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science for a changing world

Some thoughts on heterogeneity, scale and regional bedrock investigations, . . .

Allen M. Shapiro

U.S. Geological Survey

Quantitative statement of regional water resources assessment

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Modeling

Conceptual Model → Quantitative Model

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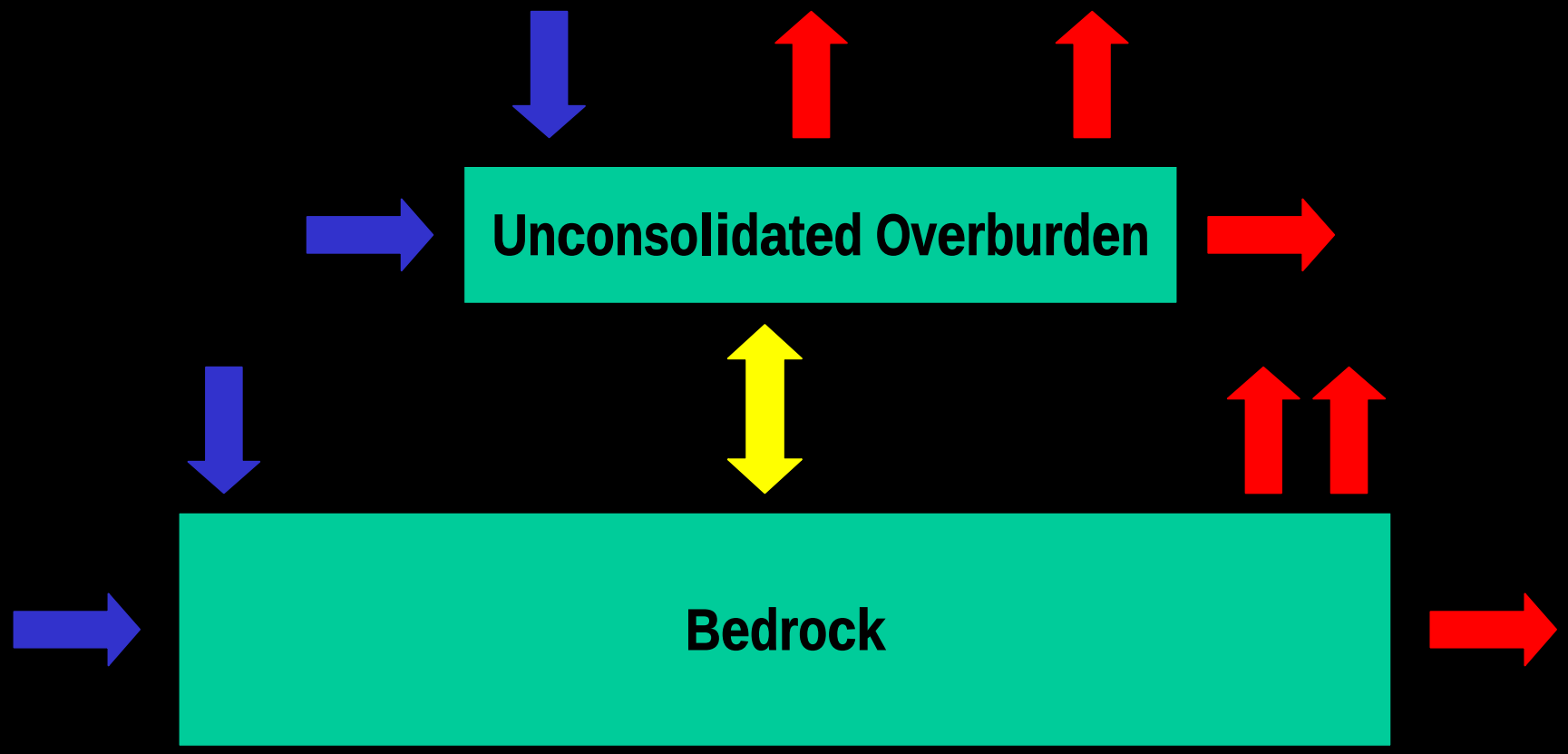
Lumped-Parameter Model:

(a good place to start)



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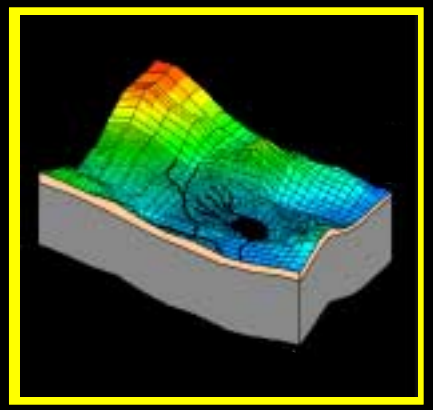
Distributed-Parameter Model:

(to define a better understanding of physical processes)



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What degree of *detail* is required in the *distributed parameters* to reproduce the *detail* in the *state variable*?

