Datation de l'eau, distribution des écoulements et protection de la ressource

Florent BARBECOT
barbecot.florent@uqam.ca

GEOTOP, Université du Québec à Montréal, QC, Canada

Rendez-vous international sur la gestion intégrée de l'eau - 2016

La plus catastrophique crise biologique de tous les temps :

on avançait jusqu'ici les chiffres de 70 à 77 % des familles de vertébrés terrestres comme n'étant plus représentées après la crise, et 63 % de diminution du nombre des familles d'insectes représentées (Lethiers, 1998).

http://geologie.mnhn.fr/
Texte portant sur la limite Permien-Trias (250 Ma)

The fresh water Living Planet Index shows that on average the **abundance of populations monitored in the freshwater system has declined by 81 %** between 1970 and 2012

Oct. 2016

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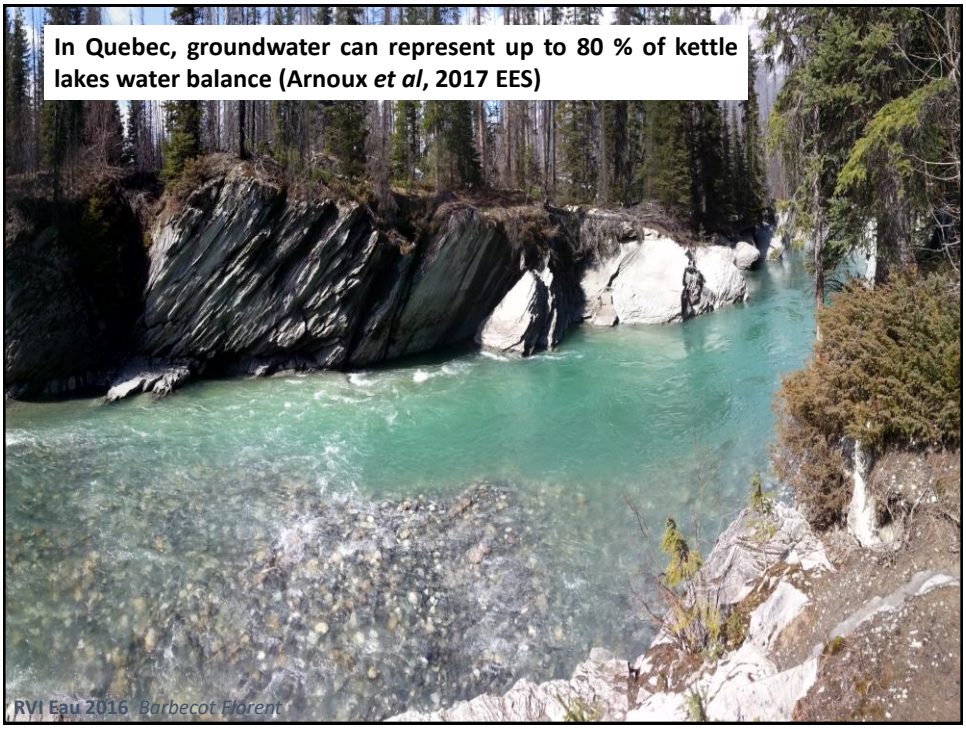

