PRESENTATION TO THE NUCLEAR WASTE
TECHNICAL REVIEW BOARD

Title: **FRACTURE PATHWAYS AND FLUX THROUGH THE UNSATURATED ZONE IN THE NORTH RAMP AREA, YUCCA MOUNTAIN**

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HYDROGEOLOGY OF THE UNSATURATED ZONE, NORTH RAMP AREA OF THE EXPLORATORY STUDIES FACILITY, YUCCA MOUNTAIN, NEVADA

Edited by Joseph P. Rousseau, Edward M. Kwicklis, and Daniel C. Gillies

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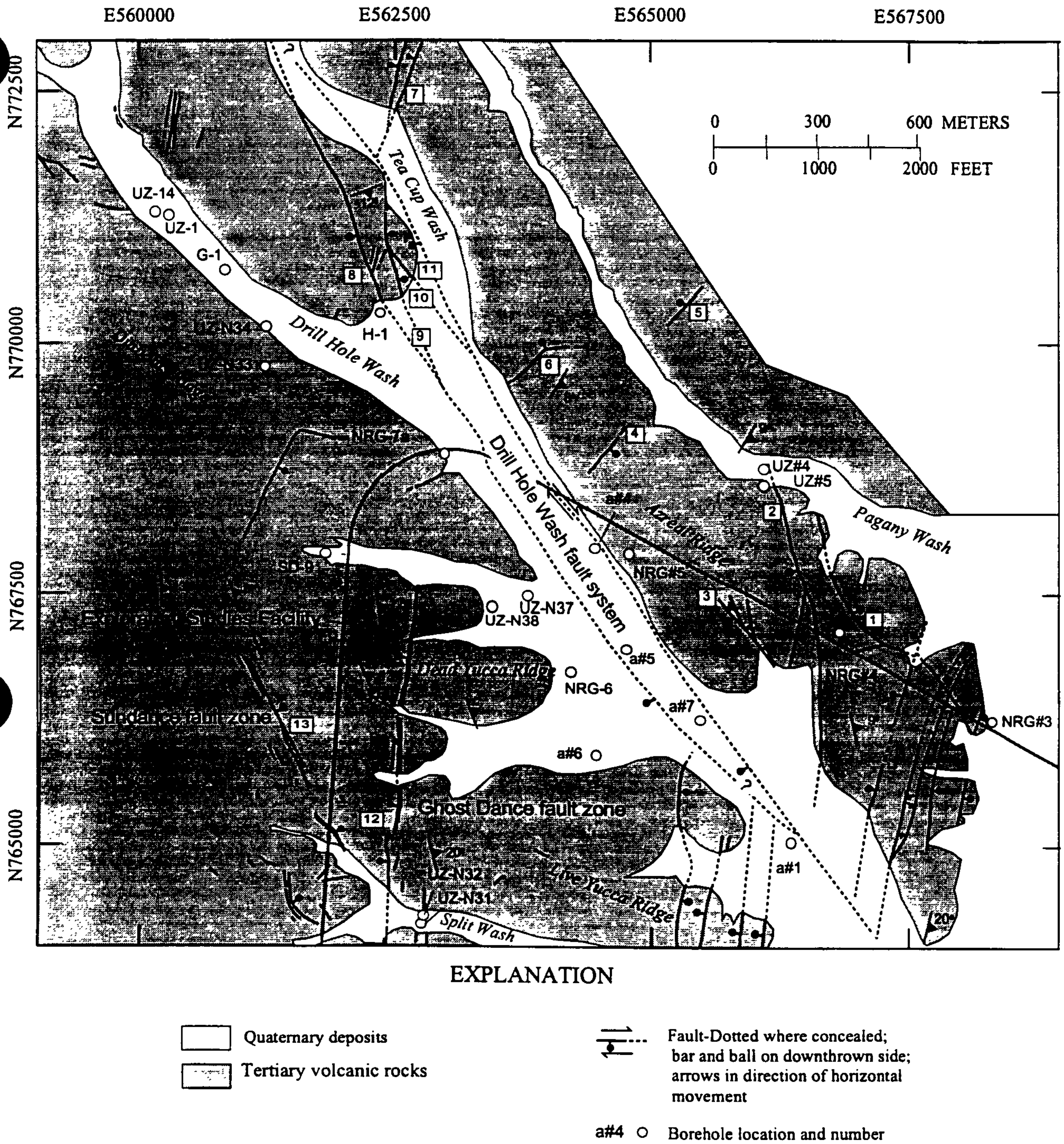


Figure 2.2-4.. Map of dominant faults within the North Ramp area of the Exploratory Studies Facility, Yucca Mountain, Nye County, Nevada. Numbers adjacent to faults delineate faults discussed in the text.

(Data from Yang, in Rousseau and others, eds. 1996)