<u>Objective of the Investigation</u>
& <u>Scale of Investigation</u>

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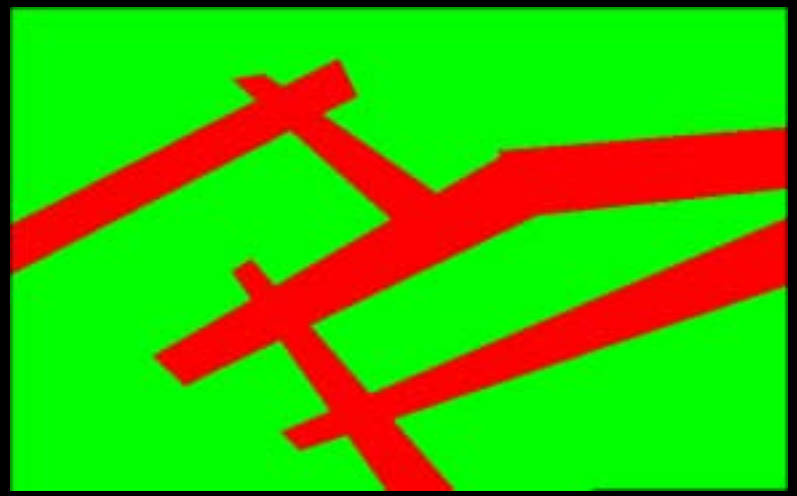
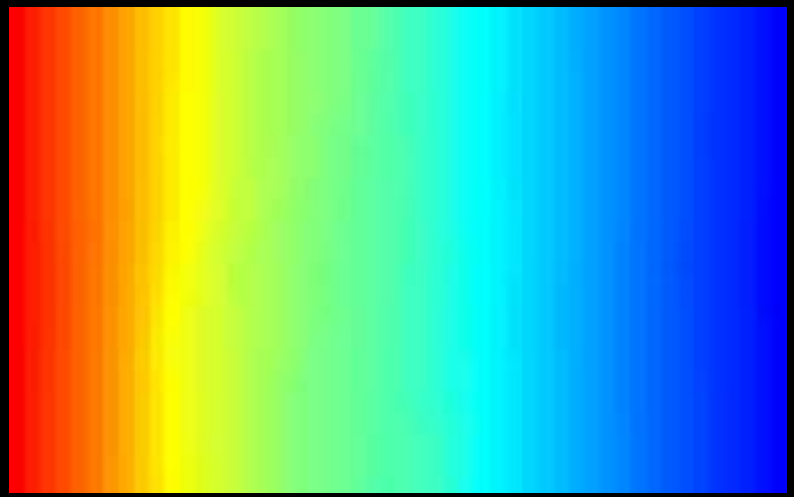
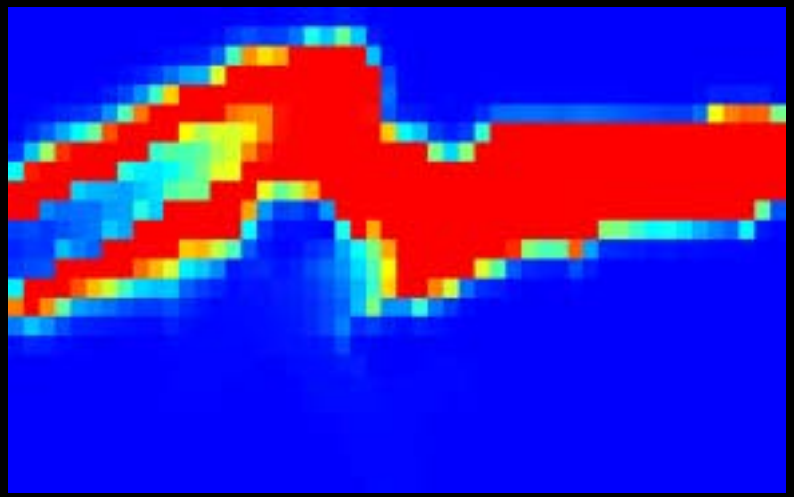
Distribution of Hydraulic Conductivity



