



# Isotope Techniques for Discriminating Methane Sources

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# Overview

- Why use methane forensics?
- Methane generation mechanisms
- Methane forensic techniques
  - Geochemistry
  - Isotopes
  - Geophysics
  - Statistics
- Case study
  - Storage cavern natural gas release



Methane bubbles in swamp

# Methane Forensics

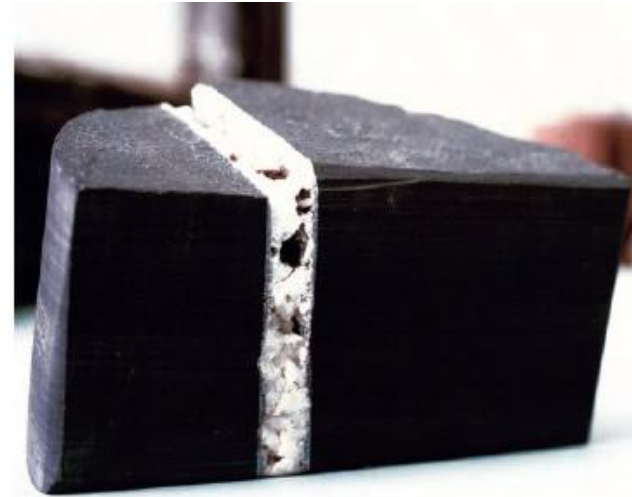
- Methane derived from numerous sources
- Potential methane release site may have multiple unrelated methane sources
- Methane forensic techniques used in various settings to differentiate methane sources



Imagine the result

# Methane Generation Mechanisms

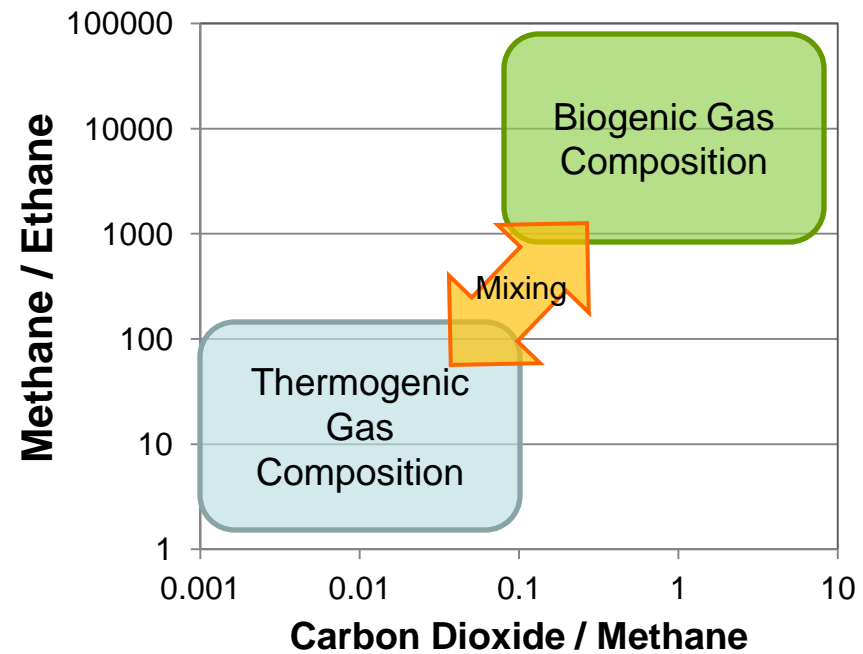
- Thermogenic
  - Coal bed and oil & gas formations
- Biogenic
  - Methanogenesis – “swamp gas” and “drift gas”
  - Acetate fermentation – “landfill gas”
- Abiogenic