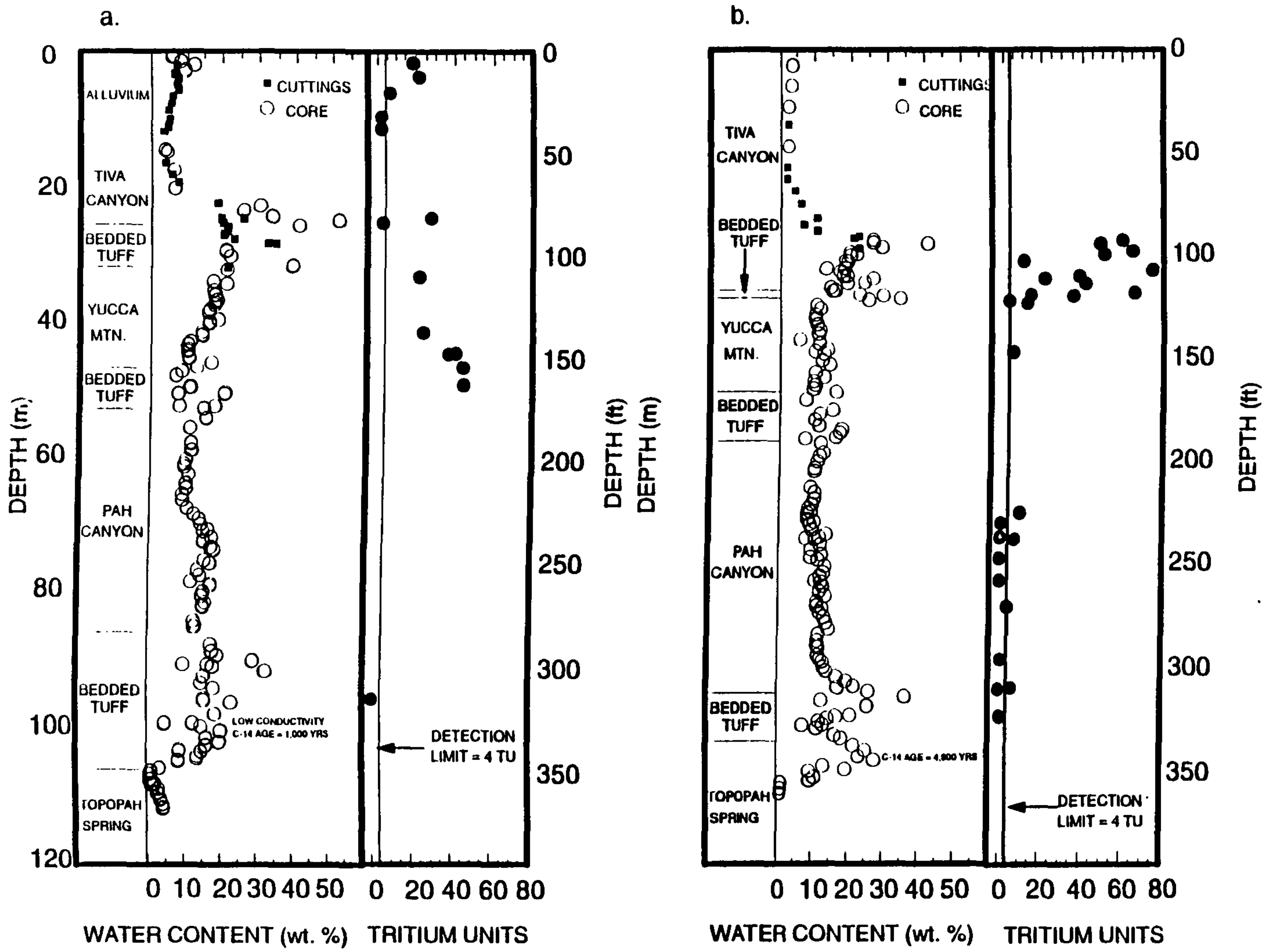


Figure 4.2.3 - 3a,b. Lithologic units, water content and tritium concentrations of test holes (a) UE-25 UZ#4 and (b) UZ#5.

(Data from Yang, in Rousseau and others, eds. 1996)