Steady-State Hydraulic Head



Concentration at $t = t_1$



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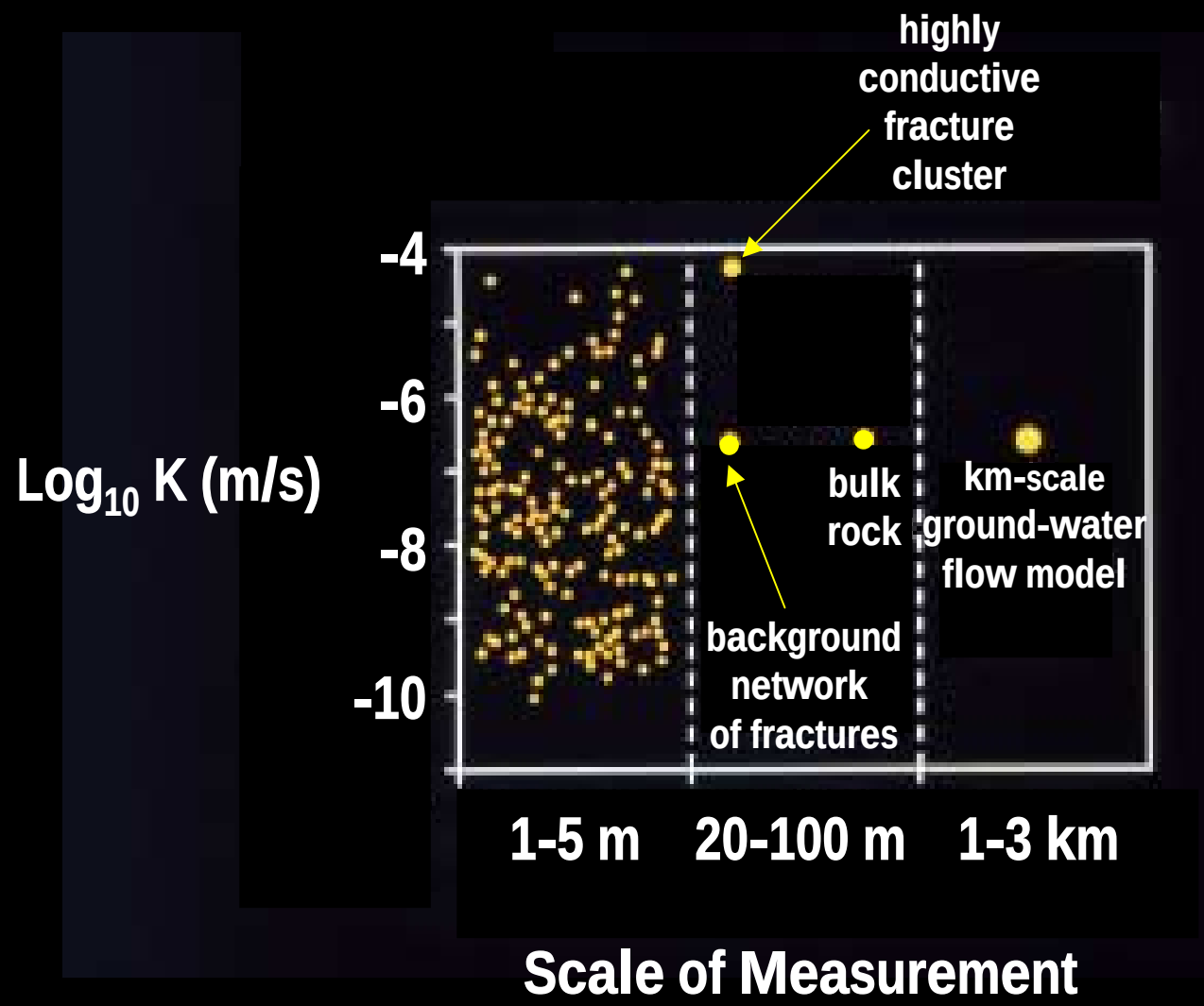
Hydraulic Conductivity Measurements at Mirror Lake



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Confidence in estimates of bedrock properties. . .

Hydraulic and chemical stresses applied in the bedrock

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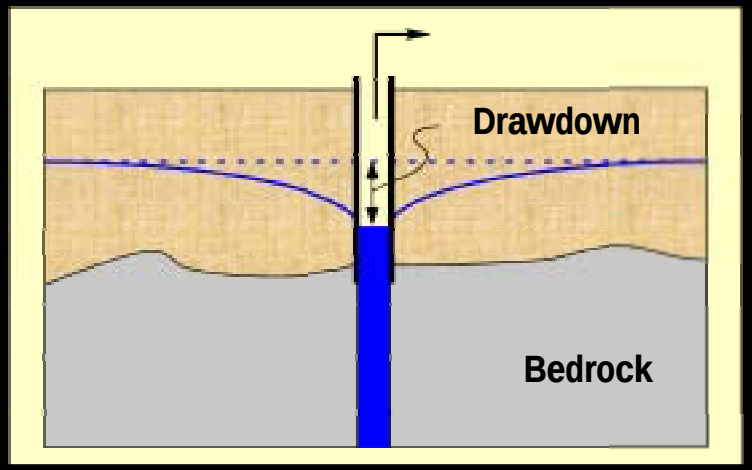
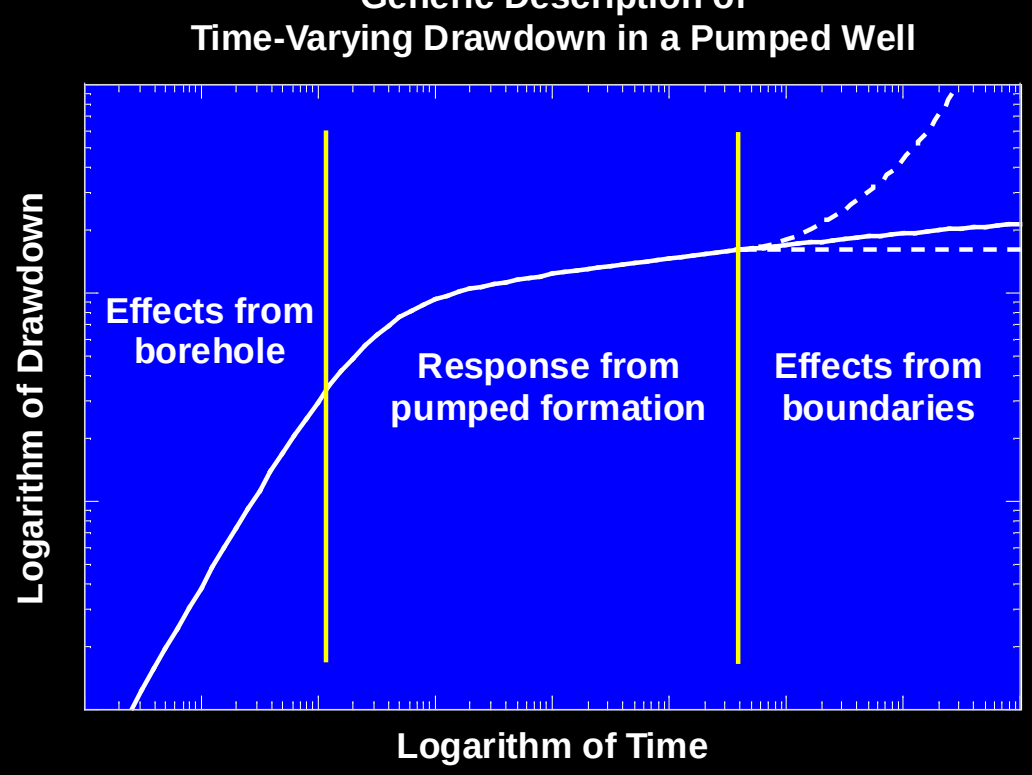


