# What Groundwater Tracers to use and why?

**A chemical tracer is a substance used to track the progress or history of a natural process.**

**Some tracers occur naturally and others are introduced experimentally.**

**A tracer can also acts as a surrogate for a solute or organism of interest.**

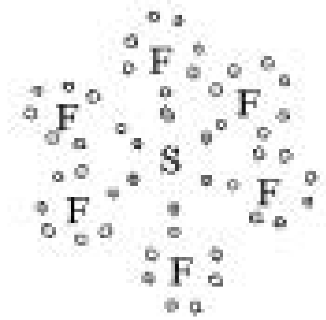
**As hydro/geo/micro subsurface folks, we must ask ourselves what we want to track and what is the best tracer to use keeping in mind:**

- **Cost**
- **Detection limits**
- **Analytical needs**
- **Reactivity**
- **What the tracer is actually mimicking**

# Dissolved tracers

Dissolved gas tracers (He, Ne, Kr)


$SF_6$

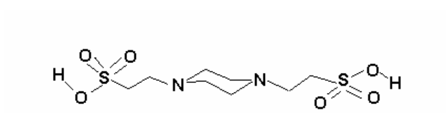


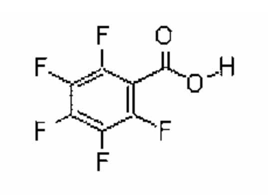
$D_2O$, I


$H^{13}CO_3^-$

Br and $^{82}Br$

PIPES





Fluorobenzoates

Chlorofluorocarbons

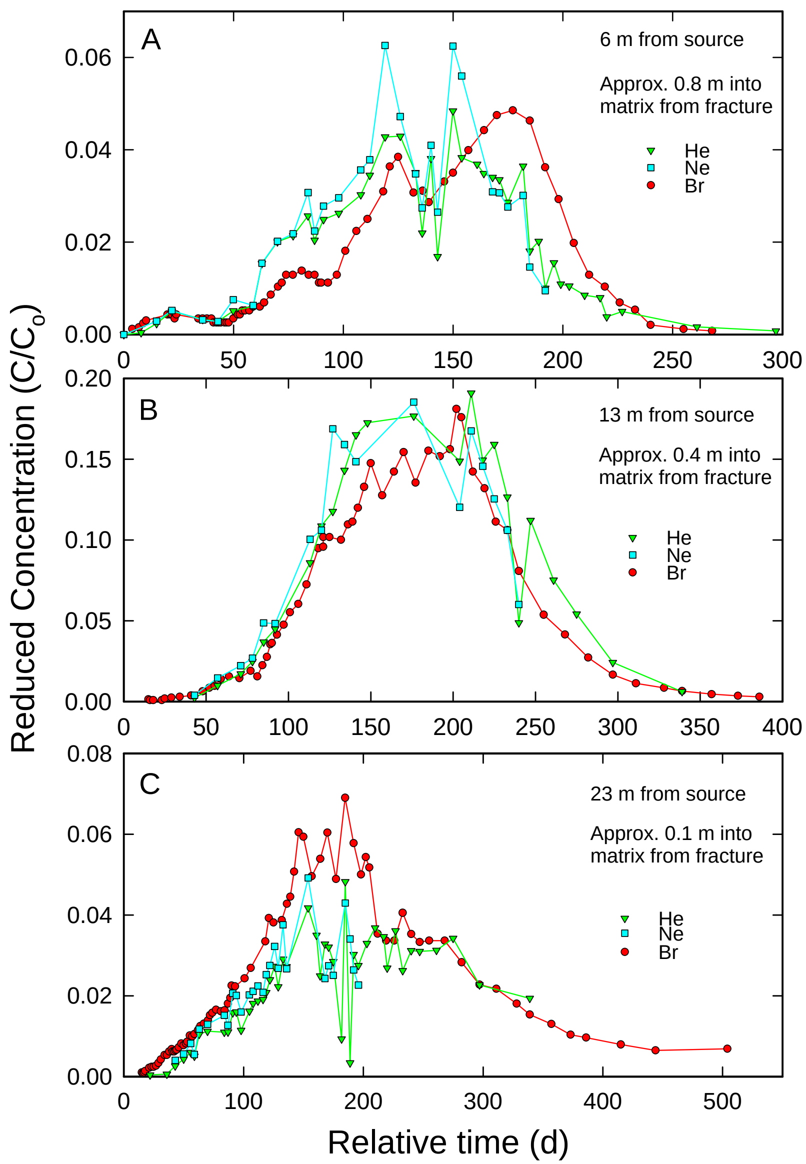
<u>Purpose</u>

- Groundwater flux and direction
- Preferential flow, matrix diffusion
- Confirming presence of multiphases
- Groundwater dating

# Dissolved tracers

Example of dissolved gas tracer in the field each having different diffusion coefficients.

Confirmation of preferential flow coupled with matrix diffusion.

