Developments in USGS Ground-Water Research: Ground-Water Age Dating

By

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Ground-Water Age-Dating

What is ground-water age dating?

How do we date ground water?

Why is age dating useful?

Some examples from Oklahoma

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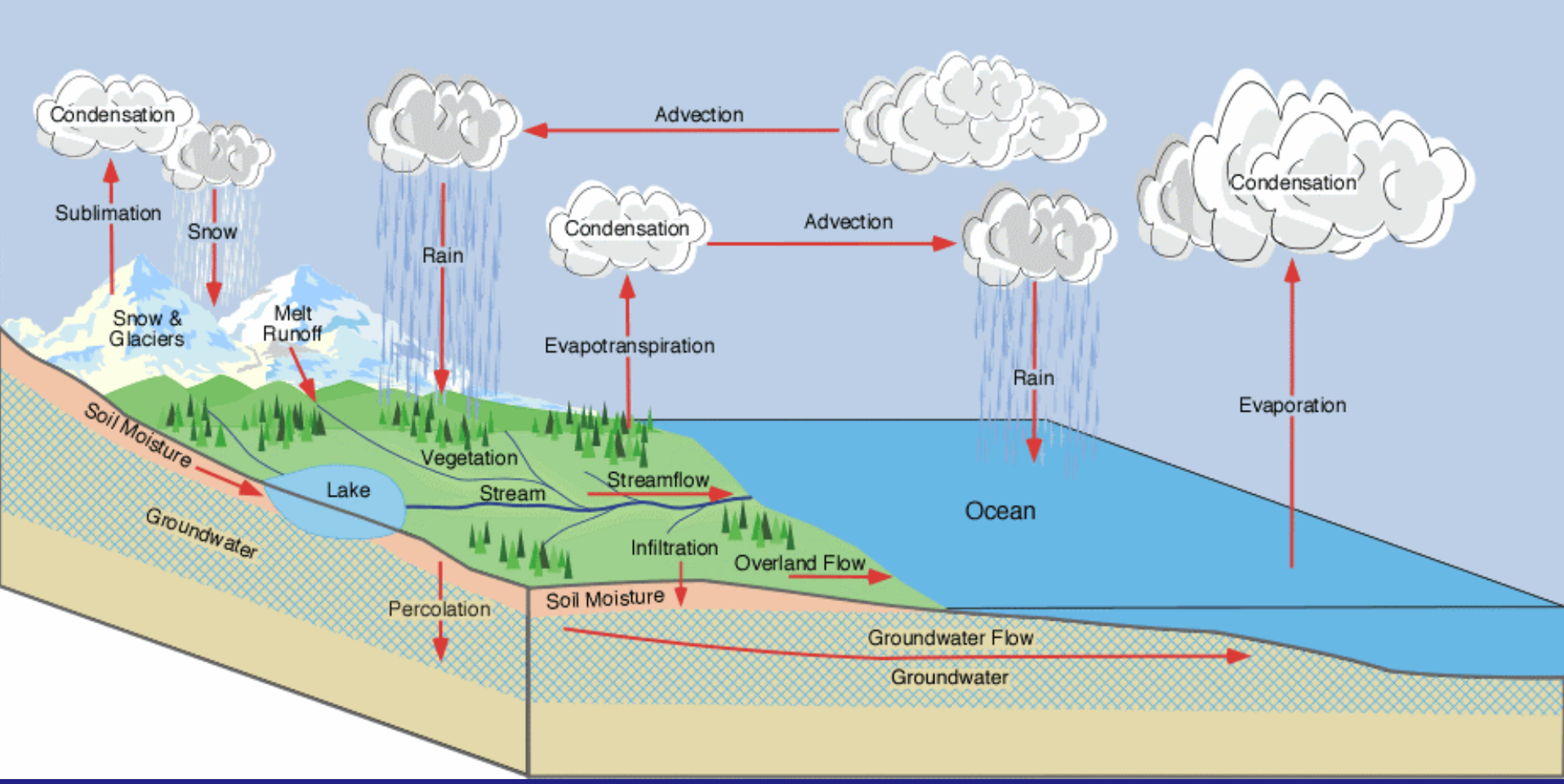

What is ground-water age dating?

Ground water originates as the infiltration of precipitation or surface water

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Ground Water Age-Dating

The age of ground water is the time period during which the water is isolated from the atmosphere.