Estimating "Bulk" Properties of the Bedrock (10's meters)

Hydraulic/Aquifer Testing:



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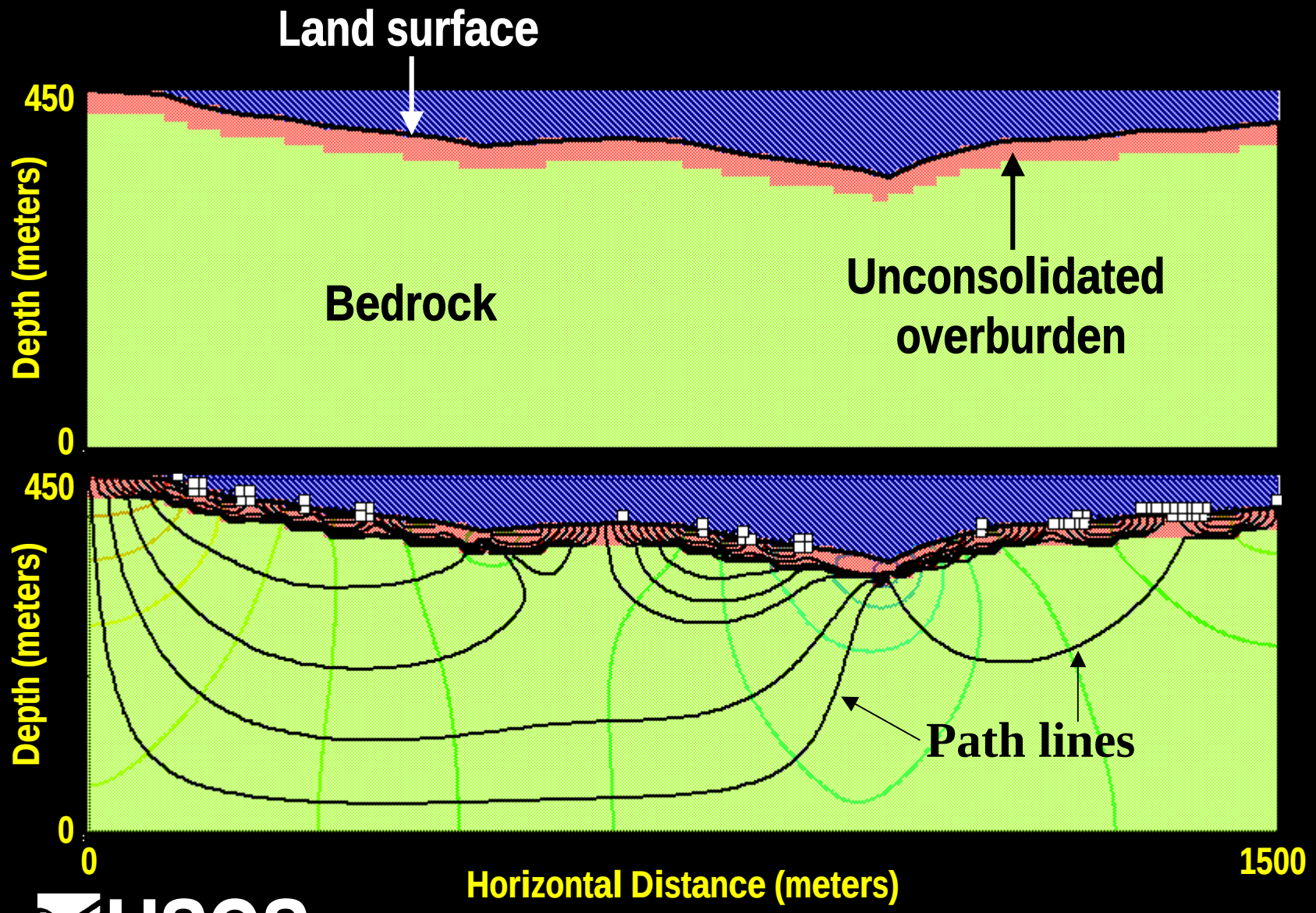
Regional Ground-Water Flow