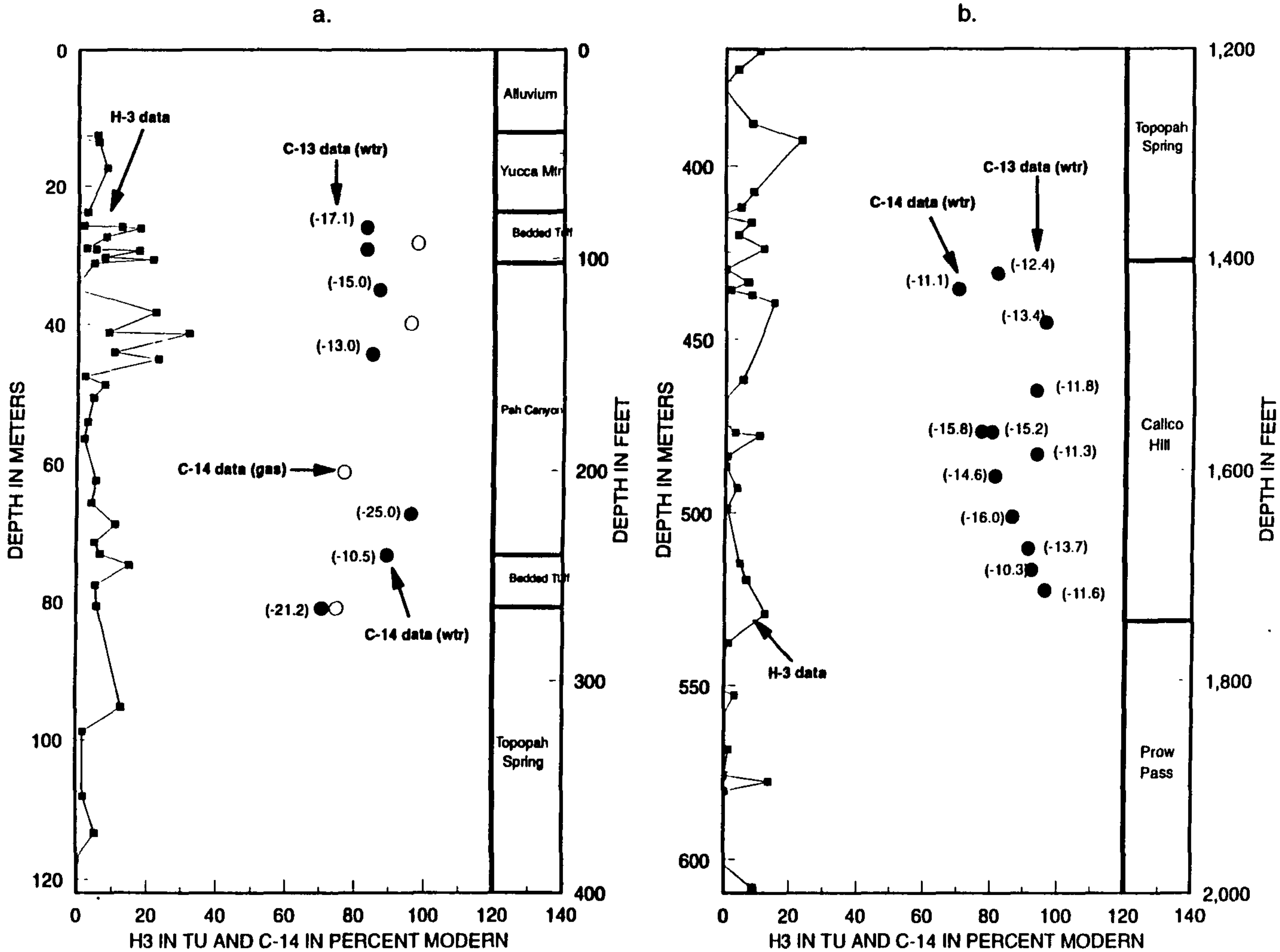


Figure 4.2.3 - 4a,b. Tritium, C-14 and C-13 values from USW UZ-14: (a) for top 400 feet of borehole, and (b) for the Calico Hills Formation

Figure 3.2.3.2-8. Measured pneumatic pressure record used in the analysis of pneumatic diffusivities at UZ#5

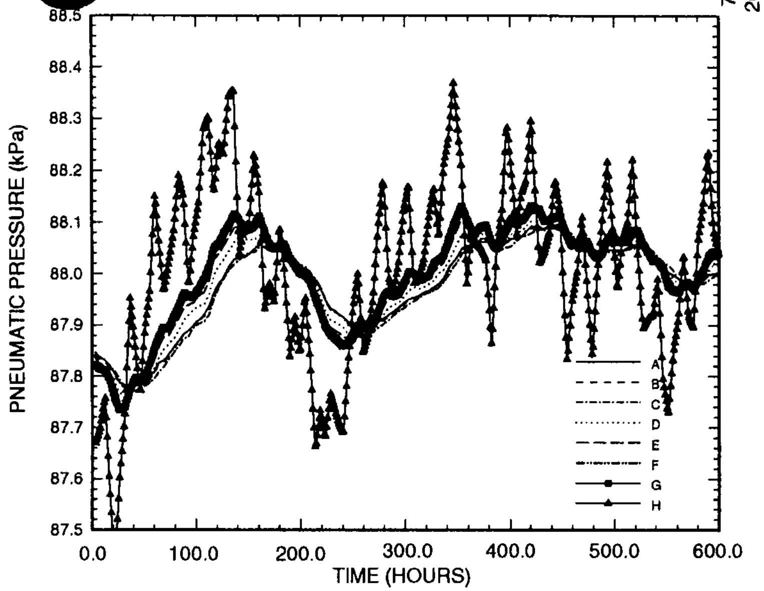


Figure 3.2.3.2-9. Match between the simulated and measured pneumatic pressures at UZ#5 for stations F,G and H.

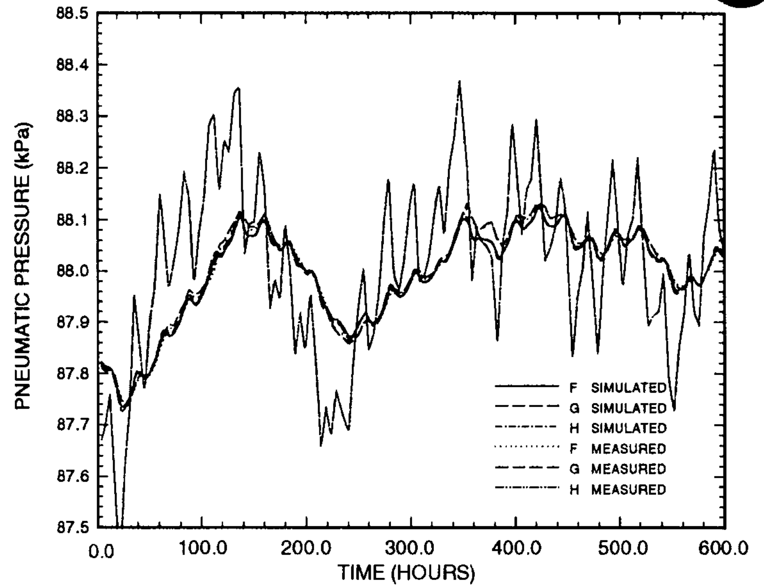


Figure 3.2.3.2-10. Match between the simulated and measured pneumatic pressures at UZ#5 for stations D,E, and F.