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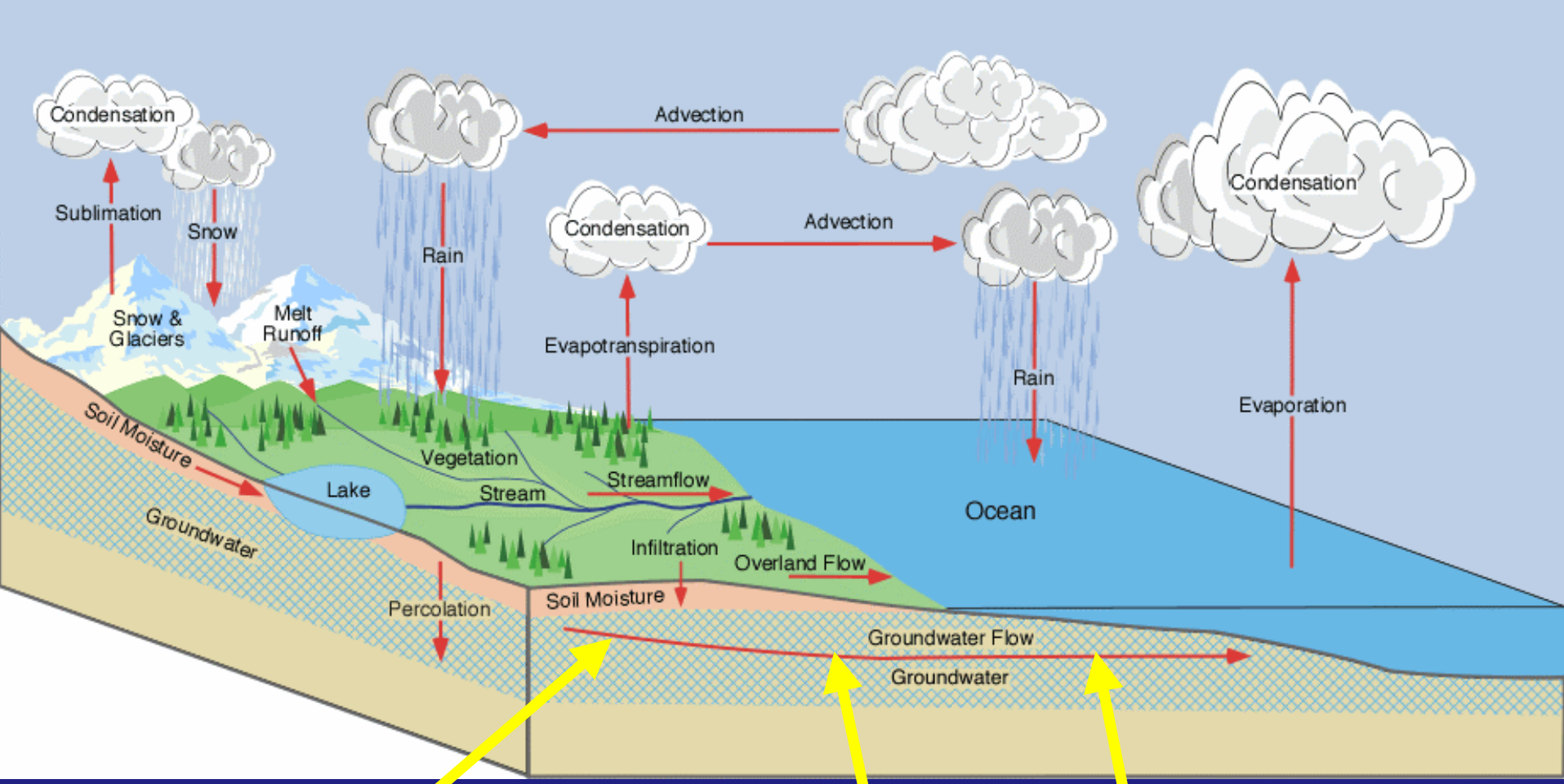

Ground water becomes isolated from the atmosphere

Age increases along flowpath

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How Do We Date Ground-Water?