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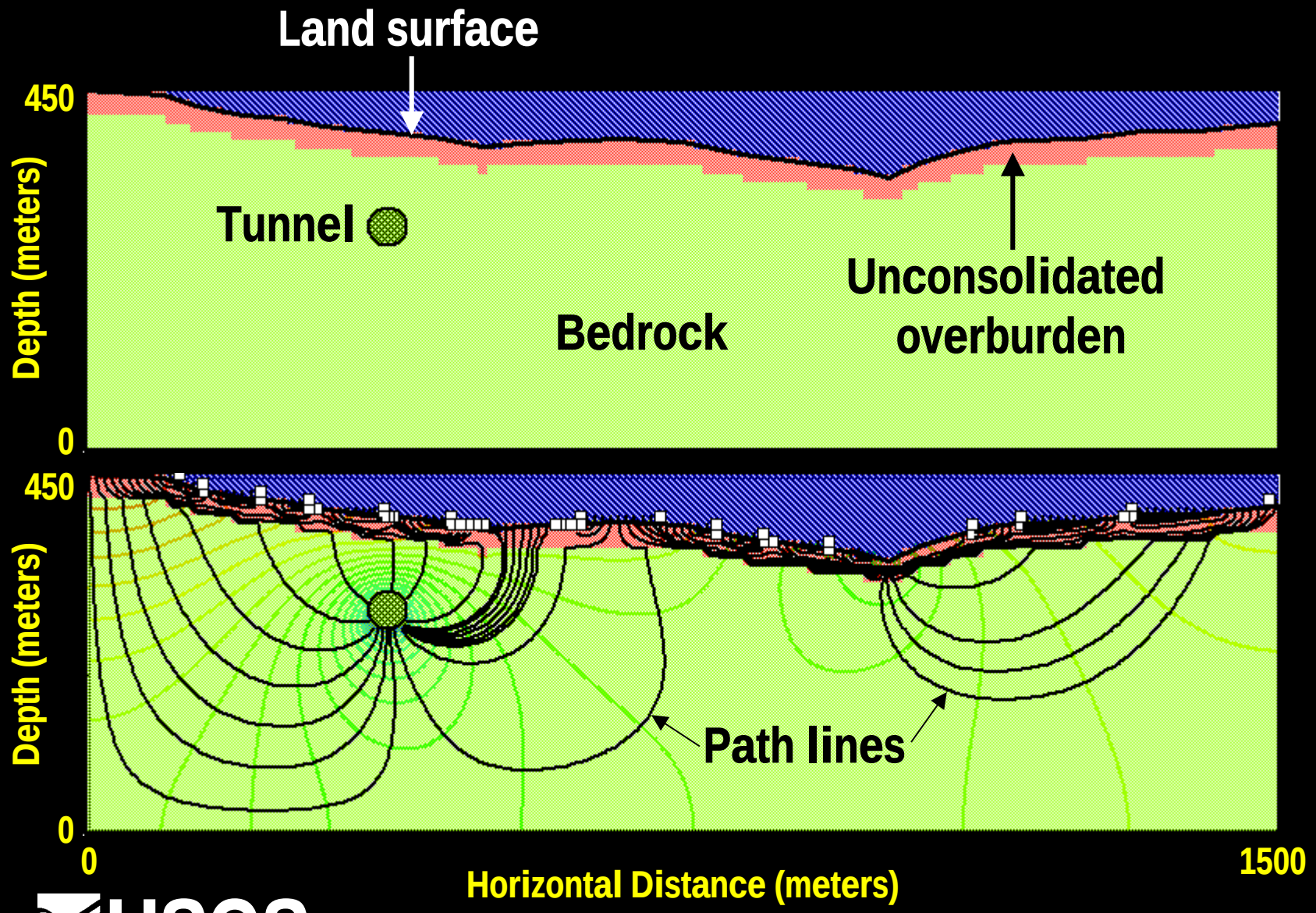
Regional Ground-Water Flow – Impact of Tunnels



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Washington Metro Tunnel Leakage
Red Line – Medical Center Station