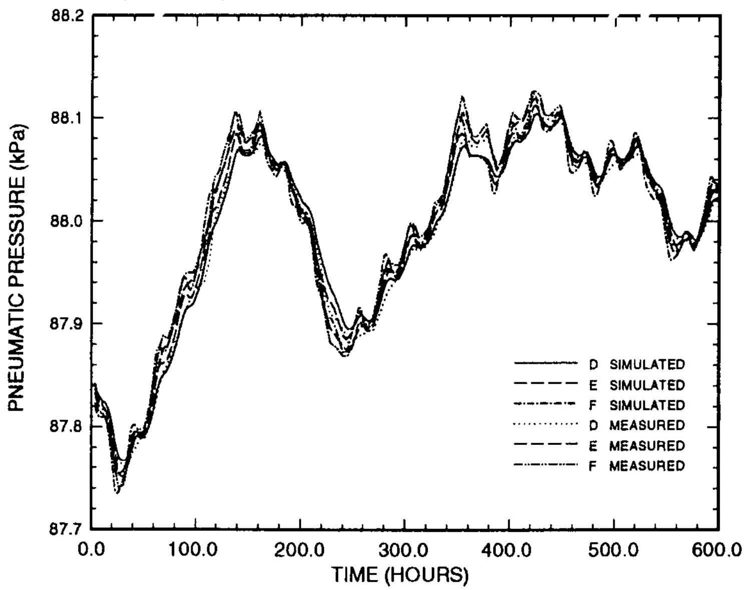
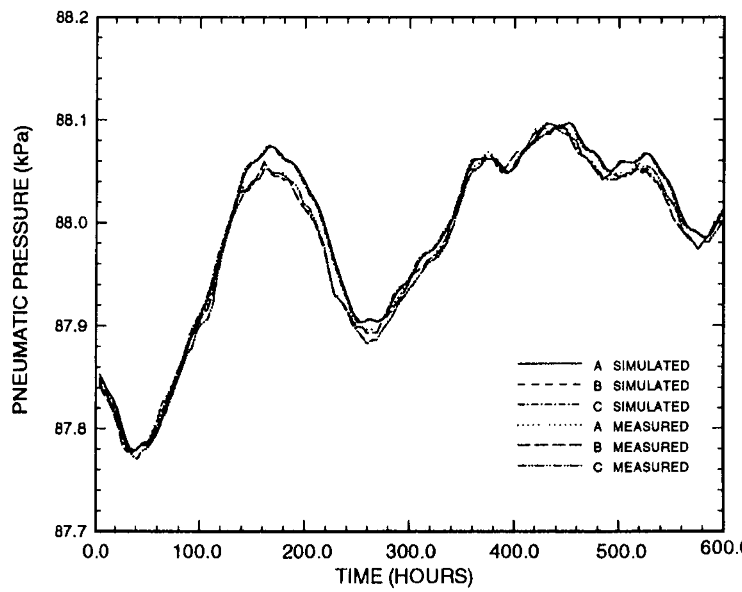


Figure 3.2.3.2-11. Match between the simulated and measured pneumatic pressures at UZ#5 for stations A,B, and C.



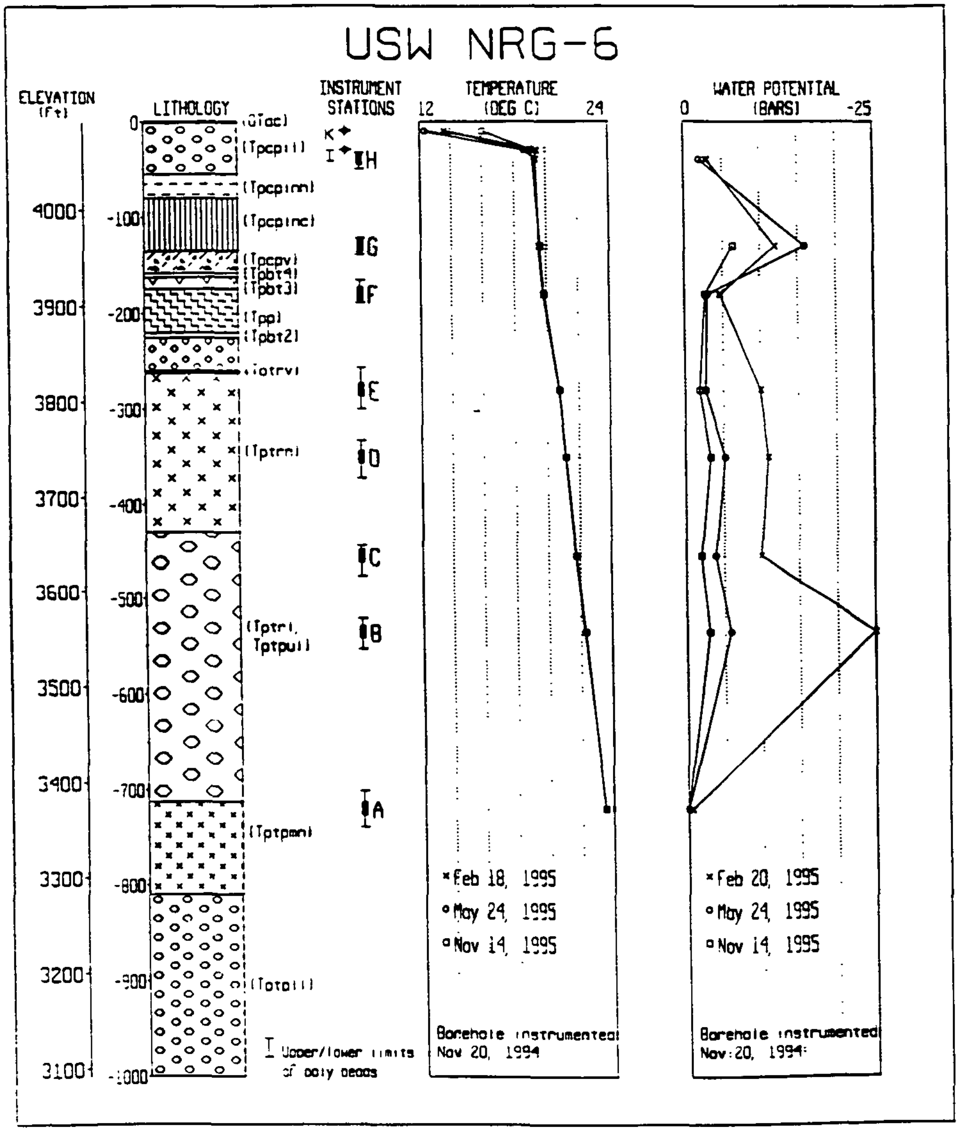


Figure 4.2.2-3 Selected water-potential profiles for USW NRG-6

EVIDENCE FOR SECONDARY PERMEABILITY AND FRACTURE FLOW THROUGH THE PTn

- **Chloride concentrations from the perched water zone and Calico Hills at UZ-14.**

PTn pore water	76.8 mg/l
Perched water	8.1mg/l
Lower TSw pore water	101.7 mg/l
Calico Hills pore water	19.8 mg/l