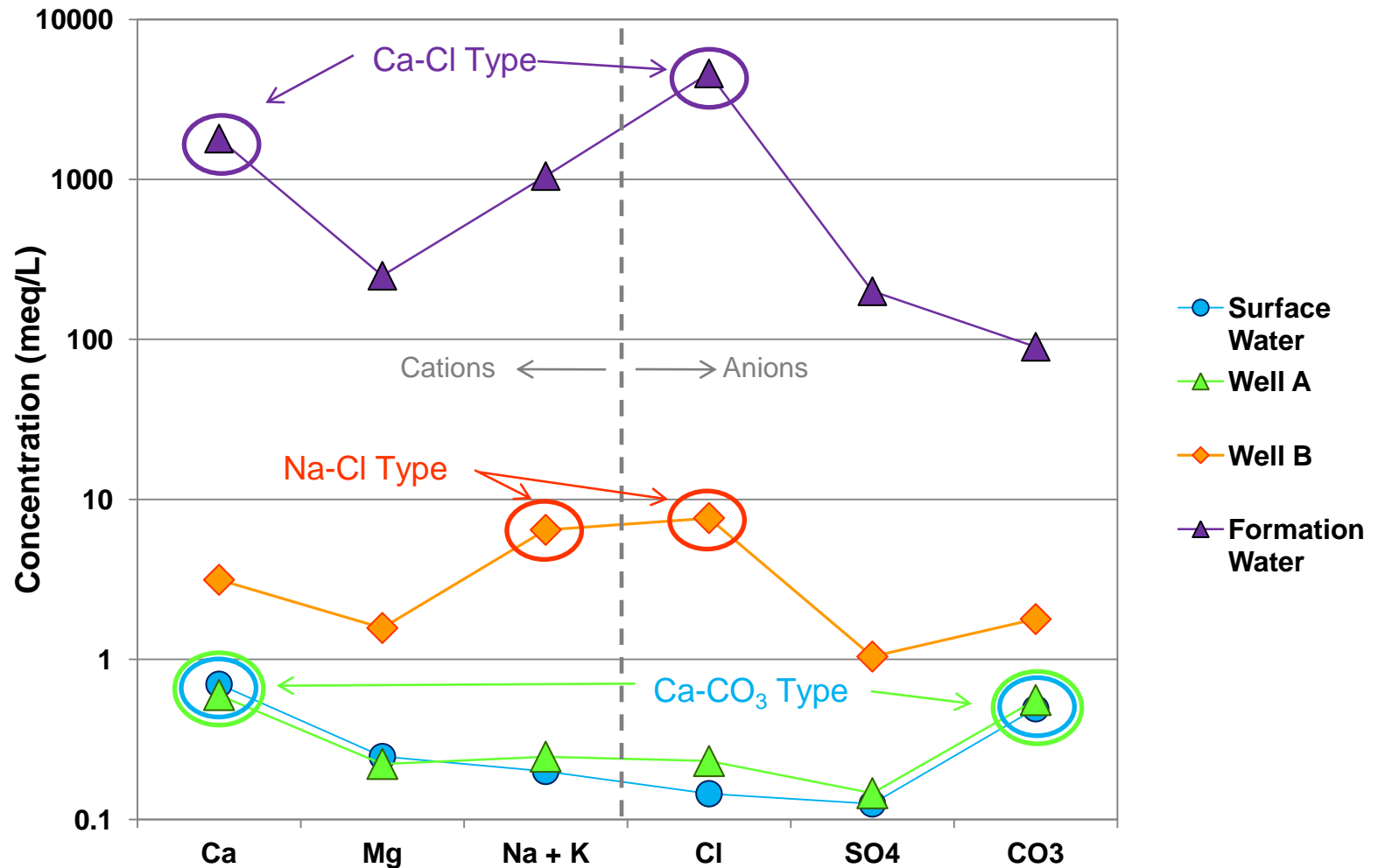
USGS

# Geochemical Techniques

- Light hydrocarbon gas composition
  - Thermogenic versus biogenic
- Composition of other gases ( $\text{CO}_2$ ,  $\text{O}_2$ ,  $\text{H}_2$ , Ar, He, etc.)
  - Gas source, migration pathway
- Groundwater geochemistry
  - Differentiate water “types”
  - Trace  $\text{CH}_4$  generation pathway
  - Identify formation/produced water