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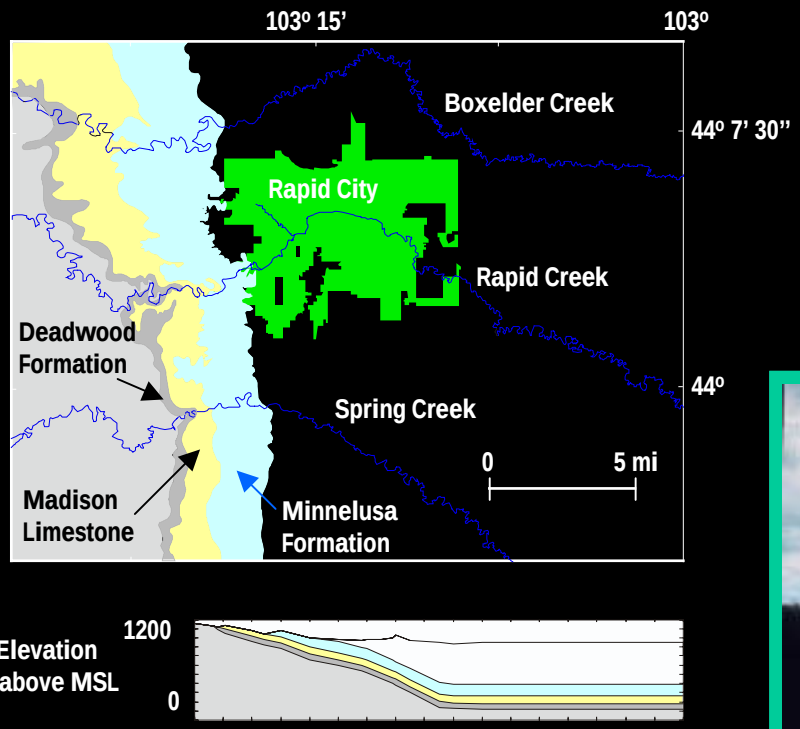
Madison Limestone
Rapid City, South Dakota



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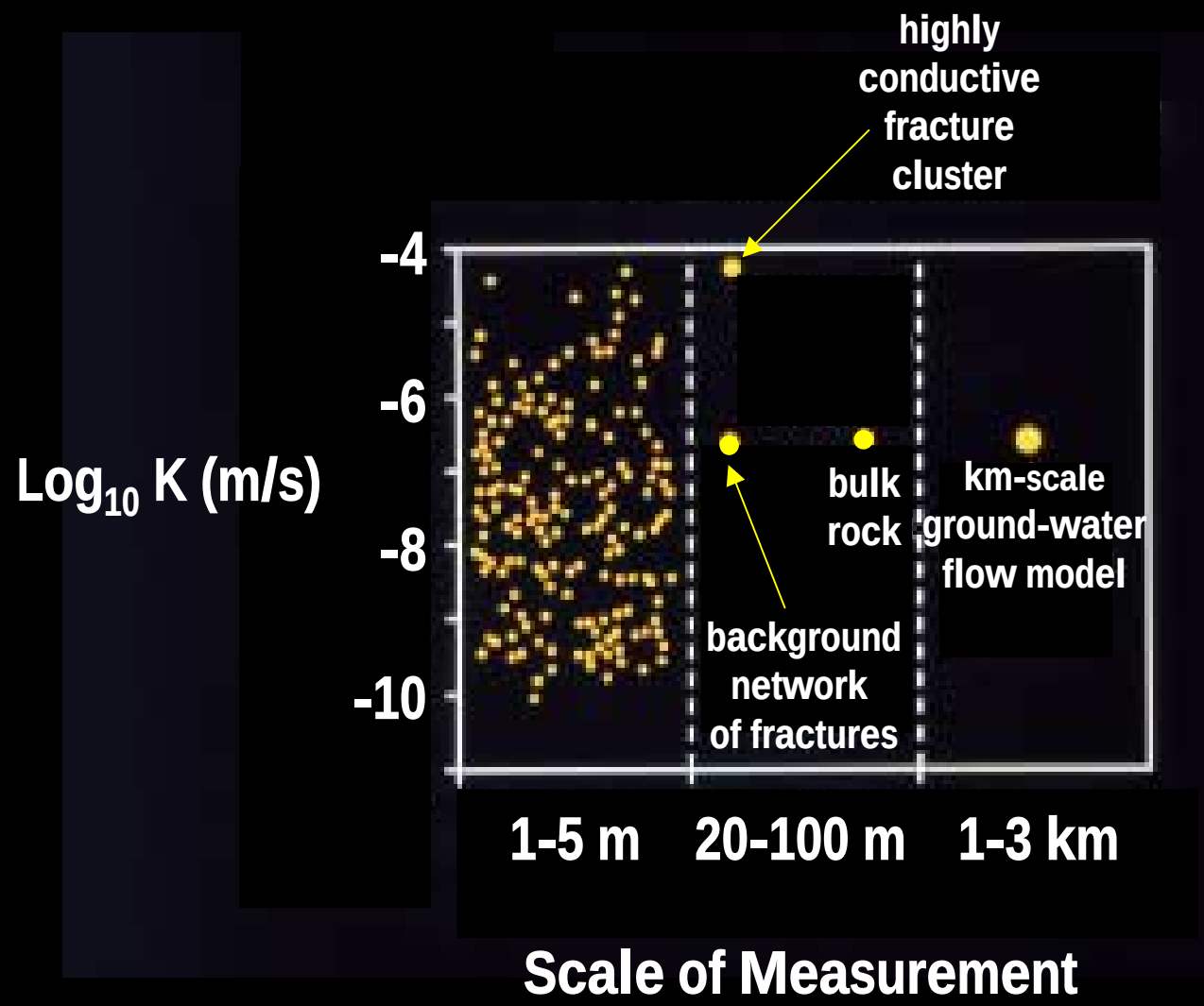