- **$\delta^{87}Sr$ data from the perched water**

Perched water	4.46 per mil
Surficial calcites and fracture coatings	4.51 per mil
Topopah Spring rock matrix	9.6 per mil

- **^{14}C data for the pumped and bailed samples from the perched water, and pore water from the Calico Hills**

Pumped and bailed perched water samples	30 to 65 pmc
Pore water from the Calico Hills	65 to 95 pmc

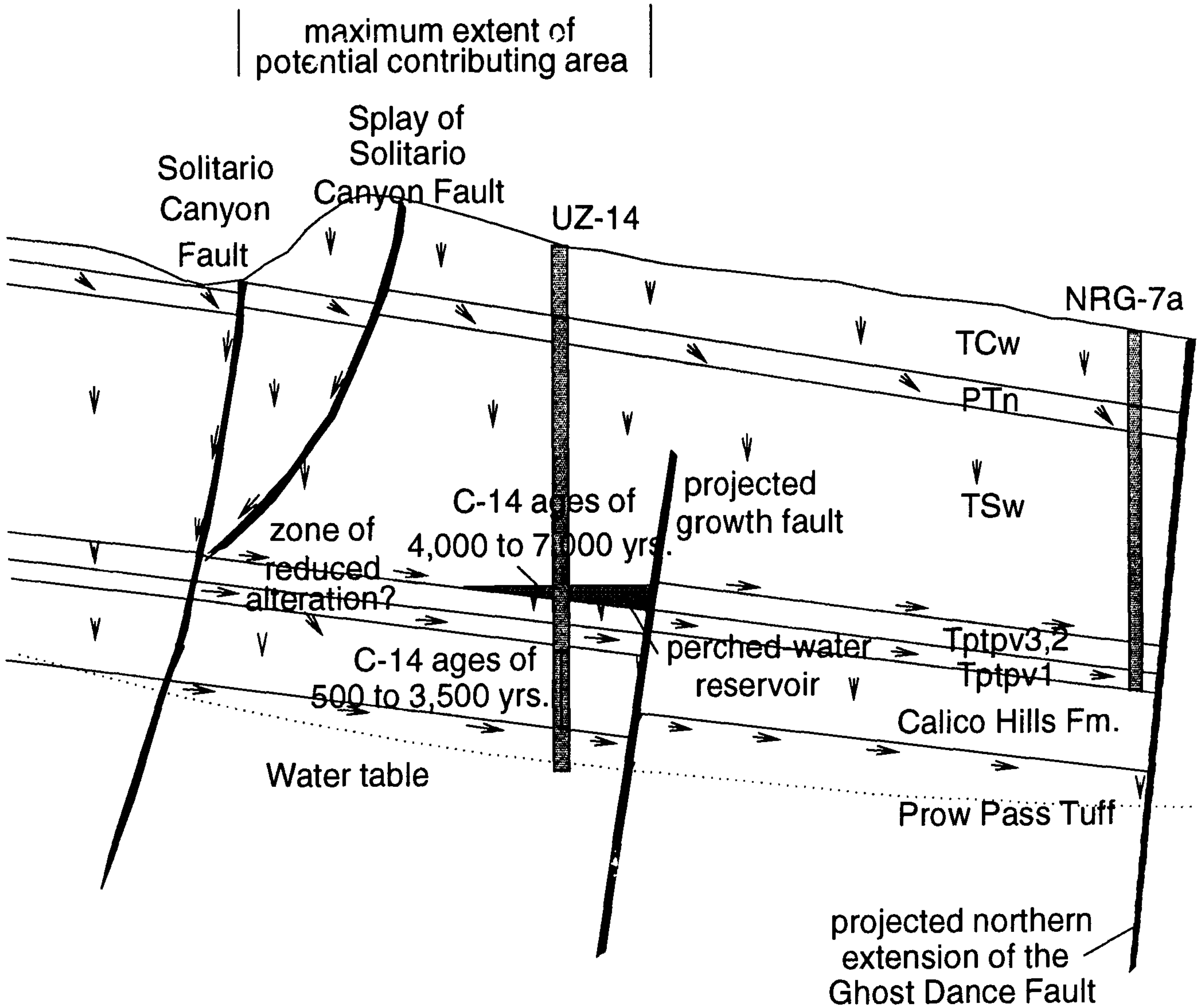
GENERAL CONCEPTUAL MODEL FOR PERCHED WATER

- Perched water may be defined as a zone above the regional water table within which water pressure is greater than atmospheric, and outside of which water pressure is less than atmospheric.
  - It is a zone from which water must flow freely when intersected by a borehole or tunnel, which are surfaces of constant atmospheric pressure.

- Perched water occurs when the percolation rate exceeds the transmission capacity of the restrictive (perching) layer, which is a function of its vertical permeability and the hydraulic gradient across that layer.

- Perched water in the North Ramp Area is widespread, if not ubiquitous, but because of lateral diversion above the perching layer due to the dip of the layers, does not accumulate except where the appropriate stratigraphic or structural conditions exist.
  - Significant positive heads do not develop except where structural or stratigraphic conditions lead to the formation of a "trap".

Figure 4.3.2-1. Conceptual model of the [illegible] field in the vicinity of perched-water reservoir intercepted by UZ-14.



SUMMARY OF THE PERCOLATION FLUX ANALYSIS BASED ON THE OCCURRENCE OF PERCHED WATER (continued)

(3) Calculate the permeability of the combined densely to moderately welded, crystal-poor vitrophyre (layers Tptpv3 and Tptpv2) beneath the perched-water reservoir.

- A simple application of Darcy's law using the range in estimated seepage rates, and the estimated head gradient across these units.

RESULT: $k = 5.9 \times 10^{-19}$ to 2.8×10^{-21} m^2.

(4) Determine the average vertical percolation flux through the Topopah Spring Tuff overlying the perched-water reservoir and in the surrounding contributing areas.

