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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

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Mr. Jeff Pohle
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Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: NTS

Dear Jeff:

This letter constitutes our semiannual update of conceptual models as required by the SOW, Subtask 1.3, for Contract No. NRC-02-85-008. No new conceptual models have been developed within the last six months. The preferred unsaturated zone conceptual model as presented by DOE in the Draft Site Characterization Plan is summarized from Montazer and Wilson (1984) as follows:

1. Moisture enters the system as net infiltration below the plant-root zone principally as liquid-water flow into and within the fractures of the surficial Tiva Canyon welded unit (TCw) with subsequent uptake under capillary forces into the TCw matrix. It is expected that at sufficiently low rates of net infiltration, all of the water entering the TCw unit may be drawn into the matrix before the full thickness of the TCw unit is traversed.

2. Hydraulic gradients directed parallel to the dip may induce down-dip lateral flow at the contact between the TCw unit and the underlying Paintbrush nonwelded unit (PTn) as a consequence of (1) efficient fracture-dominated flow in the TCw unit at high infiltration rates or (2) capillary barrier effects. Capillary barriers may inhibit water movement from a unit of low matrix or fracture conductivity into a unit of higher conductivity by capillary forces in the low-conductivity unit (at unsteady flow conditions).

3. Both vertical and lateral down-dip flow may occur in the relatively high-conductivity PTn unit. Lateral flow (may) occur because of the intrinsic anisotropy of this unit as well as because the low matrix

conductivity of the underlying Topopah Spring welded unit (TSw) may impede the vertical movement of water from the PTn unit into the TSw unit.

4. Flow in the TSw unit is expected to be essentially vertical and under steady-state conditions, to occur as flow within the matrix for fluxes less than some critical value of flux related to the saturated matrix hydraulic conductivity, and to occur predominantly as fracture flow at fluxes higher than the critical value.

5. Down-dip lateral flow may be induced in the TSw unit at its contact with the underlying Calico Hills nonwelded unit (CHn). The circumstances under which this may occur depend upon the magnitude of the flux in the TSw unit and whether this unit is underlain by the low-conductivity zeolitic facies (CHnz) or the relatively higher-conductivity vitric facies (CHnv) of the CHn unit. At low fluxes within the TSw unit, lateral flow may be produced by capillary-barrier effects within the matrix of the TSw unit where it overlies the CHnv unit. At high fluxes, efficient fracture flow in the TSw unit may produce lateral flow as well as vertical flow where the low-conductivity CHn unit underlies the TSw unit.

6. Flow in both the CHnv and CHnz units is predominantly vertical through the matrix (although a down-dip lateral component may occur parallel to the bedding within the vitric CHnv unit) and continues directly to the water table wherever the latter transects the CHn unit. It is presumed that where the CHn unit lies above the water table, flow proceeds vertically downward to the water table through the Crater Flat undifferentiated unit (CFu).

7. The nearly vertically oriented fault zones and their associated fracturing may be highly effective pathways for vertical moisture flow (at saturated conditions), especially in the competent TCw and TSw units. But faults may impede lateral flow and may thus produce perched-water bodies where the faults transect zones or horizons of significant downdip lateral flow.

8. Temperature-driven moisture transport may occur, especially within the highly fractured TSw unit. This could be expected to occur by molecular diffusion if local thermodynamic phase equilibrium is maintained between liquid water and water vapor within the system, which would produce a water-vapor concentration gradient along the natural geothermal gradient. Of greater importance may be the advective transport of water vapor accompanying thermal or barometric upward bulk-gas flow within the fractures of the TSw unit. Under steady-state conditions the upward movement of water vapor in the air-filled fracture openings would be compensated by downward return flow of liquid water within the rock matrix.

9. Moisture flow within the deep unsaturated zone at Yucca Mountain may be occurring under essentially steady-state conditions. The steady-state hypothesis implies that moisture flow within the natural system is occurring predominantly as vertically downward liquid-water flow within the rock matrix of the hydrogeologic units with possible water-vapor movement within the air-filled pore and fracture space. Significant liquid-water flow within the fractures may occur but only as near-surface, transient, nonequilibrium events that are followed by eventual uptake by the rock matrix of water descending through the fractures. Equilibrium would prevail between the liquid-water matric potentials in the fractures and the unsaturated rock matrix at depth. Liquid water movement could occur in fractures as well as the matrix. Although the amount of fracture flow probably would be small, additional understanding of the factors controlling fracture flow is needed to assess this phenomenon. Under these conditions, the liquid-water flux through the matrix of the TSw unit would be expected to be less than the mean matrix saturated hydraulic conductivity of about 1 mm/yr as determined for this unit by Peters et al. (1984).

As noted in our last semiannual conceptual model update (Communication No. 114), the effects of matrix heterogeneity are not considered in the DOE conceptual model for NNWSI (Montazer and Wilson, 1984). Currently we are in the process of testing our conceptual model by investigating the effects of matrix heterogeneity using the model UNSAT2. We have not been able to get the model to converge on a solution to date; however, we still believe that a conceptual model that incorporates matrix heterogeneity can explain the conditions being observed in Yucca Mountain.

No new conceptual models for the saturated zone have been published since our last semiannual update. According to the DOE (1987) (Draft Site Characterization Plan), a general conceptual model for the saturated zone is based upon the division of the Tertiary stratigraphic units as follows:

1. Moderately and densely welded tuffs and

2. Nonwelded and bedded tuffs.

The moderately and densely welded tuffs are characterized as having low porosities, abundant fractures and low-matrix permeability. Groundwater movement occurs primarily through the fractures rather than through the matrix.

The nonwelded and bedded tuffs are characterized as having higher porosities, higher permeabilities, and fewer fractures than moderately and densely welded tuffs. Groundwater movement occurs primarily through the matrix; however, flow through fractures occurs also.

According to the Draft SCP, this conceptual model "provides a basis for predicting saturated hydraulic properties near Yucca Mountain, provided that the welding characteristics and extent of secondary mineralization of units are known." Based on the data from drill hole UE-25p#1 (which is the only hole that penetrates Paleozoic carbonate rocks beneath Yucca Mountain), the Draft SCP suggests that "ground water moving through the shallow part of the saturated zone in the vicinity of the Yucca Mountain repository block probably does not have significant local interaction with water from the Paleozoic rocks."

The Draft SCP suggests that "In general, ground-water flow beneath Yucca Mountain probably is southward through the site, southeastward away from the site into the Fortymile Wash area. However, because of the nearly flat potentiometric surface under parts of Yucca Mountain, specific flowpath directions are currently difficult to define."

In summary, no new conceptual models have been developed for NNWSI since our last update (February 26, 1987). We will continue our modeling effort that includes the effects of matrix heterogeneity to test our conceptual model for the unsaturated zone at Yucca Mountain.

Sincerely,

James Osiensky/sl

James L. Osiensky

JLO:sl

References

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