Carbon-14: Radioactive; natural and anthropogenic

Tritium: Radioactive; natural and anthropogenic

CFCs: Stable but degradable; anthropogenic

Other constituents

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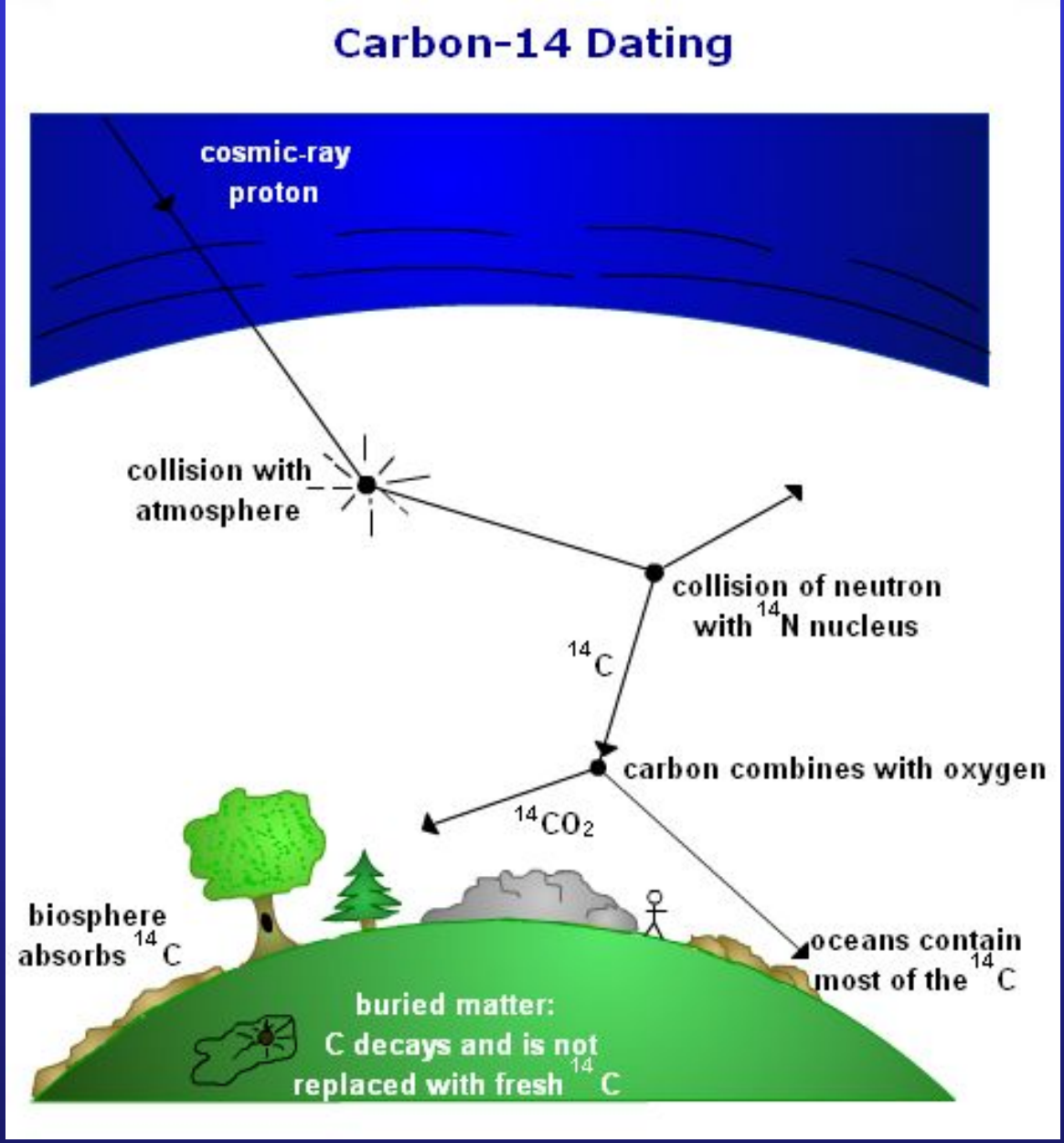
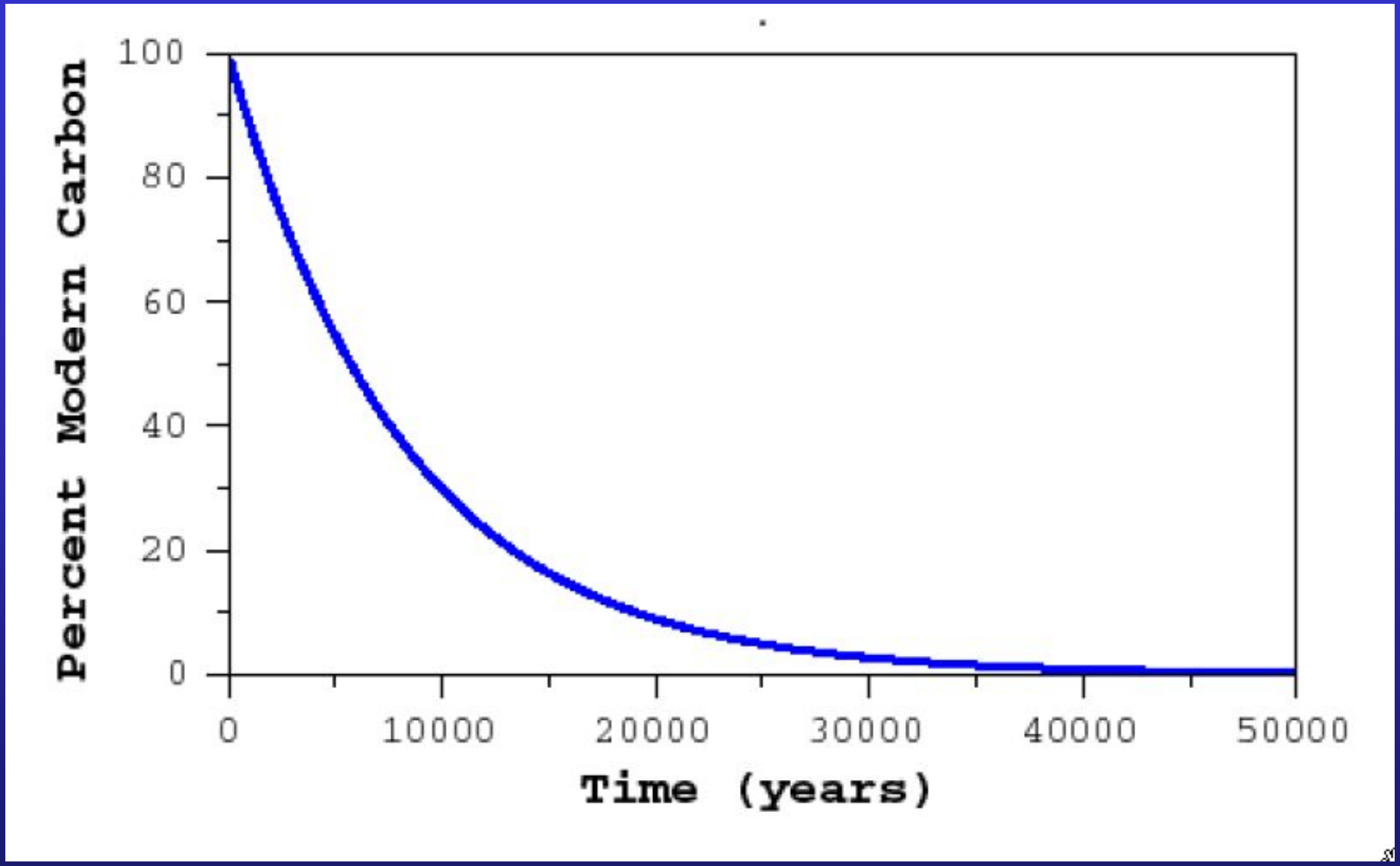