- Calculated with a water-balance equation that equates the total water volume percolating vertically through the Topopah Spring Tuff to the sum of the water volumes seeping through the combined Tptpv3 and Tptpv2 layers in the area beneath the perched-water reservoir and within the adjacent contributing areas.

RESULT: perched-water volumes and residence times are consistent with vertical percolation rates through the Topopah Spring Tuff of 0.001 to 0.29 mm/yr.

CALCULATION OF PERCOLATION FLUX BASED ON AN ANALYSIS OF HEAT FLUX BENEATH PAGANY WASH

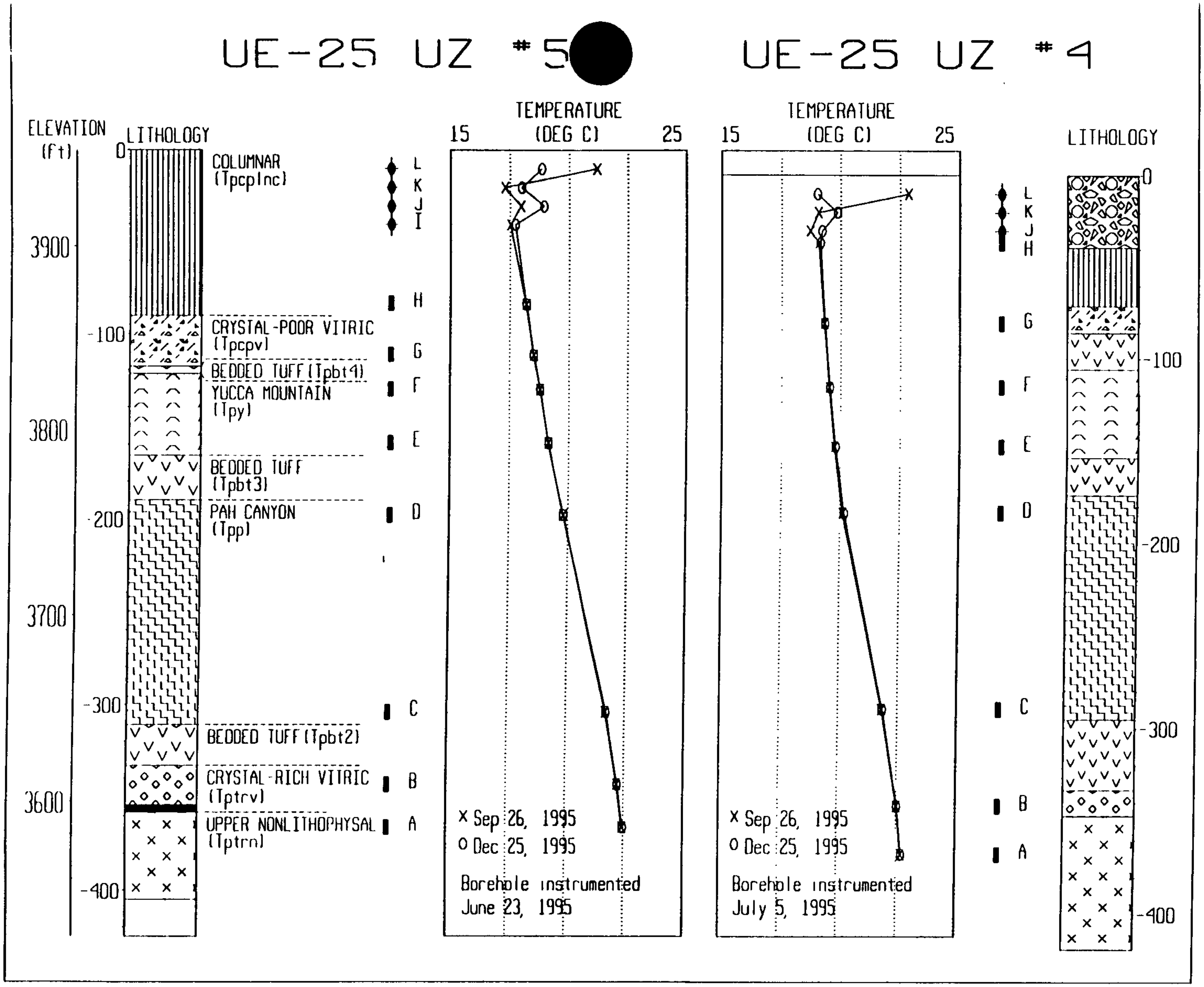


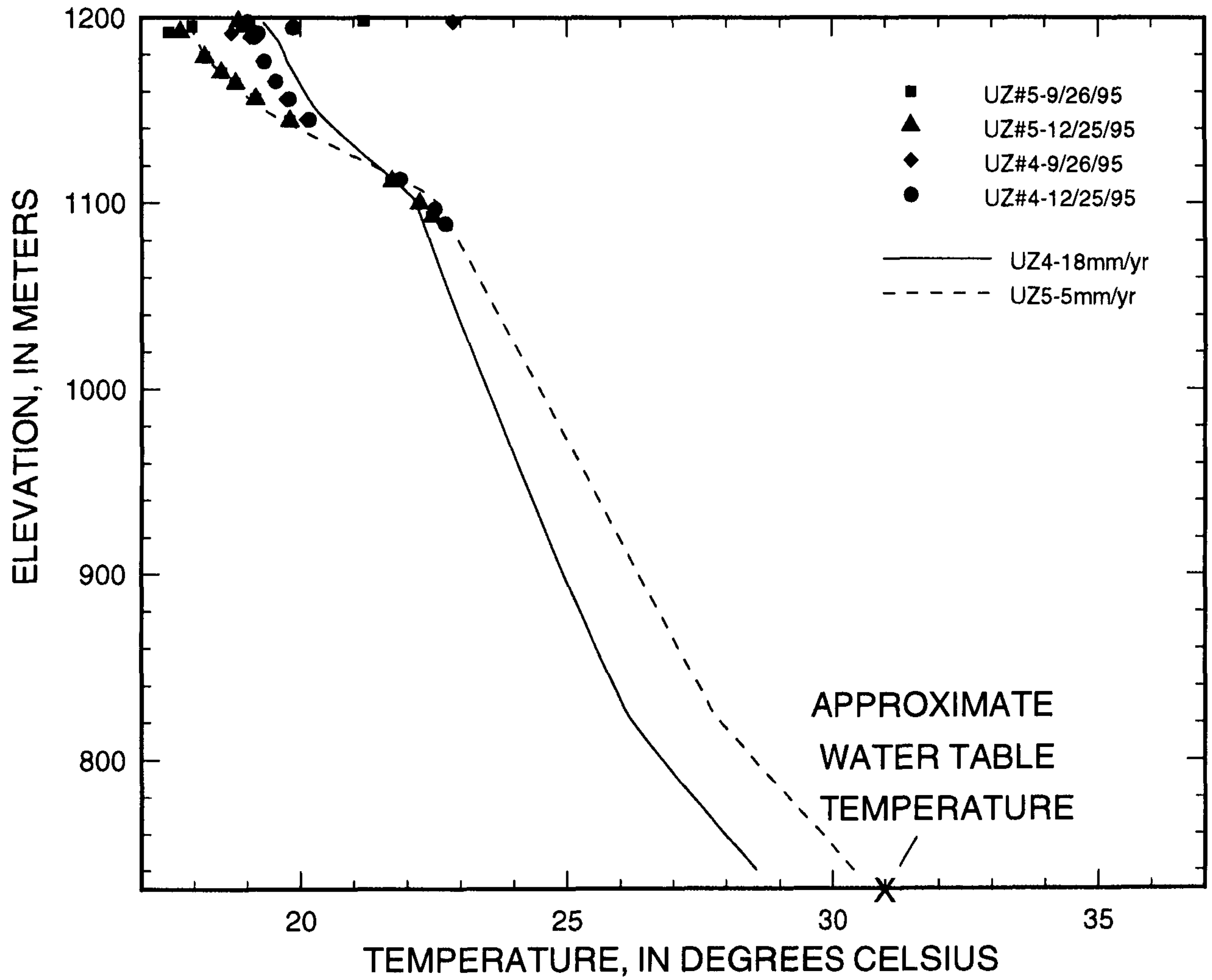
Figure 4.2.2-9 Selected temperature profiles for UE-25 UZ#4 AND UE-25 UZ#5

PAGANY WASH HEAT-FLUX ANALYSIS

- **An analysis of temperature profiles showed that, for a given elevation, temperatures at UZ#4 were greater than those at UZ#5, and that this difference increased with greater proximity to the alluvium.**