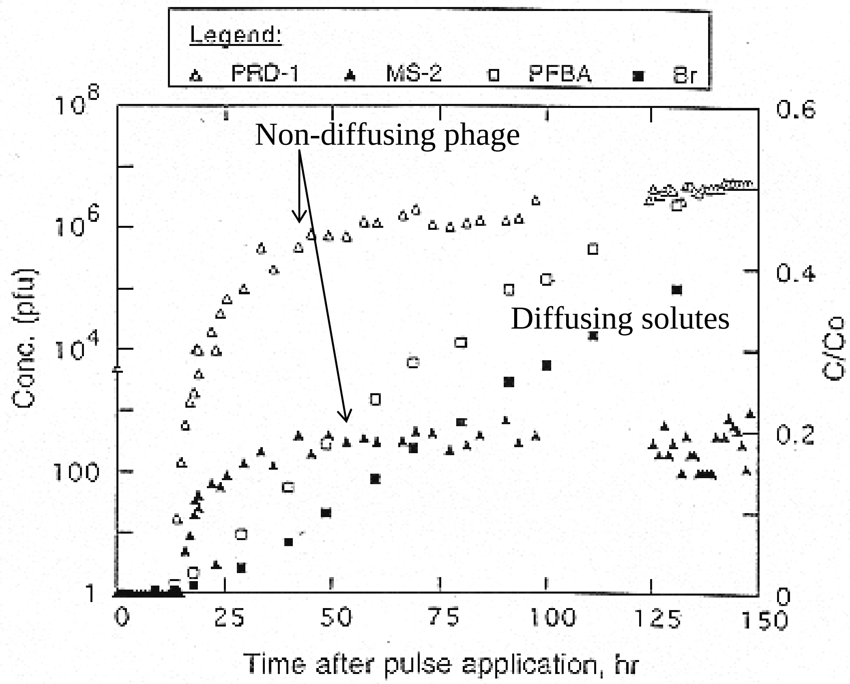


# Colloidal tracers

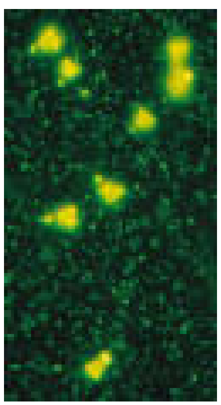
Examples:

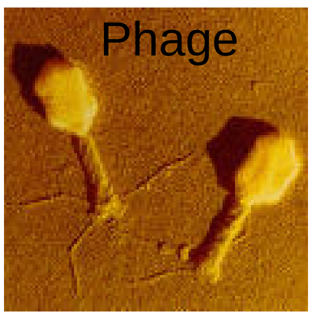
- Fluorescent microspheres
- DNA labeled microspheres
- Radiolabeled Fe-oxide particles
- Fe-oxide nanoparticles
- Bacteriaphage
- Eu-tagged bacteria

Tracers of different size




Microspheres

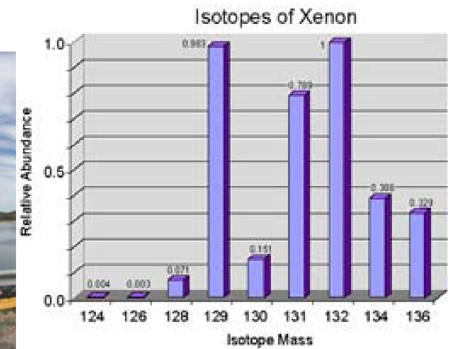




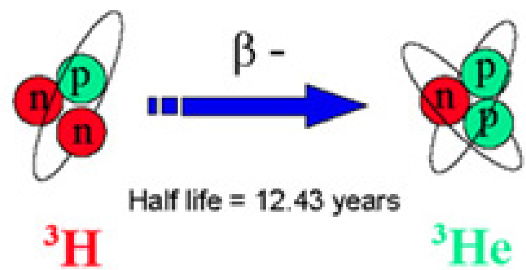

Purpose

- Too large to diffuse into matrix
- Ideal for quantifying advective flow
- Typically reactive, but some get through quickly
- Best when coupled with dissolved tracers

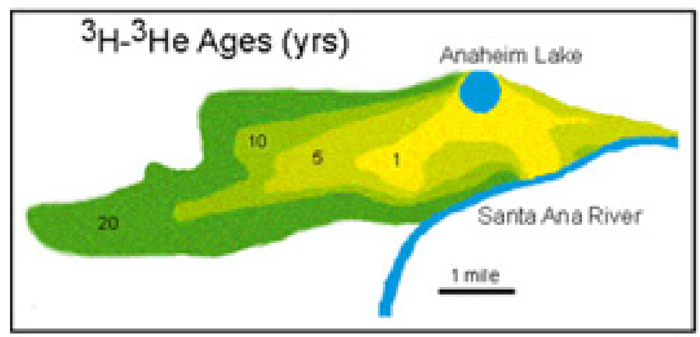
# Natural isotopic tracers




Examples:
$^{2}H/^{1}H$, $^{18}O/^{16}O$, $^{3}H/^{3}He$
$^{85}Kr$
Radium
$^{87}Sr/^{86}Sr$




- Storm event monitoring, old water/ new water.
- Groundwater dating.
- Coupled isotopes approaches help to distinguish groundwater sources.



