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

NUCLEAR WASTE TECHNICAL REVIEW BOARD
PANEL ON STRUCTURAL GEOLOGY & GEOENGINEERING

SUBJECT: COSMOGENIC HELIUM DATING STUDIES

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ALEXIS PARK HOTEL
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Outline

- Conclusions from helium dates
- Background for cosmogenic $^3$He dating
- Work in progress
- Observation, interpretation, and implication
Conclusions from Helium Dates

- $QI_3$, $QI_4$, and $QI_5$ lavas all erupted about 65 ka ago

- Within the current resolution of this technique (+/- 10ka) $QI_3$ and $QI_5$ are the same age

- Numerical age ranges for these lavas are 42 to 98 ka

- Most recent volcanism (cone) was >18 ka ago, but we cannot rule out that it is the same age as the lavas
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Background for Cosmogenic $^3$He Dating

- Ideally, the buildup of cosmogenic $^3$He in a surface sample provides an estimate for the age of eruption.

- Due to effects such as erosion, in practice a surface exposure age is always less than or equal to the eruption age.

- Due to uncertainty in the production rate for cosmogenic $^3$He, uncertainty in the $^3$He ages of +/-30% must be assumed when comparing to ages from other techniques.

- Olivine retains cosmogenic $^3$He quantitatively.
$^3$He Surface Exposure Ages for Lathrop Wells

Sample

- Cone (Bombs)
- Lavas
  - QI$_3$
  - QI$_4$
  - QI$_5$

"Age" (ka)
Retention of Cosmogenic $^3$He in Olivine

The diagram shows the retention of cosmogenic $^3$He in olivine samples from Potrillos and Lathrop Wells, compared to predicted values. The data points are labeled with sample IDs and the horizontal axis represents the year of sampling.
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Work in Progress

At Lathrop Wells

- Multiple surfaces of QI\textsubscript{3}, QI\textsubscript{4}, QI\textsubscript{5} have been collected to look at reproducibility/reliability of He ages

- In-place bombs from the side of the cone, unlikely to have had significant cover over their lifetime

- Will collect and analyze QI\textsubscript{6} and spatter mound
Work in Progress
(Continued)

Cross calibration to other chronometers

• We are searching for well-dated lavas in the Western U.S.

Zuni-Bandera flow near Grants, NM

• $^{14}$C ages on charcoal: $9.1 \pm 0.08$ka and $9.8 \pm 0.06$ka.
  Cosmogenic He: $13.0 \pm 1.3$ka (analytical precision)

Bluewater flow near Grants, NM

• Uranium series disequilibrium age of $80 (\pm 20/-15)$ka
• 2 Ma K-Ar age
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Observation:

- Isotopic composition of Ar released by crushing olivine:

  $^{40}\text{Ar}/^{36}\text{Ar}$

  $Q_{l_3}: 328 \pm 7$
  $Q_{l_5}: 371 \pm 8$

  Air Ar: 295.5
Interpretation:

- These lavas contain excess $^{40}$Ar that is not due to in situ decay of $^{40}$K

Concentrations released by crushing olivine:

$Q_{I3}: 5 \pm 1 \times 10^{-9}$ cm$^3$STP/g of excess $^{40}$Ar
$Q_{I5}: 7.3 \pm 0.6 \times 10^{-9}$ cm$^3$STP/g of excess $^{40}$Ar

Expect $10 \times 10^{-9}$ cm$^3$STP/g of excess $^{40}$Ar from decay of K in bulk rock (1.8% K) in 130ka. Note, however, that olivine makes up only 2% of the rock as microphenocrysts. May be more important in groundmass. Glass phase unknown
Implication:

- Need to know more about the distribution of this excess (mantle) Ar component between minerals before we can believe (or disbelieve) the K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ ages