HLWYM HEmails

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Sent: Thursday, March 03, 2005 10:23 PM
To: dpickett@swri.edu
Subject: rates
Attachments: Oxidation Rate at Pena Blanca.doc

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David,

Attached is my current discussion of the limiting rate estimates. I think I'll prepare a slide or two with the positive results for the Goldschmidt talk.

Do we have any photomicrographs of the caliche? It might be interesting to compare it to the detailed petrography (and dating) of vein filling calcites in the Paces papers. Do you think we should show the recent calcite precipitation rate data for Yucca Mountaion from the micro dating by Paces et al.? I think I have a PowerPoint slide of his results somewhere. I suspect htat there are other estimates of episodic caliche precipitation rates in the literature.

Bill

Hearing Identifier: HLW_YuccaMountain_Hold_EX
Email Number: 550

Mail Envelope Properties (000b01c52069$992ac8a0$6dcc480c)

Subject: rates
Sent Date: 3/3/2005 10:22:32 PM
Received Date: 3/3/2005 10:30:37 PM
From: Bill Murphy and Rui Chen

Created By: BillRui@worldnet.att.net

Recipients:
"dpickett@swri.edu" <dpickett@swri.edu>
Tracking Status: None

Post Office: 7sc3201

Files	**Size**	**Date & Time**
MESSAGE	640	3/3/2005 10:30:37 PM
Oxidation Rate at Pena Blanca.doc	26176	

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Sensitivity: Normal
Expiration Date:
Recipients Received: Follow up

Maximum Limit on Average Release Rate at Peña Blanca (based on oxidation rate of uraninite: oxidation rate is faster than release rate because oxidized products persist at the site)

Rate = (Oxidized Uranium + Uranium Removed) / Time (Ue + Ur) / t

Oxidized Uranium = 320 tons (estimates from exploration)

Minimum Time = 3 million years (ages of uranophane, a late forming oxidized product) (Murphy, Pickett, and Pearcy, 1997)

Maximum Uranium Removed = Maximum Flow x Concentration x Time (Ur = FCt)

Maximum Flow = 24 cm/y rainfall x 5000 m^2 area = 1.2 x 10^6 liter/y (Murphy and Pearcy, 1992)

Concentration of uranium based on uranophane solubility = 10^{-7} moles/liter (Murphy and Pearcy, 1992)

Maximum Rate = (Ue + Ur) / t = (Ue + FCt) / t
= Ue/t + FC = 106.6 g/y + 32.4 g/y = 139 g/y
(Murphy, Pickett, and Pearcy, 1997; reported as 140 g/y)

Using 10,000 years as the minimum time based on uplift rates, Murphy and Pearcy (1992) performed the same calculation and got 0.032 tons of UO_2 /y
(0.032 ton/y x 10^6 g/ton = 3.2 x 10^4 g/y)

Minimum Limit on Episodic Release Rate at Peña Blanca (based on precipitation rate of uranium in caliche at 50 ky: precipitation rate is less than release rate)

Precipitation Rate = Caliche Precipitated x Uranium Concentration in Caliche / Duration of Episode
(P = Mc * Cu / te)

Mass of Caliche = 1000 m^3 (10 cm thick x 10,000 m^2) (observed thickness up to 15 cm) (Pickett, Murphy, Leslie, 2001)

Concentration of Uranium = 100 ppm (lower limit; Pickett et al., 2001)

Duration of Episode = 10,000 y (upper limit (?), based on U-series data; Pickett et al., 2001)

P = (1000 m^3 caliche / 10,000 y) x (100 mg U / kg caliche) x (2 g caliche / cm^3 caliche) x (100^3 cm^3/m^3) x (kg/1000 g) x (g/1000 mg) = 20 g/y
(Reported as 30 g/y in Pickett et al., 2001)

Comments:

As the time period for the maximum average rate increases, the contribution of uranium leached from the system increases relative to the amount that is still there. For the 3 Ma date the leached amount is about 23 percent of the total.

For the episodic release rate estimate to be a minimum rate, the mass of caliche should be a minimum, the duration of the episode should be a maximum, and the concentration of uranium in caliche should be a minimum.

The surface area of 10,000 m^2 for the minimum episodic rate estimate is twice as large as the "maximum" surface area for infiltration used in the maximum average rate calculation. 10,000 m^2 needs to be justified as a minimum area for caliche precipitation.

The discrepancy in the calculation of the minimum episodic rate of 20 g/y above and 30 g/y in Pickett et al. (2001) could be the density used: 2 g/cm^3 here and 3 g/cm^3 (?) in Pickett et al. The density should apply to caliche if uranium concentrations are in ppm for caliche.

A small inconsistency is that the maximum average release (oxidation) rate is calculated for UO_2 and the minimum episodic precipitation rate is calculated for U.

The value of the maximum average release rate attributed in Pickett et al. (2001) to Murphy and Pearcy (1992) is 30 g U/y, which corresponds closely to the maximum leaching rate of UO_2 in that paper (32.4 g/y, which is 28.6 g U/y). However, this value is not the maximum average oxidation rate, which is 3.2×10^4 g/y as reported in Murphy and Pearcy (1992) for a 10,000 year period. The maximum average oxidation rate (140 g UO_2 /y) reported in Murphy et al. (1997) for a 3 million year period is also close to the minimum episodic rate of uranium release given in Pickett et al. (2001).

The condition that all released uranium is captured in the caliche is a very conservative (minimum) limit on the release rate. Could a conservative argument be made for the minimum amount of uranium that is also lost in the outgoing solution as the caliche is precipitated? Another term could be added:
P = (Mc * Cu / te) + Minimum estimate of the rate of uranium leached out of the system during the episode.