  - This temperature difference is attributable to the insulating effects of the low thermal conductivity alluvium at UZ#4.
  - The estimated heat flux increases with elevation within the PTn at UZ#5, due to lateral diversion of heat around the alluvium and into the sideslope.

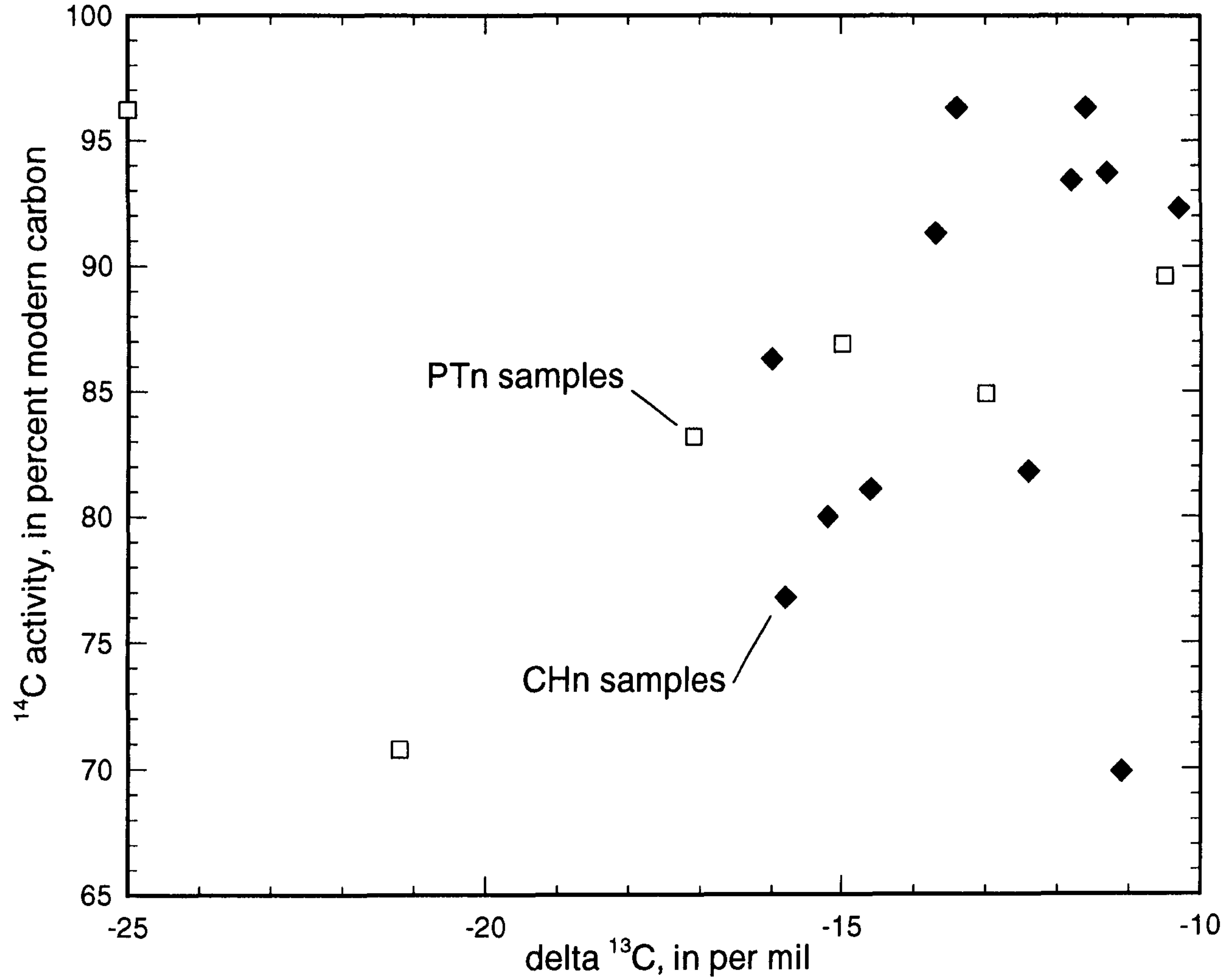
- **The estimated vertical heat flux in the Pah Canyon Tuff at both UZ#4 and UZ#5 is only 15.5 x 10^{-3} Joules sec^{-1} m^{-2}, a substantial reduction in the heat flux of 32 x 10^{-3} to 40 x 10^{-3} Joules sec^{-1} m^{-2} estimated to occur in the lower unsaturated zone, based on previous regional heat-flow studies.**
  - Implies active percolation between the Pah Canyon Tuff and the water table beneath both UZ#4 and UZ#5.