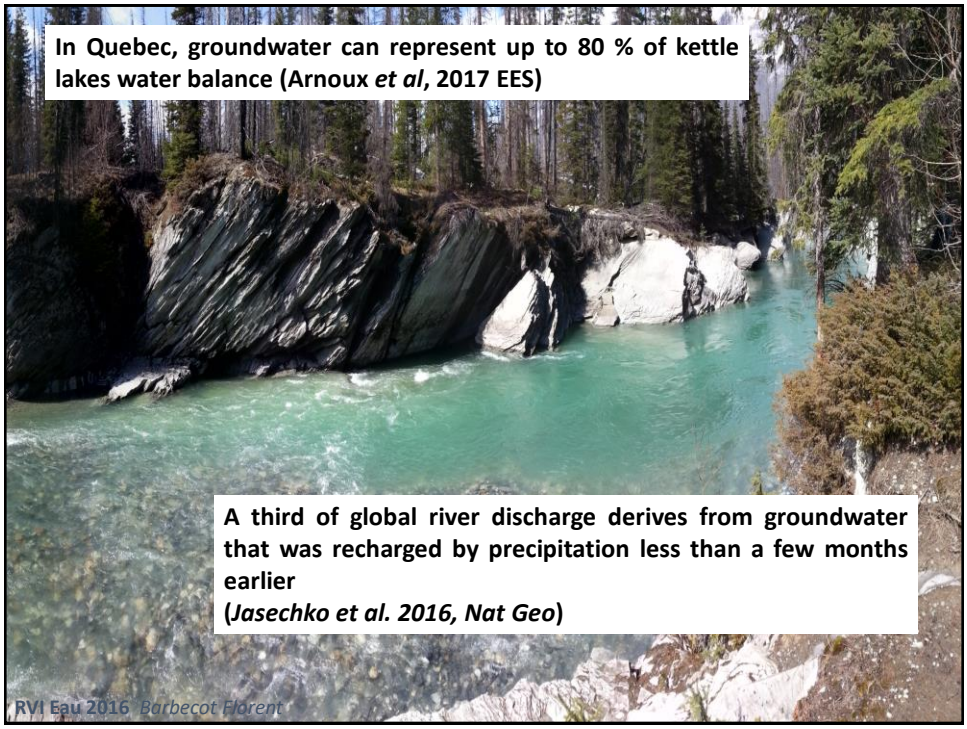
In Quebec, groundwater can represent up to 80 % of kettle lakes water balance (Arnoux *et al*, 2017 EES)
A third of global river discharge derives from groundwater that was recharged by precipitation less than a few months earlier
(*Jasechko et al. 2016, Nat Geo*)
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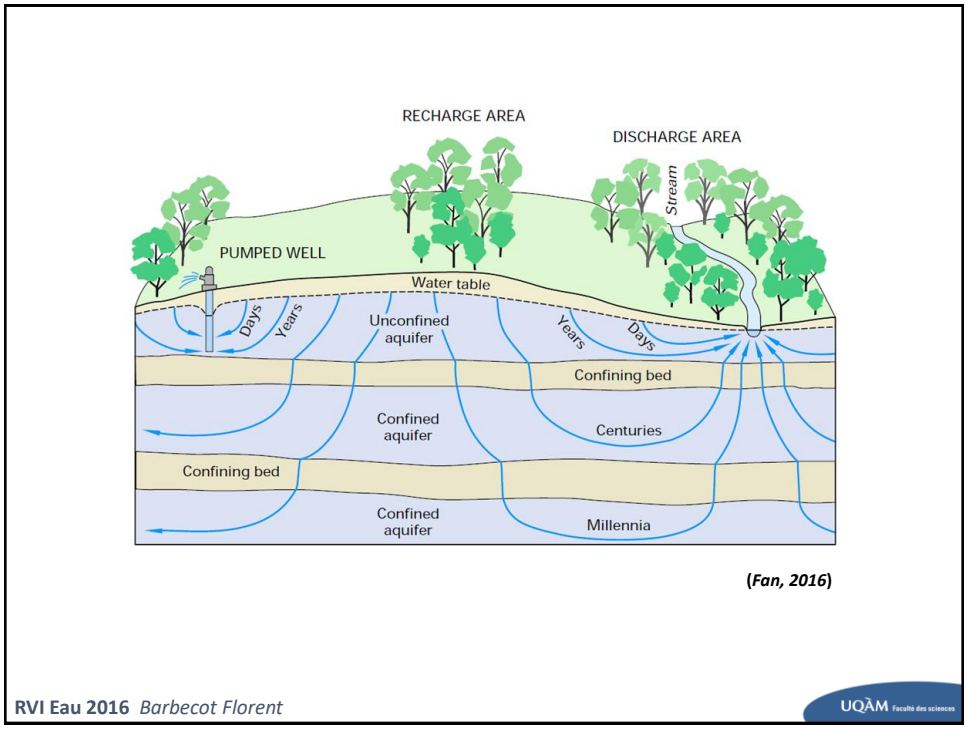
RECHARGE AREA
DISCHARGE AREA
Stream
PUMPED WELL
Water table
Days
Years
Unconfined aquifer
Years
Days
Confining bed
Confined aquifer
Centuries
Confining bed
Confined aquifer
Millennia
(*Fan, 2016*)
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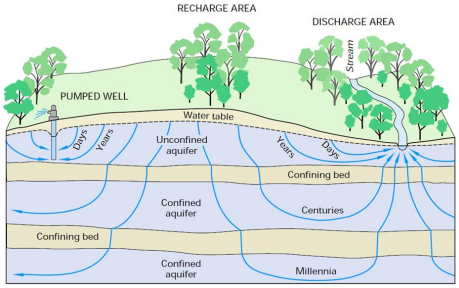
Very young age suggests that groundwater comes from recent and local precipitation