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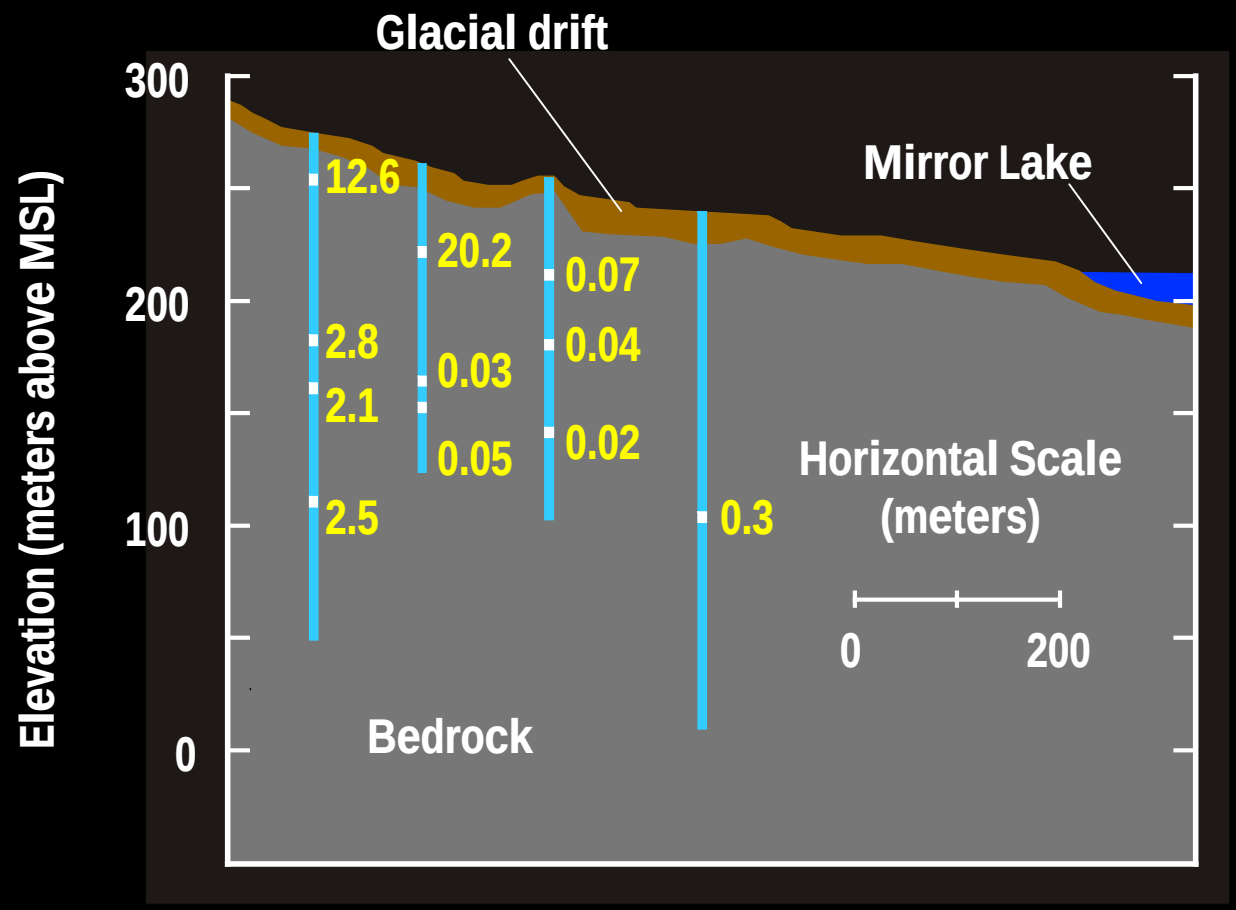
Tritium Concentrations - 1992