Figure 4.2.2-31. Comparison of measured temperatures at UZ#4 and UZ#5 with best-fit simulated temperatures using a one-dimensional model and steady-state infiltration fluxes of 18 mm/yr at UZ#4 and 5 mm/yr at UZ#5.



SUPPLEMENTARY INFORMATION

^{14}C AND DELTA ^{13}C DATA FROM BOREHOLE UZ-14
(data from Yang, 1996)



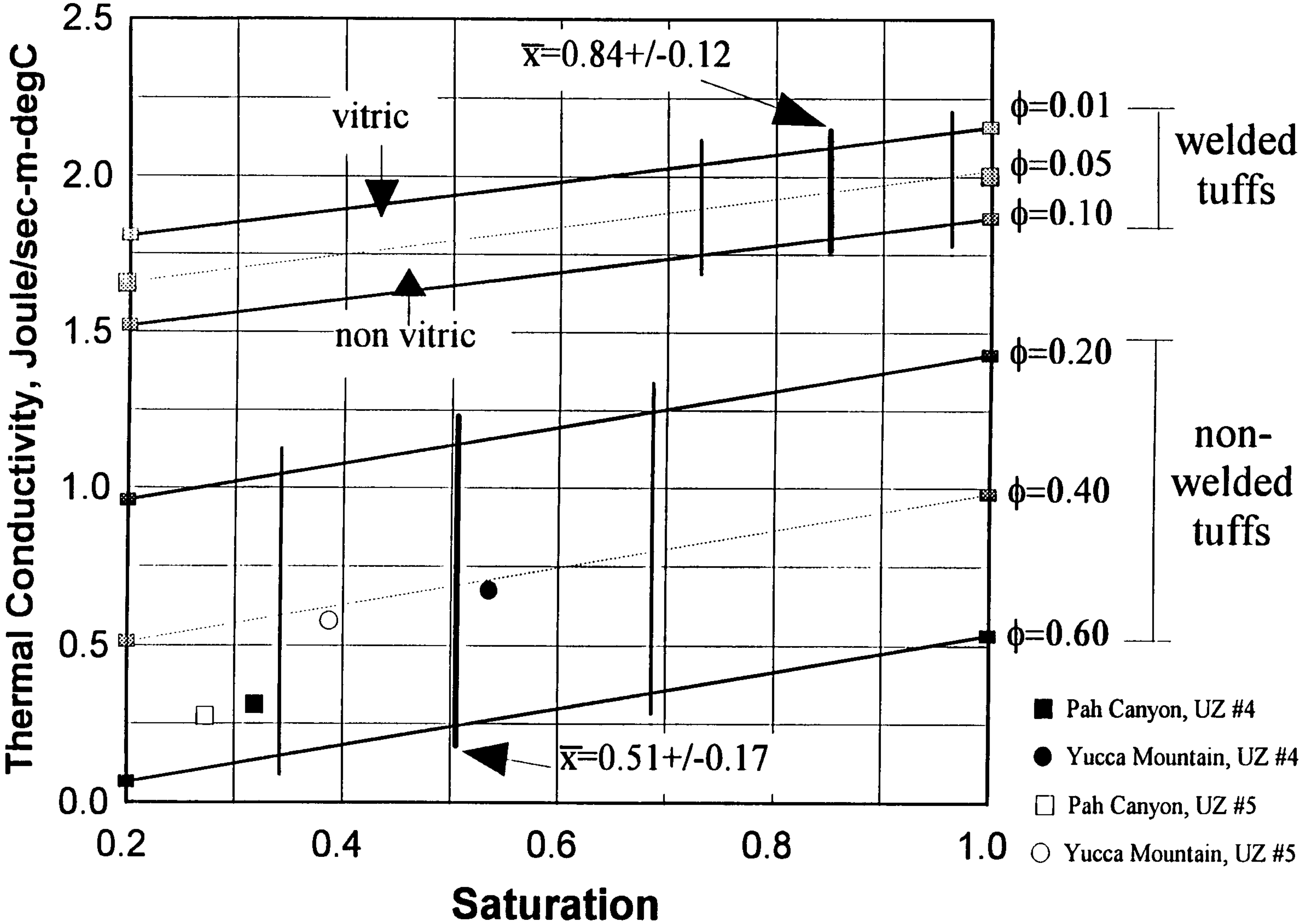


Figure 4.2.2-16 Thermal conductivity of welded and nonwelded tuffs plotted as a function of saturation and porosity for T=20 deg C.

COMPARISON OF SIMULATED AND OBSERVED TEMPERATURES AT UZ#4