(***Fan, 2016***)

Norilsk City darkroastedblend.com

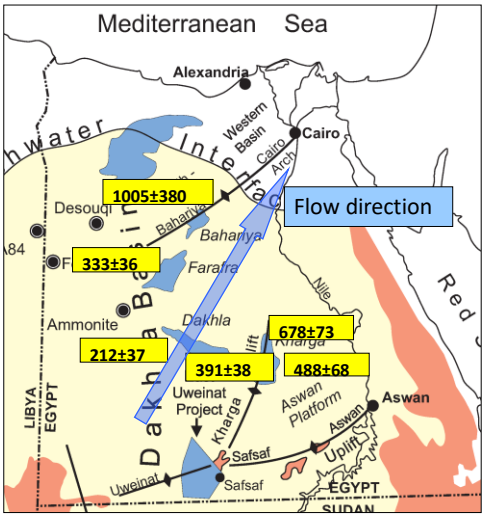
Very old age suggests that groundwater was recharged long ago

Le forage d'Aïn Galaka, Tchad. panoramio.com

Aquifère des grès nubiens

Aquifère des grès nubiens

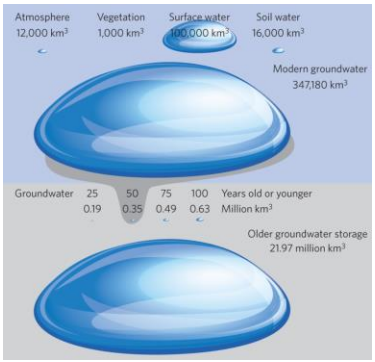
Groundwater ages [kyears]



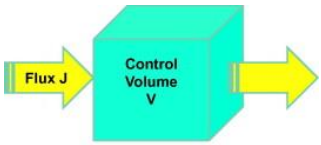
- **6 samples were dated**
- **Error < 10% with one exception**
- **Age range : 0.2-1 Mio years**

Sturchio, N. C., Z. T. Lu, R. Purtschert, B. E. Lehmann, M. Sultan, L. Patterson, X. Du, P. Mueller, T. Bigler, K. Bailey, T. P. O.Connor, L. Young, R. Lorenzo, Z. El Alfi, B. El Kaliouby, Y. Dawood, and A. M. Abdallah. 2004. **One million year old groundwater in the Sahara revealed by krypton-81 and chlorine-36**. Geophys. Res. Lett. **31**.

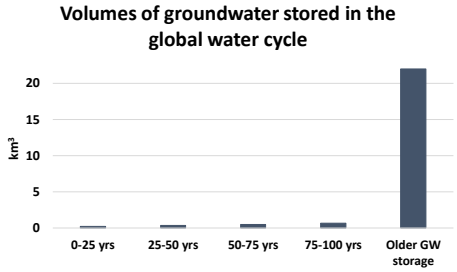
How much and how old?

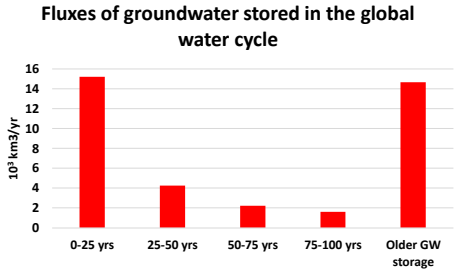


(*Gleeson et al. 2016*)



Residence time t:
t = V/J





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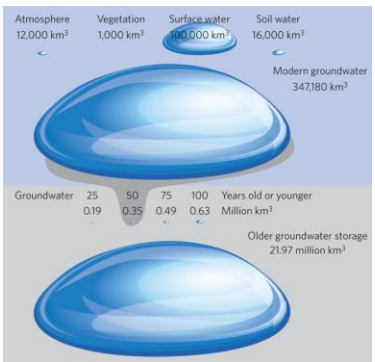
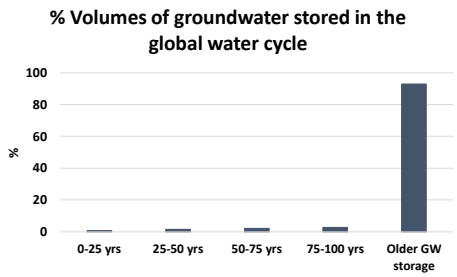
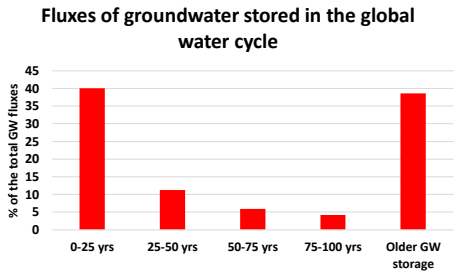
How much and how old?