Cosmogenic Carbon-14

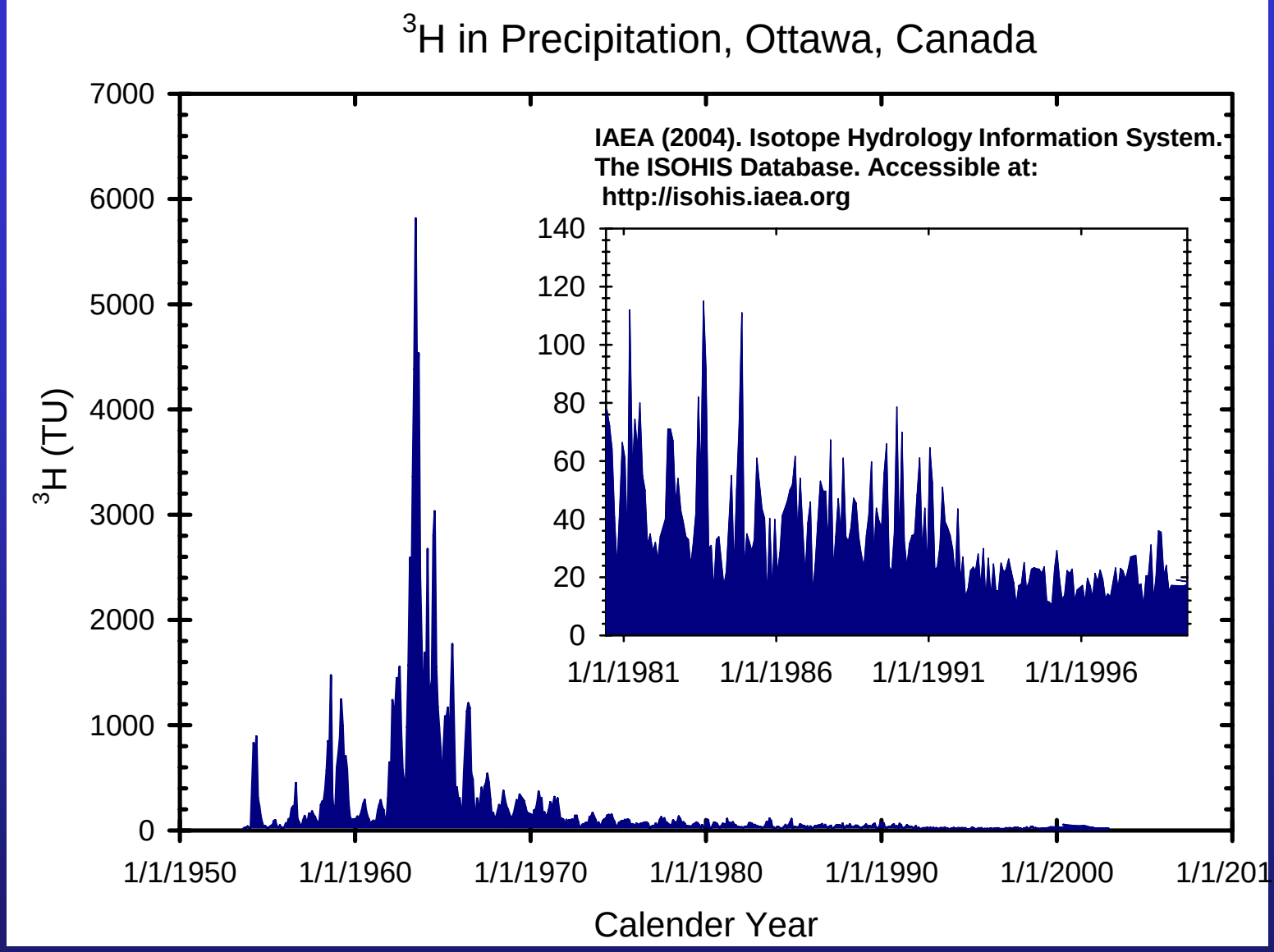


Carbon-14 ½-life is 5,730 years

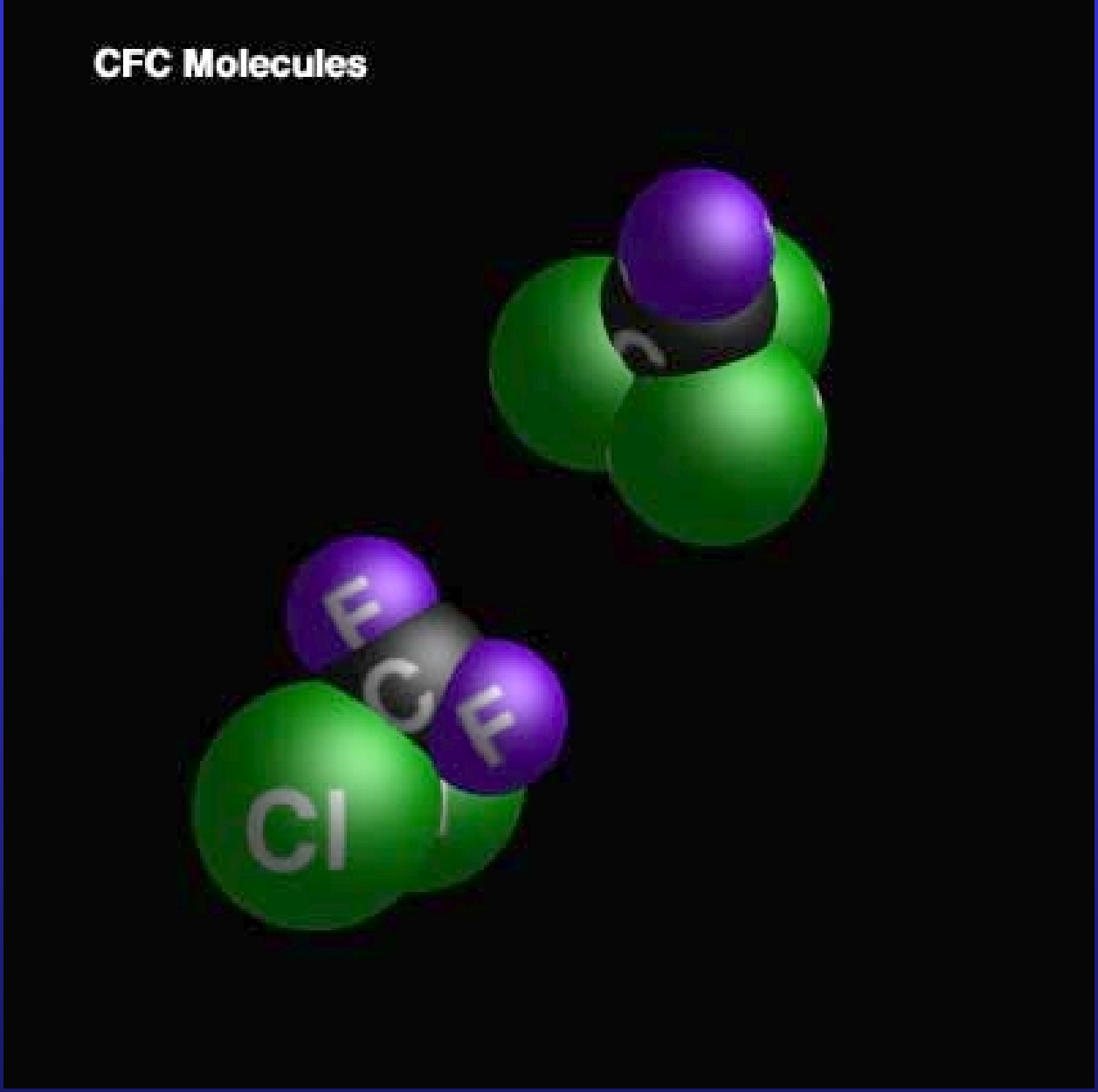
^{1}H	^{2}H	^{3}H
1.00794 99.985%	2.0141 0.015%	$t_{1/2}$ =12.32yrs
Stable	Stable	Cosmogenic/ anthropogenic

