Influence of Paleosols on Fluid Flow and Transport: Perspective on Alluvial Complexity and Hydrogeology


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* Thesis/Dissertation work
Kings River Fan Aquifer System

- Stream-dominated alluvial fan system (fluvial depositional system);
- Located southeast of Fresno, California;
- Study area located in medial fan area.
Driller's Logs
Salinas Valley, California

To Correlate, Or Not to Correlate?
Transition Probability Definitions

From Probability Theory:

\[ t_{jk}(h_y) = \Pr\{k \text{ occurs at } x + h_y \mid j \text{ occurs at } x\} \]

w.r.t. Indicator Variables:

\[ t_{jk}(h_y) = \frac{E[I_j(x)I_k(x + h_y)]}{E[I_j(x)]} \]
Transition Probability Matrix

\[ T(h_\phi) = \begin{bmatrix}
    t_{11}(h_\phi) & L & t_{1K}(h_\phi) \\
    M & O & M \\
    t_{K1}(h_\phi) & L & t_{KK}(h_\phi)
\end{bmatrix} \]

**LLNL STUDY AREA**

- debris flow
- floodplain
- levee
- channel
Typical Subsurface Complexity, LLNL Site (Carle & Fogg, 1996)
Consequences of Heterogeneity

Movie of LLNL results.....
Geostatistical Simulations

- Unconditional
- Conditional Elevation (m)
- w. Seismic Interp.

Offset (m)

Orange Co., CA (Tompson, Carle, Rosenberg, and Maxwell, 1999)
Understanding Alluvial Fans:
A Sequence Stratigraphic Approach

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Kings River Fan Aquifer System

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From Burow et al. (1999)
Sequence Stratigraphic Organization;
Paleosol Aquitards

Weissmann & Fogg, 1999
Where Paleosols Channeled Out,
Vertical Flow Enhanced

Graham E. Fogg, University of California, Davis
Sequence Stratigraphic Units for Non-Stationary Conditional Simulation

Combined Realization

Graham E. Fogg, University of California, Davis
Kings River Alluvial Fan
Realization 5

From Burow et al. (1999)
Groundwater Age:

Elapsed time since a water "particle" entered the saturated zone.

Quite a bit different.....

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Flow lines
-- Equipotential lines
Contaminated ground water
Backward Tracking Results: Heterogeneous

QuickTime™ and a GIF decompressor are needed to see this picture.

Graham E. Fogg, University of California, Davis

Groundwater age distributions for well B4-2 (screen depth: 35.1 m)

C. WELL B4-2
Simulated and Measured CFC Age

Simulated CFC-11 Age (yr)

Reported CFC-11 Age (yr)

Neglects pre-1950's water

Simulated Mean Age vs Simulated CFC Age

Simulated Mean Age (yr)

Simulated Average CFC-11 Age (yr)

One-to-One Line
Essence of an Age Distribution

Backward Tracking Results: Heterogeneous, Paleosols
Summary

- Hydrofacies (geologic) approach provides added perspective on hydrogeologic processes.
- Transition probability, Markov chain method (TProGS) generates heterogeneous models (realizations) that honor the data AND geologic fundamentals.
- TP-MC approach allows relatively easy incorporation of geologic information.
- Sequence-stratigraphic approach enhances characterization of the Kings River alluvial fan.
- Paleosols can be mapped regionally in KRF and are aquitards.
Summary continued

- Typical alluvial heterogeneity leads to significant dispersion of groundwater ages within water samples, even when samples are collected from short-screen wells.
- Significant age dispersion confounds interpretation of estimated or inferred groundwater ages.
- Conventional, nearly-homogeneous models of groundwater flow and transport can be grossly misleading when used to forecast groundwater travel times.