(*Gleeson et al. 2016*)

More than 60 % of groundwater fluxes correspond to RT lower than 100 yrs





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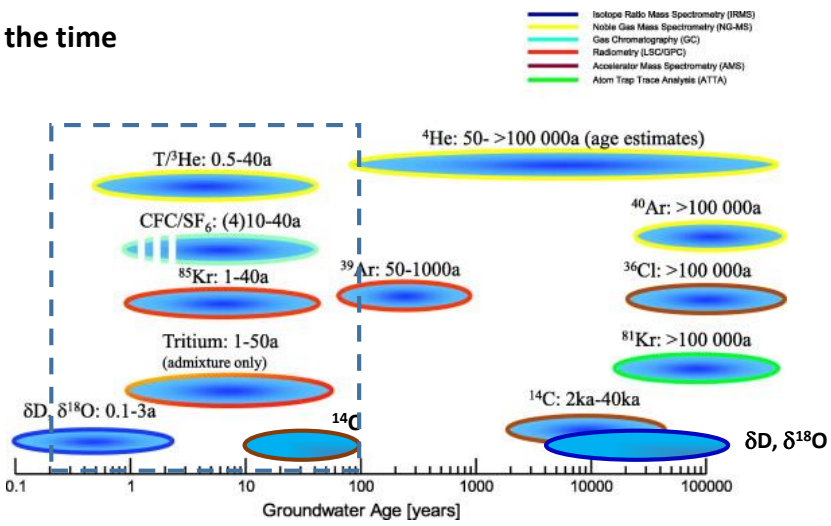
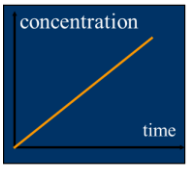
Trace the time

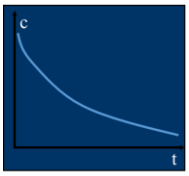


- **Basics on few tracers**
- **Examples**

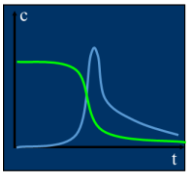
Trace the time



- **Accumulation:** decay of radioactive elements whitin the aquifer ^{4}He, ^{40}Ar,….

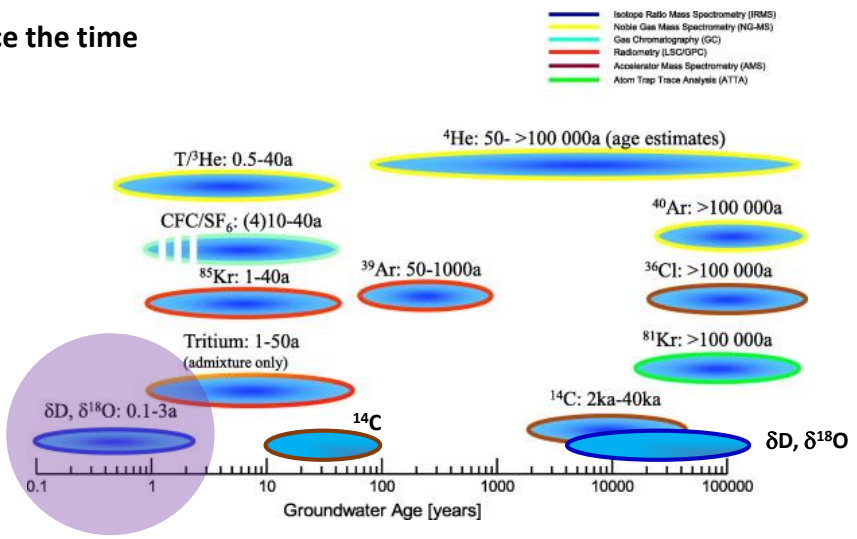


- **Radioactive tracers:** decay of a initial activity ^{3}H, ^{85}Kr, ^{39}Ar, ^{14}C, ^{81}Kr