Hydrogen Isotopes

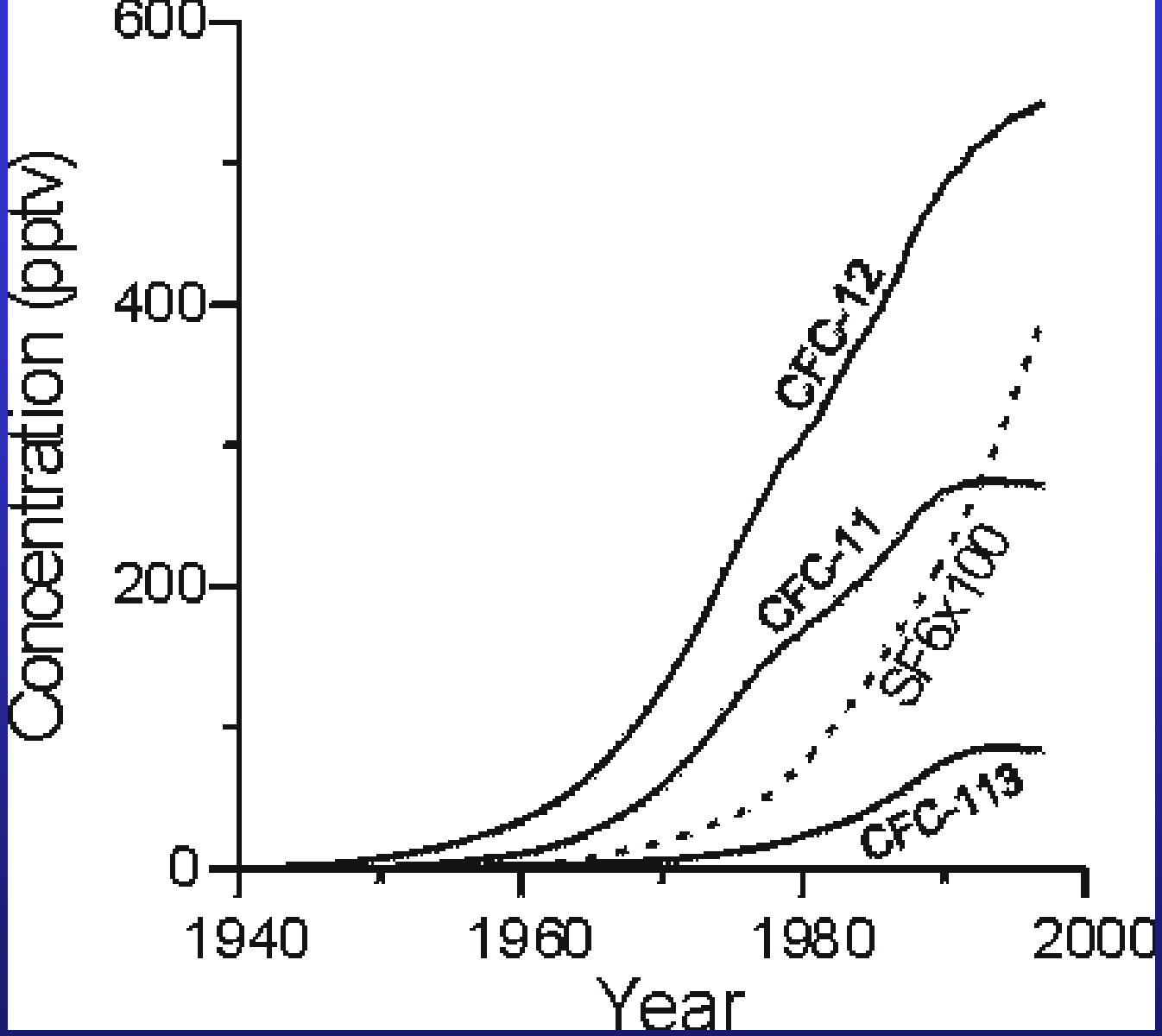
Hydrogen Bomb “Mike”
October 31, 1952



Atmospheric Nuclear Testing Elevated Tritium Concentration



Chlorofluorocarbons



Atmospheric Chlorofluorocarbon Concentrations

Why Use Ground-Water Age Dating?