# Dye tracers


- Rhodamine B and WT
- Uranine (fluorescein)
- Tinopal
- Eosine Y

<u>Purpose</u>

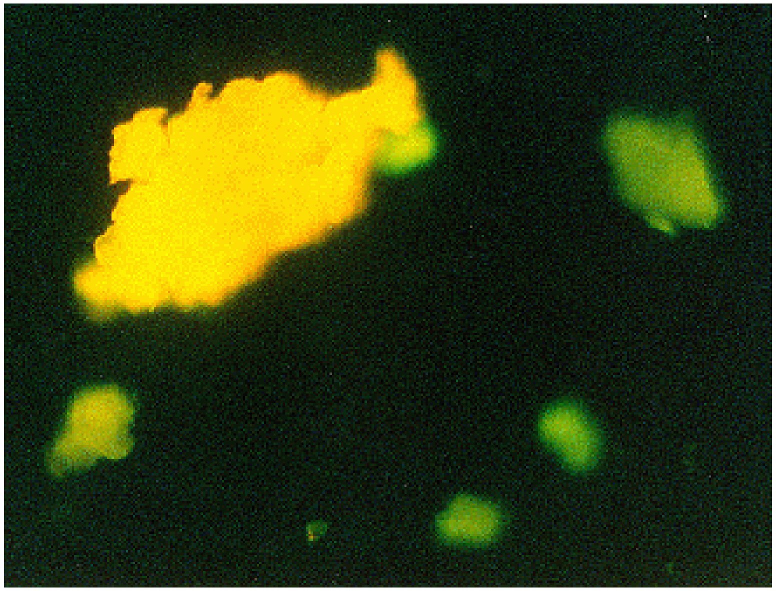
- Track the migration of surface and groundwater.
- Both reactive and non-reactive; however, non-reactivity must be verified.
- Best when coupled with non-reactive dissolved tracers.

# Novel tracers

## *Silicon beads tagged with DNA fragments*

**More than a trillion DNA tags are available.**

**Therein lies a key strength of the technology: It allows production of virtually unlimited numbers of tracers that behave identically but that are easily distinguished because each DNA tag naturally pairs with complementary DNA fragments of a known sequence.**



## Novel tracers

### *Diatom proteins*

**Proteins extracted from common diatom species**

**Proteins used to develop monoclonal antibodies and accompanying enzyme immunoassays (Walker, 1996) that will facilitate the identification and quantification of the proteins in ground water.**

**Uses advanced cellular, biochemical, and immunological techniques for assessing ground water/surface water interactions.**

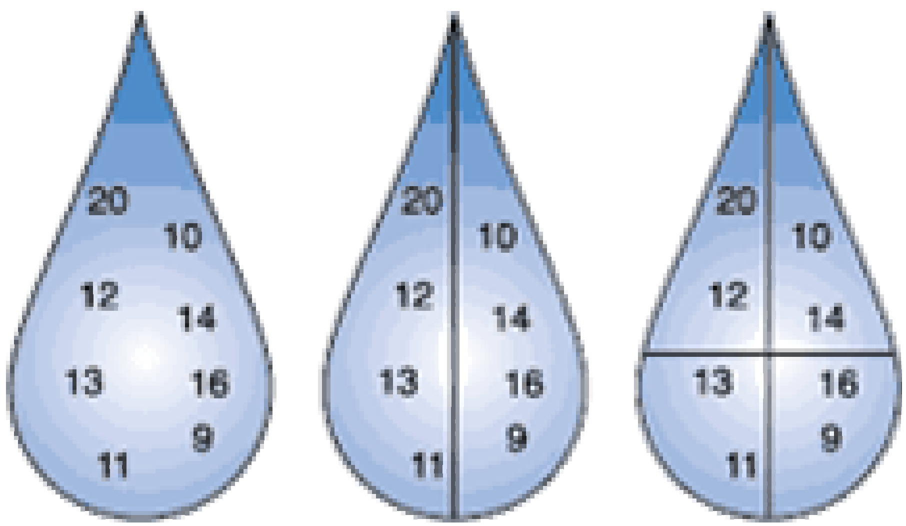
# Novel tracers

## *Ice- nucleating bacteria*

**Certain bacteria can serve as nuclei that initiate the formation of ice in supercooled water (ice-nucleating active Pseudomonas)**

**Super duper low detection limits.**

**I think they are sticky to the subsurface media…however, some might get through thus providing advective fluxes in heterogeneous media.**



# Short-lived Radioactive Tracers

Both reactive and non-reactive.

Ideal surrogates.

Regulatory acceptance for injection into groundwater may be tough, especially in California.

Very low detection limits.