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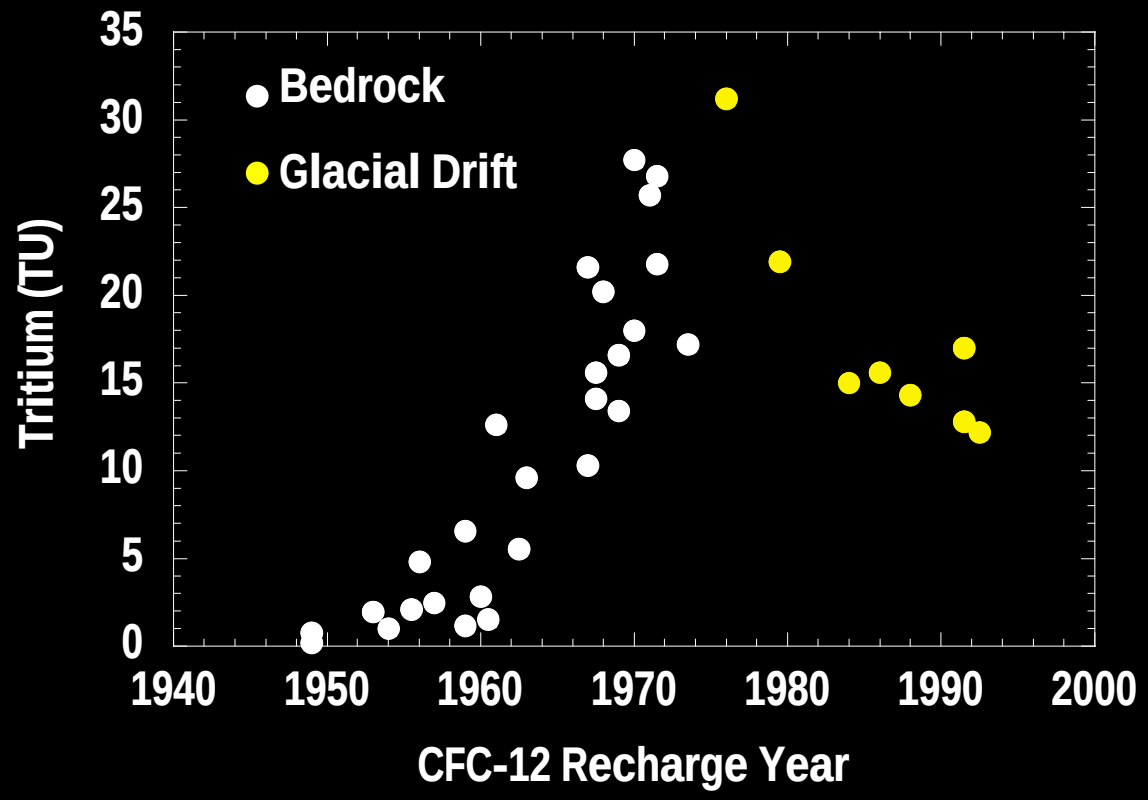
Tritium Versus CFC-12 Recharge Year



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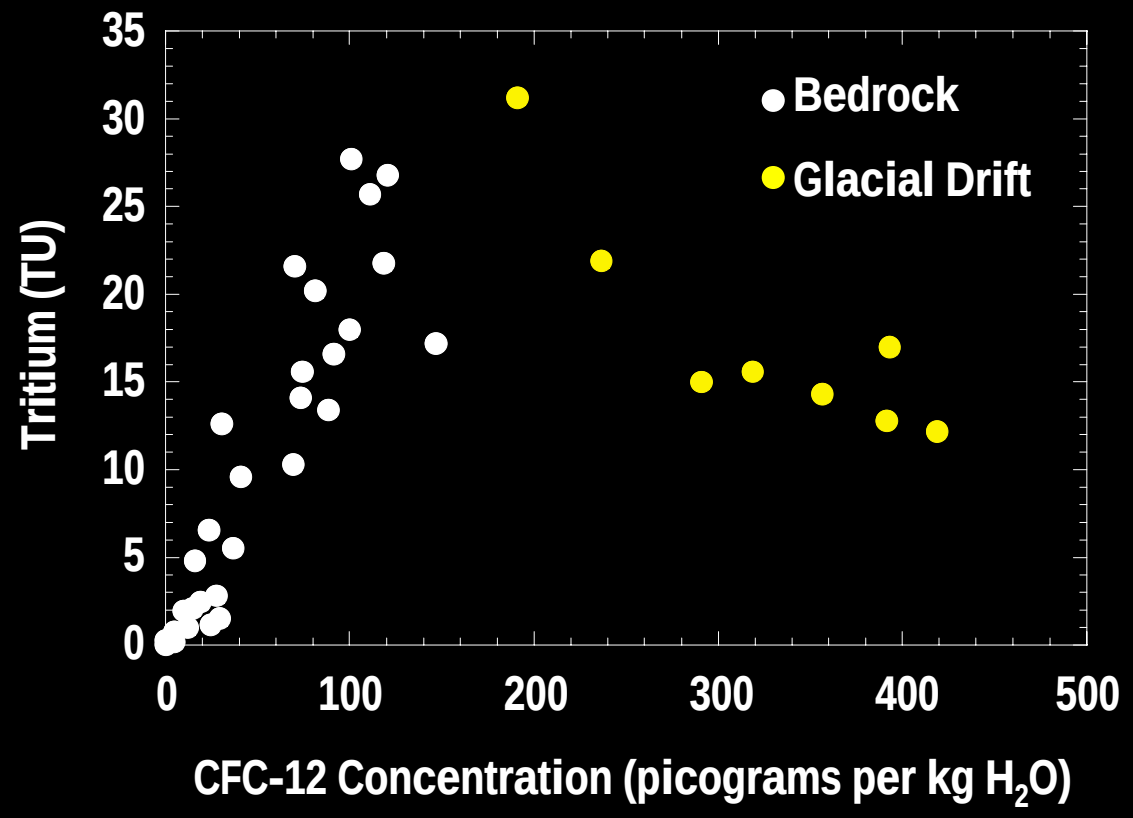
Tritium Versus CFC-12 Concentration



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Some closing thoughts. . .

1. Synthesis → modeling → starting on day 1 !

2. Multiple lines of supporting evidence

3. Everything in moderation, even moderation

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