- Vulnerability to anthropogenic contamination
- Direction and velocity of ground-water flow
- Calculate recharge rate
- *Improve our understand of ground-water flow systems, hopefully leading to better management*

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Vulnerability to Contamination

Vendome Well
Uncorrected carbon-14 age is 17,000 years

Vulnerability to Contamination
Tar Creek Superfund Site

Tritium Concentrations Show Vulnerability of Roubidoux Aquifer to Contamination

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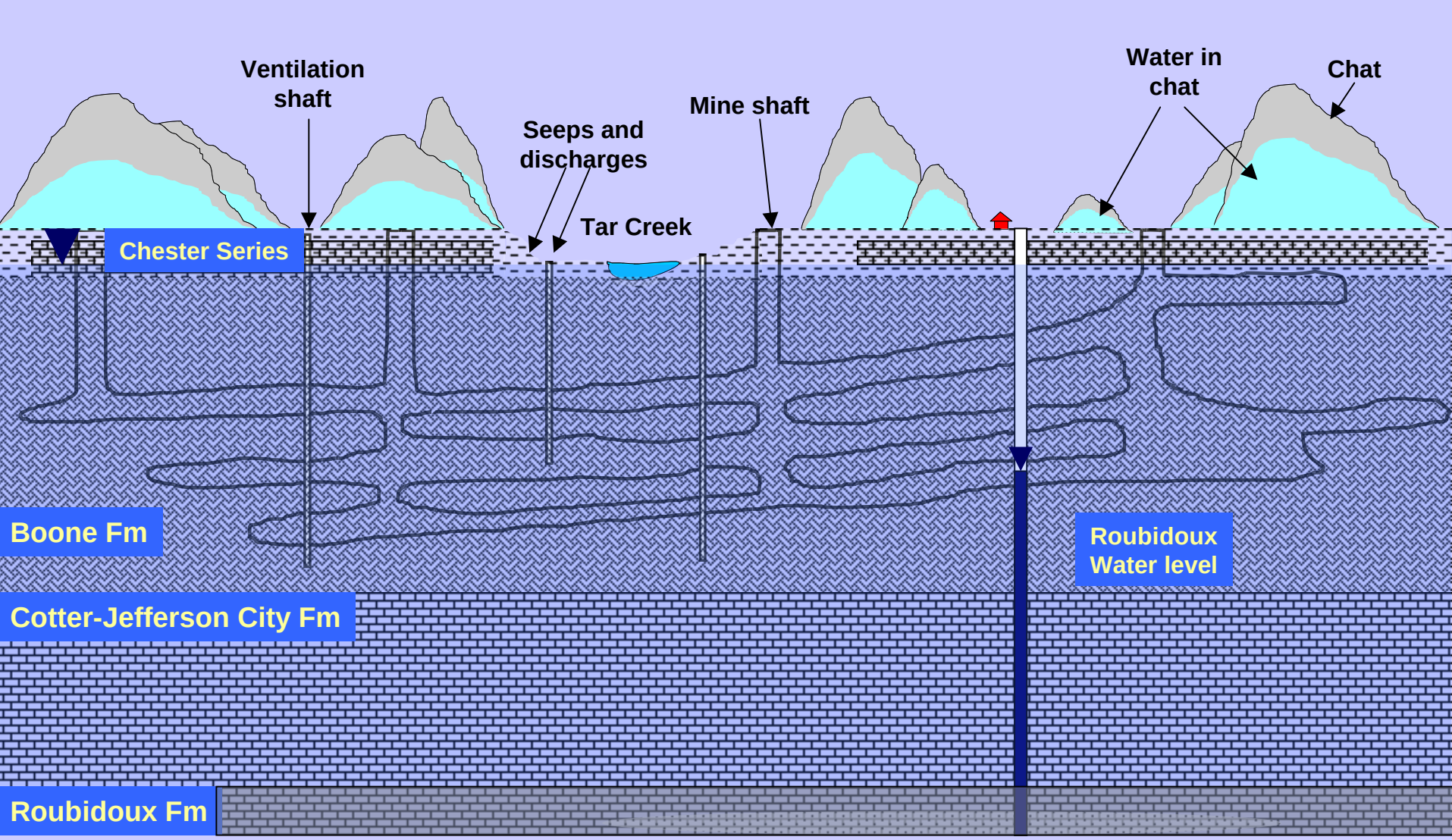
Ventilation shaft
Seeps and discharges
Mine shaft
Water in chat
Chat
Tar Creek
Chester Series
Boone Fm
Roubidoux Water level
Cotter-Jefferson City Fm
Roubidoux Fm

Sulfate Concentration in December 1992

Well	Sulfate Concentration (mg/L)
Ottawa Co RWD 4-4	*11*
Cardin	73
Commerce 1	58
Picher 2	136
Quapaw 2	194

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Tritium Concentration in December 1992

Well	Sulfate Concentration (mg/L)	Tritium Concentration (pCi/L)
Ottawa Co RWD 4-4	*11*	*<0.3*
Cardin	73	0.6
Commerce 1	58	0.5
Picher 2	136	1.3
Quapaw 2	194	1.8