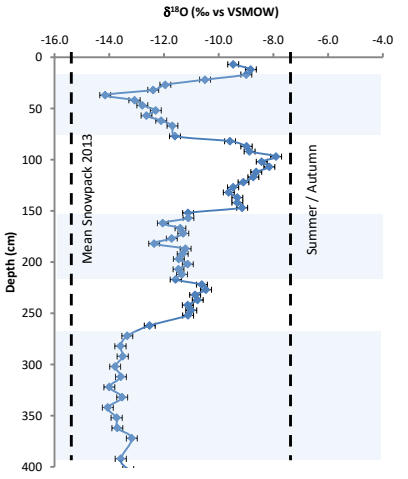
- **Transient tracers :** variable input, related to human activities (^{3}H), (^{14}C), CFC, SF_6, ^{2}H-^{18}O

Trace the time



(Modified from Suckow *2014, Baudron 2014, Bartyzel & Rozanski 2016*)

Trace the time using stable isotopes



Snowpack melting

INNOVATION.CA

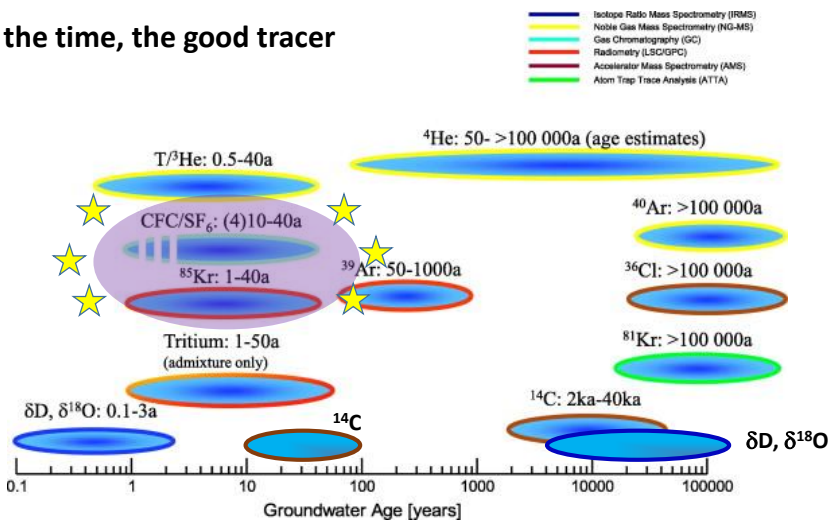
IRRES : Infrastructure de Recherche sur la Recharge des Eaux Souterraines

Research facility on Groundwater recharge (IRRES)

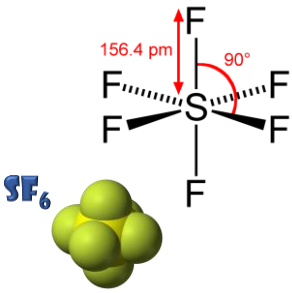
geotop

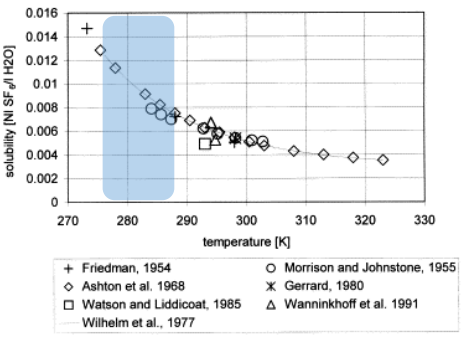
RVI Eau 2016 *Barbecot Florent* ***(Barbecot et al, 2014)***

Trace the time, the good tracer



(Modified from Suckow *2014, Baudron 2014, Bartyzel & Rozanski 2016*)





(Klump, 2007)

- inorganic, colorless, odorless, non-flammable, **extremely potent greenhouse gas**
- excellent electrical insulator.
- High atmospheric residence time : up to 3200 yrs ***(Ravishankara et al., 1993)***
- Low solubility + T dependence

