Supporting information to "Desiccation-Crack-Induced Salinization in Deep Clay Sediment"

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Equations used for estimations of water evaporation potential from the vadose zone due to thermally driven convective air flow in the desiccation crack voids

Calculations of evaporation due to thermally driven convection in desiccation cracks were based on theoretical equations that were previously presented by *Nachshon et al.* [2008] and *Weisbrod and Dragila* [2006]. In their work, they proposed that air convection within the void of a vertical open fracture was thought to start when the Rayleigh number (Ra), which compares buoyant and viscous forces, exceeded the critical value of 40 [*Nachshon et al.*, 2008; *Nield*, 1982]:

$$Ra = \frac{\Delta T \alpha g k L}{\nu \kappa} \qquad (1)$$

where ΔT (°C) is the temperature difference between the crack air at the top and the bottom of the crack over the length scale L (m), g is the gravitational constant (9.80 m s^{-2}), k is the crack permeability (m^2) [$k = (2b)^2/12$, where 2b is the crack aperture [*Shemin*, 1997]], ν is the kinematic viscosity (1.51×10^{-5} m^2 s^{-1}) and κ is the thermal diffusivity (2.0×10^{-5} m^2 s^{-1}). Within the range of 0 to 80° C, air density can be assumed to be a linear function of temperature and is expressed by the thermal expansion coefficient [α = 0.00367(1/°C)]. Eq. (1) considers temperature-dependent volume changes of gas to be negligible, such that there is no latent heating due to gas compressibility, which is justifiable for the situation considered [*Weisbrod and Dragila*, 2006].

Once convection is initiated, the entry of cool dry fingers of atmospheric air and the venting of the crack were thought to continue until atmospheric warming reversed the thermal gradient in the crack. Based on the suggestion of *Weisbrod and Dragila* [2006], in which the velocity of the entering cool and dry atmospheric air fingers is strongly influenced by the crack's aperture, the average air venting speed (u_{ave}) was approximated by Poiseuille flow (assuming laminar conditions persist throughout the process):

$$u_{ave} = \frac{g \alpha \Delta T k}{\nu} \qquad (2)$$

The rate by which vapor is lost from the crack was computed using *Weisbrod and Dragila's* [2006] equation:

$$Q_C = V(\Delta C)N \qquad (3)$$

where V is the volume of fracture air (m^3), ΔC is the difference in water vapor concentration (kg m^{-3}) between the fracture air and the atmospheric air (ΔC =

$(\Delta R_H) R(T)\ \rho_{\text{air}})$, ΔR_H is the difference in relative humidity between the fracture air and the atmospheric air, $R(T) = 0.0145$ at 20° C is the saturated mixing ratio of water vapor in the air, and $\rho_{\text{air}} = 1.2$ (kg m^{-3}) is the density of moist air, N is the number of venting cycles per nighttime (u_{ave}/L), and L is the depth of the convection cell (m).

References

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