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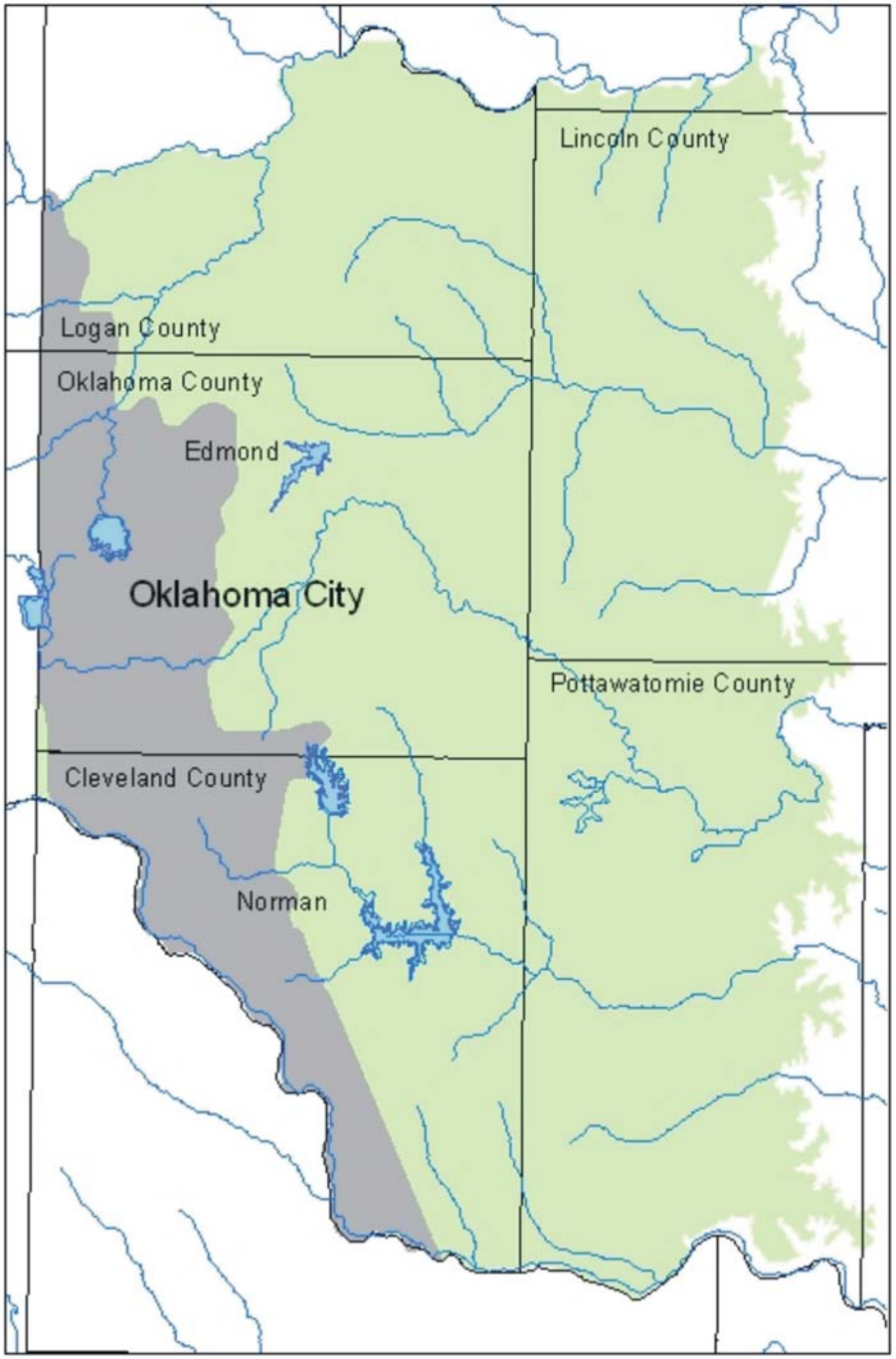

Carbon-14 used to determine flow direction and velocity in the Central Oklahoma (Garber-Wellington) Aquifer

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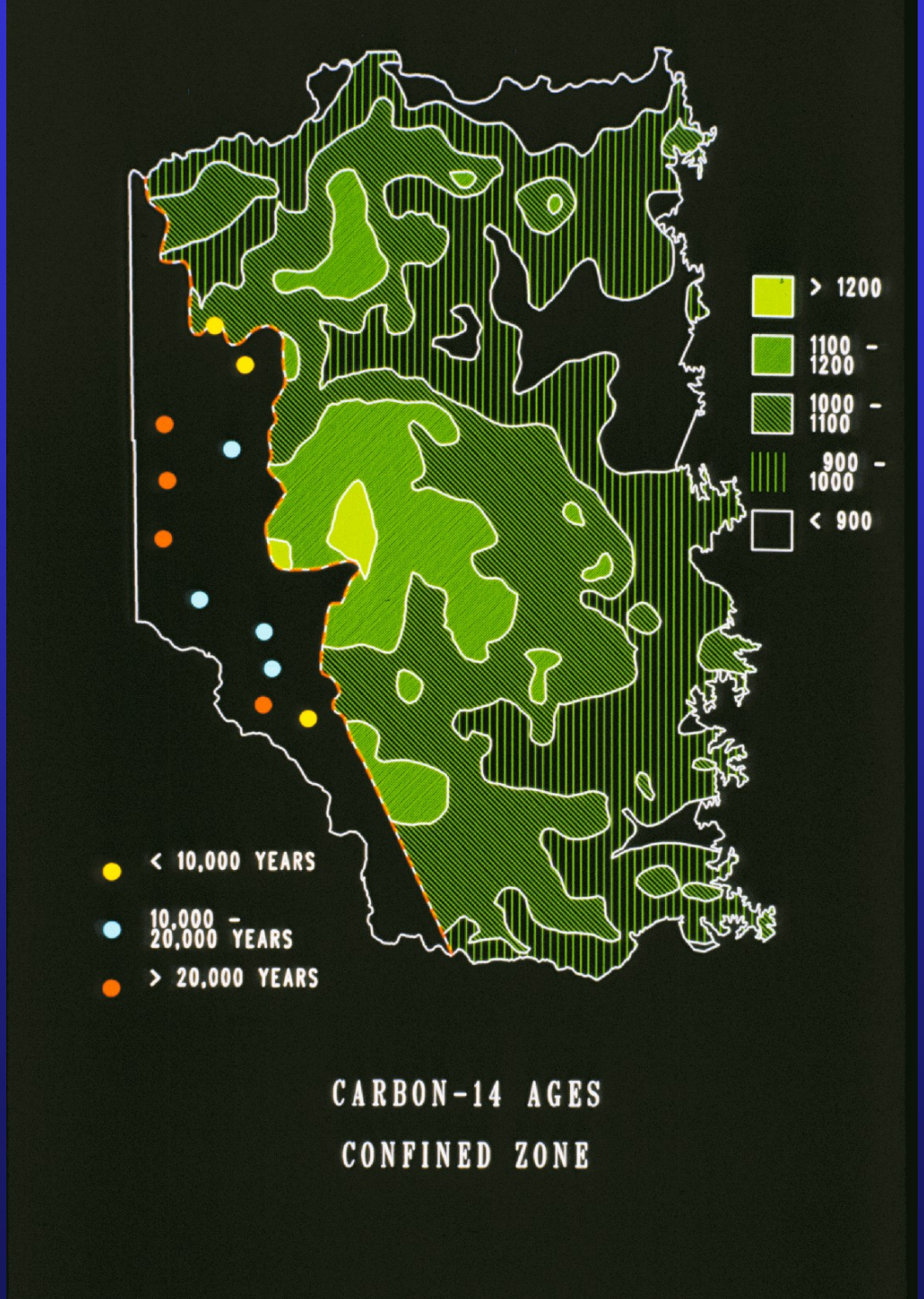

