directions and mixing of different groundwater sources.**

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