- Head space + chromatographic separation
- GC + ECD
- ~ 0,5 L of water

geotop Laboratoire de Géochimie des Eaux

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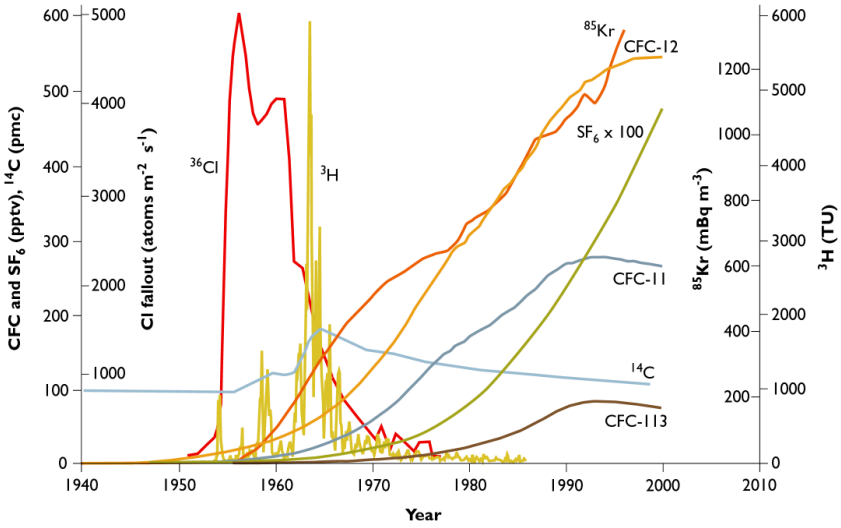
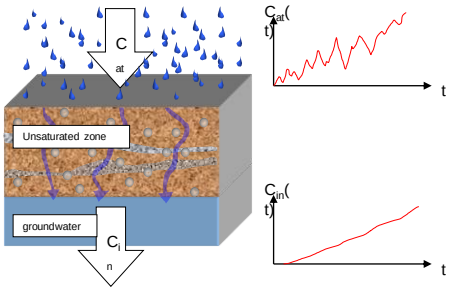
Trace the time





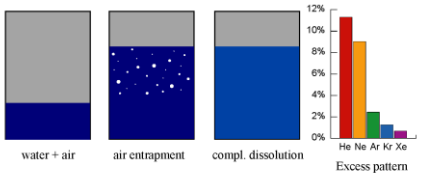
- USZ buffer the atmospheric variability ([SF_6] and T)

(Klump et al, 2008; Corcho et al, 2007; Gooddy et al 2006)

Sampling the USZ in the Paris Basin

Origin and composition of excess air

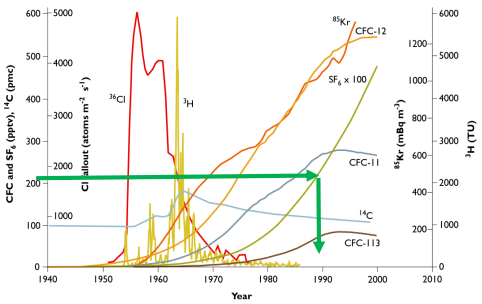
Classical model: Complete dissolution of entrapped air bubbles
⇒ composition of excess air = composition of atmospheric air



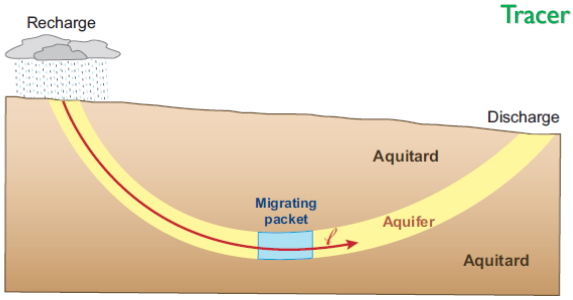
$C_i = C_i^{eq}(T,S,P) + Az_i$ A: Concentration of excess air