Ground-Water Ages

Central Oklahoma (Garber-Wellington) Aquifer

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Ground-water age data can be used to calculate recharge rate

Area	Source	Recharge
High Plains aquifer	Gutentag et al (1984)	0.05 to 6.0 in/yr
Texas Co. OK	Morton (1980)	0.2 to 2.2 in/yr
OK HP aquifer	Becker and Luckey (1999)	0.07 to 0.71 in/yr

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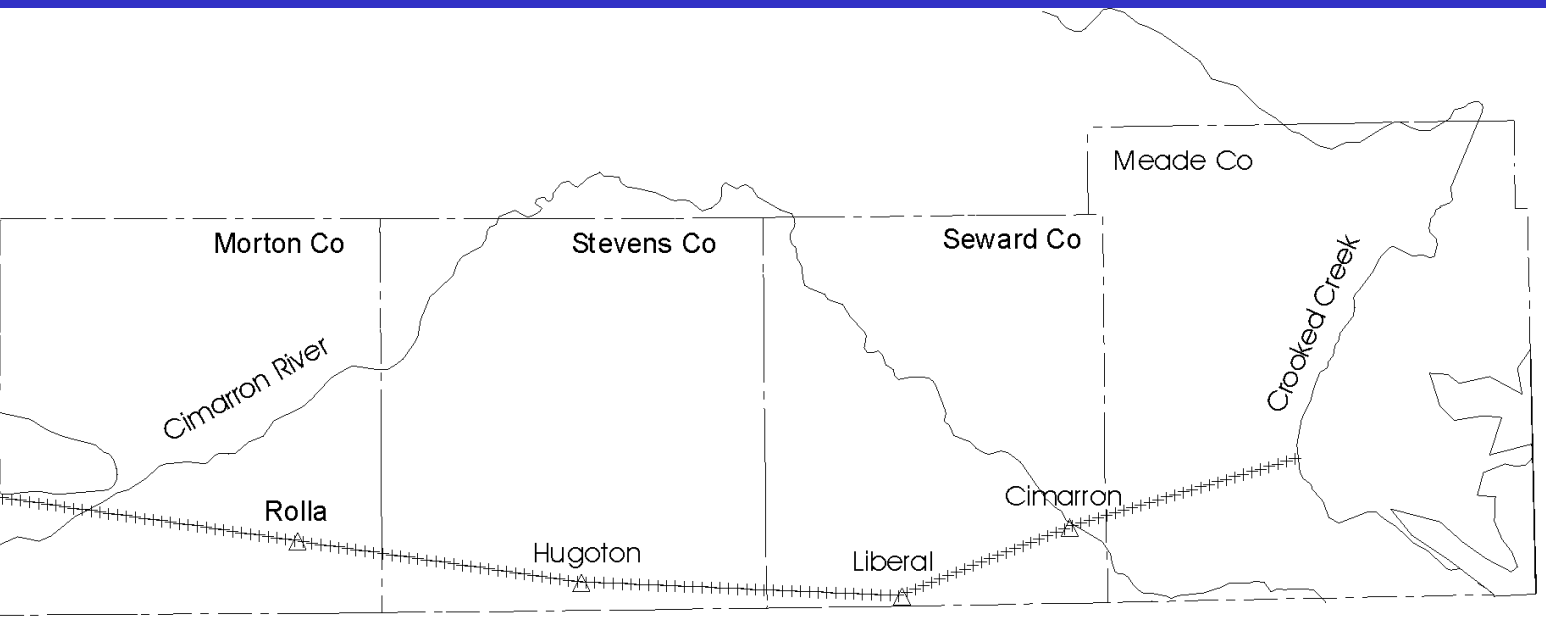

Explanation

+ Node in High Plains ground-water flow model

△ Transect well

High Plains aquifer absent

Figure 1. Location of the High Plains cross-section ground-water flow model

Recharge Rates for High Plains Aquifer

Area	Source	Recharge
High Plains aquifer	Gutentag et al (1984)	0.05 -- 6.0 in/yr
Texas Co. OK	Morton (1980)	0.2 -- 2.2 in/yr
OK HP aquifer	Becker and Luckey (1999)	0.07 -- 0.71 in/yr
SW Kansas	McMahon et al (2004)	0.03 -- 0.31 in/yr

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Summary

- Age dating can be used to determine aquifer vulnerability, ground-water flow direction and velocity, and rate of recharge
- Age dating is a powerful tool for understanding ground-water flow and managing ground-water resources

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