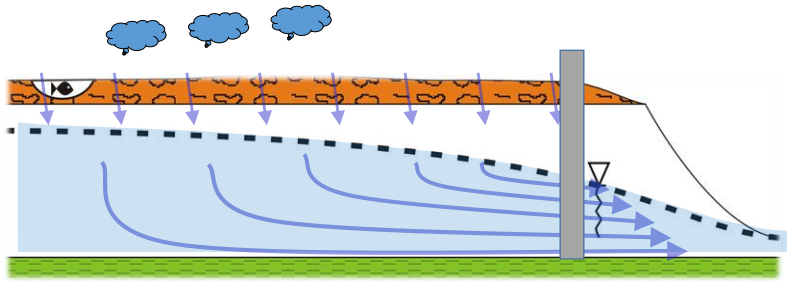
From W. Aeschbach-Hertigb

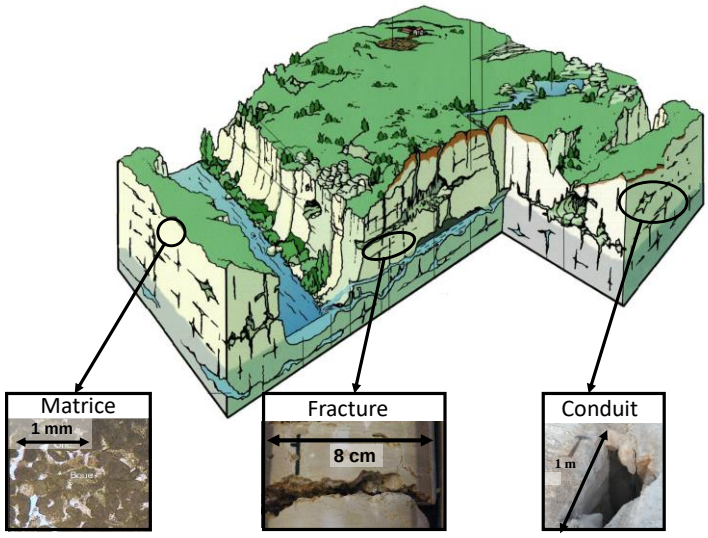
Trace the time, not the age !



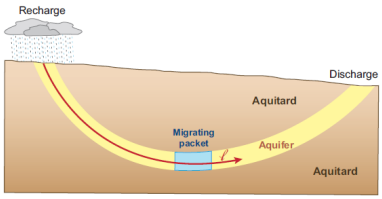
Tracer "Age"



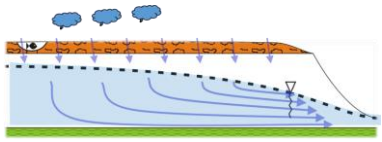




(Modified from Bakalowicz, 2003 in Delbart 2013)



My age is 400 kdays ±1



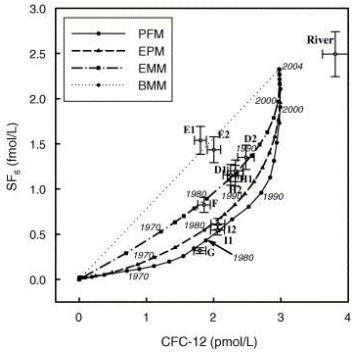
The Rvi eau assembly "age" is a nonsense

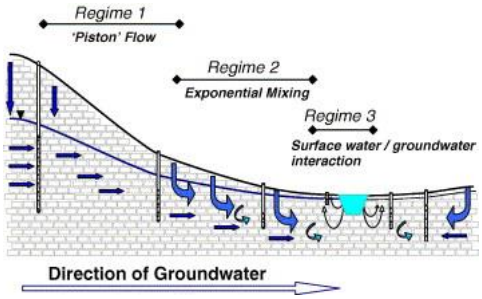
Don't use AGE s.s., consider the age distribution and Mean Residence Time for managing resources

Determine flow types and recharge areas

Chalk catchment in southern England

2 tracers, 10 samples

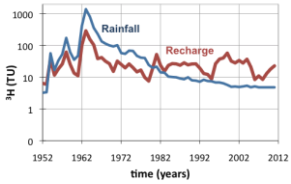


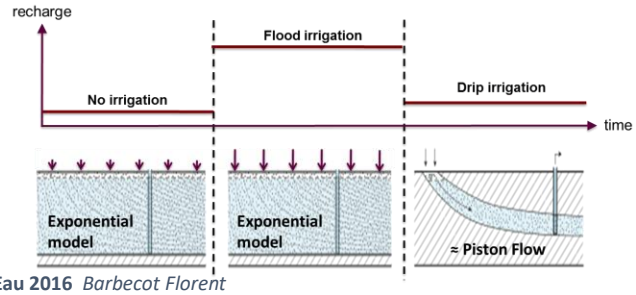


(Gooddy et al, 2006)

Modern groundwater residence time changes in a highly anthropized watershed

2 tracers
+ Variable recharge rates
+ Variable tracers input





(P. Baudron et al, 2013)

"ages" of 25 yrs, ..50 yrs..

Significant only if :
age + a distribution (age structure)

As same mean age may lead to different issue

+

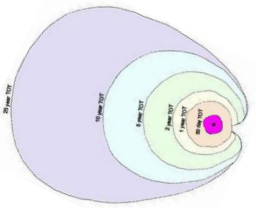
$$\frac{\qquad\qquad}{2} \neq$$

Ongoing projects

Projet For'Age (Québec, Canada)

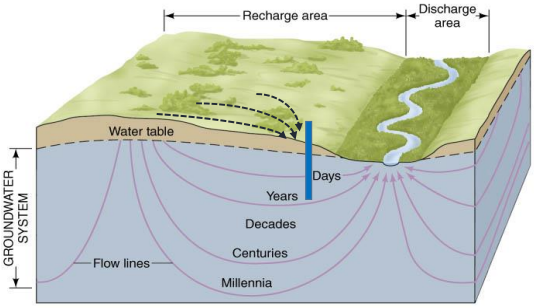
Vertical disstribution of ages to contstrain wellhead protection area

Guillaume Meyzonnat PhD



Envir'eau PUITS

TechnoRem



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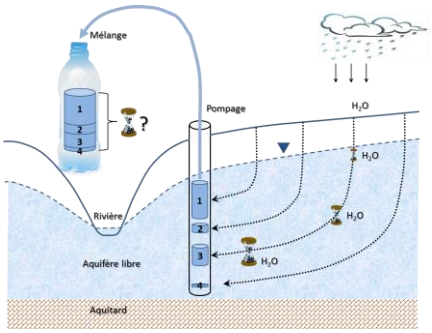
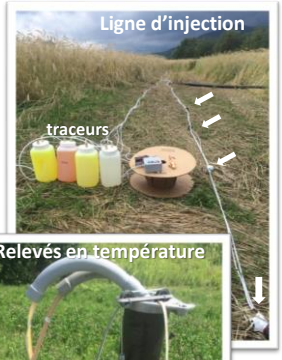
Trace flow stratification and subsample for discrete age measurements

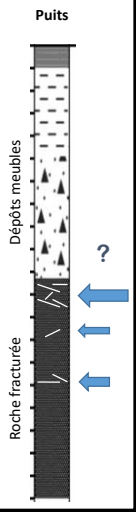
Envir'eau PUITS

TechnoRem



Modifié de GA, Kazemi, « Groundwater age »





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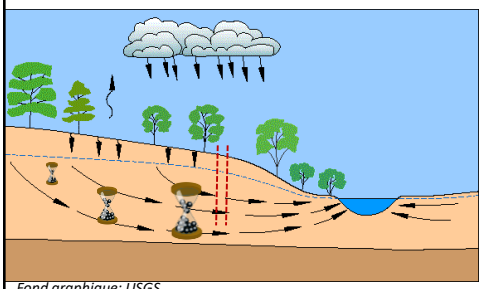
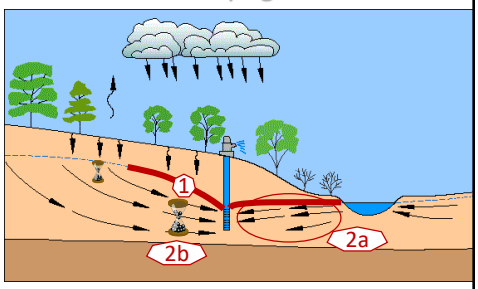
Ongoing projects

Human induced long term change on groundwater flow

État naturel



Pompage



Fond graphique: USGS

1. Baisse du niveau de nappe
2. Modification des écoulements
   a. Origine de l'eau (Qualité…)
   b. Âge (Qualité…)

Combined use of GW dating and isotopes tracing of water origin

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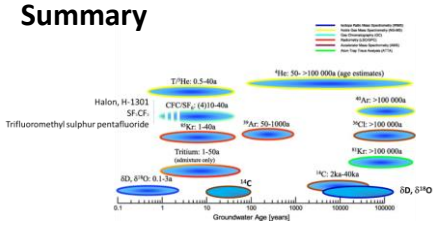
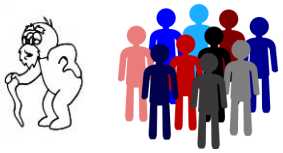
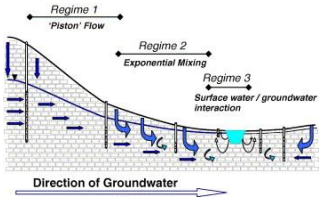
Summary



A complete set of tracers in the perfect range of MRT

Avoid "age" for GW
Use "Mean Residence Time"





Evidence, characterize hidden pathways

GW management gain from age structure identification

geotop

DANGER
GAZ