# Geochemical Techniques

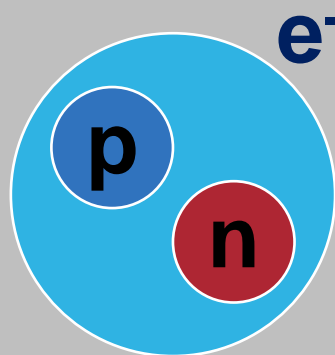


# What are Isotopes?

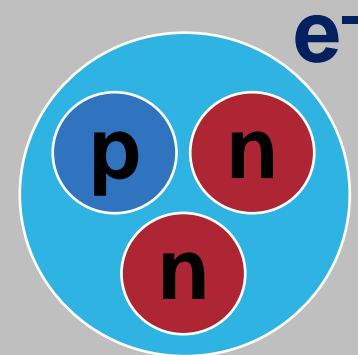
- Atoms of same element with differing masses
  - same # of protons, different # of neutrons



Hydrogen  
 $^1\text{H}$



Deuterium  
 $^2\text{H}$ , D



Tritium  
 $^3\text{H}$ , T

*Lighter*

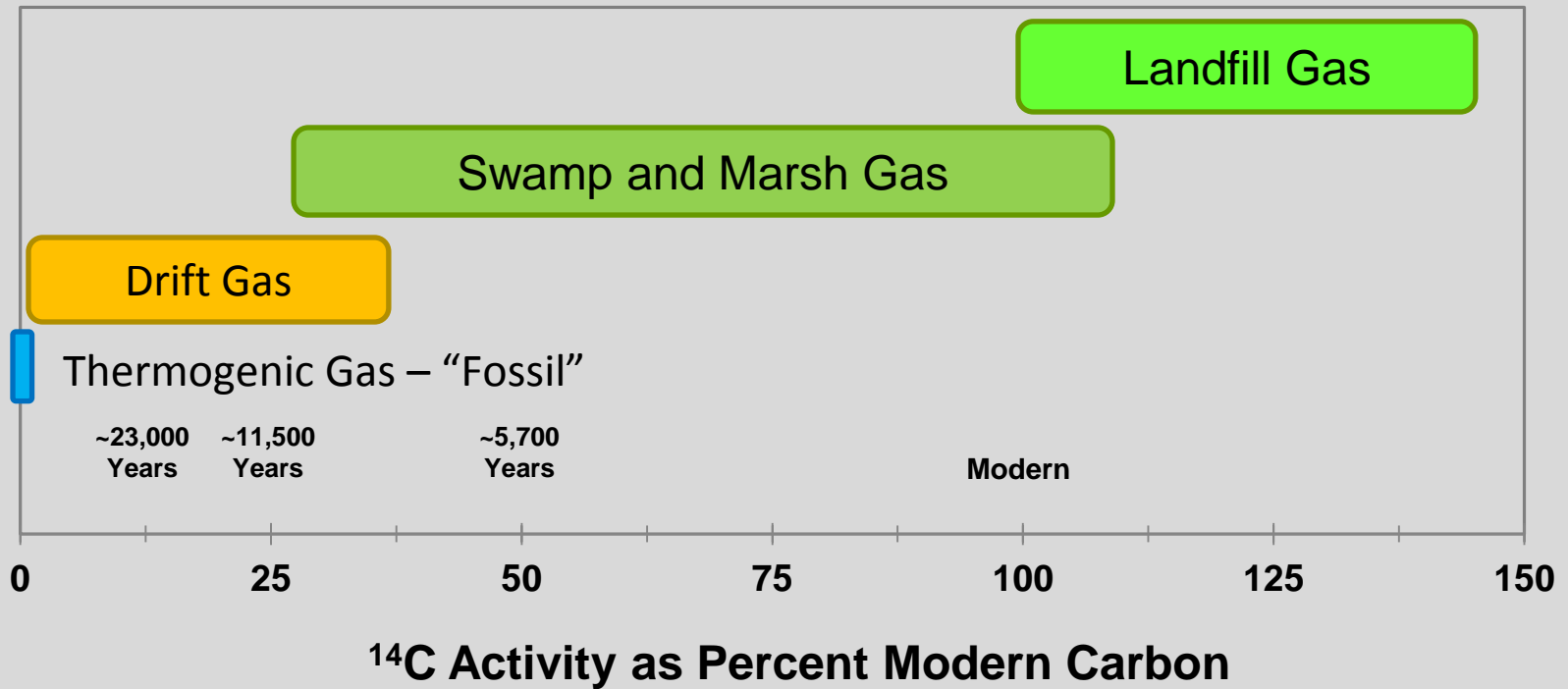


*Heavier*

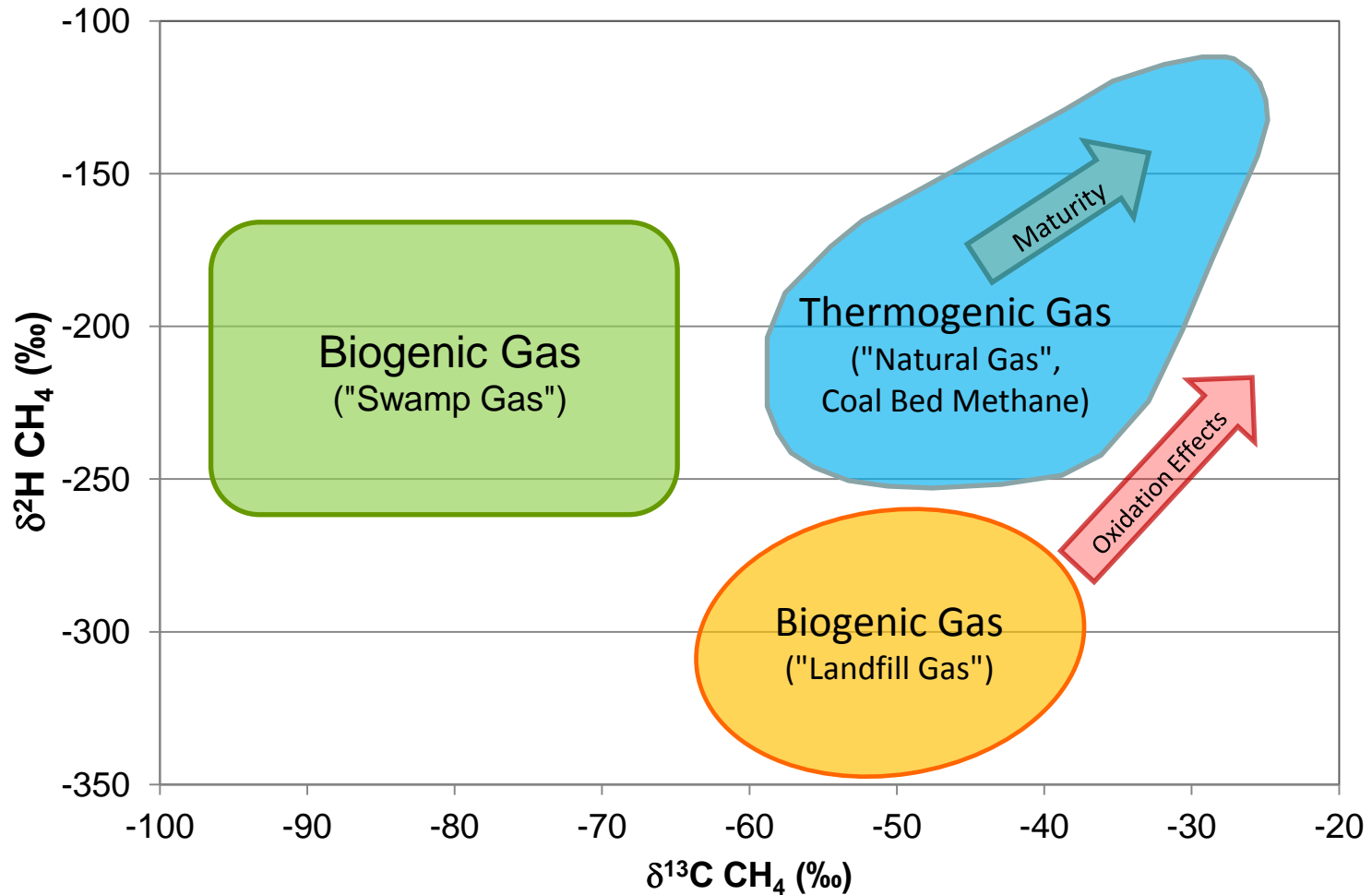
*Sum of protons and neutrons is the atomic mass*

# Isotope Techniques

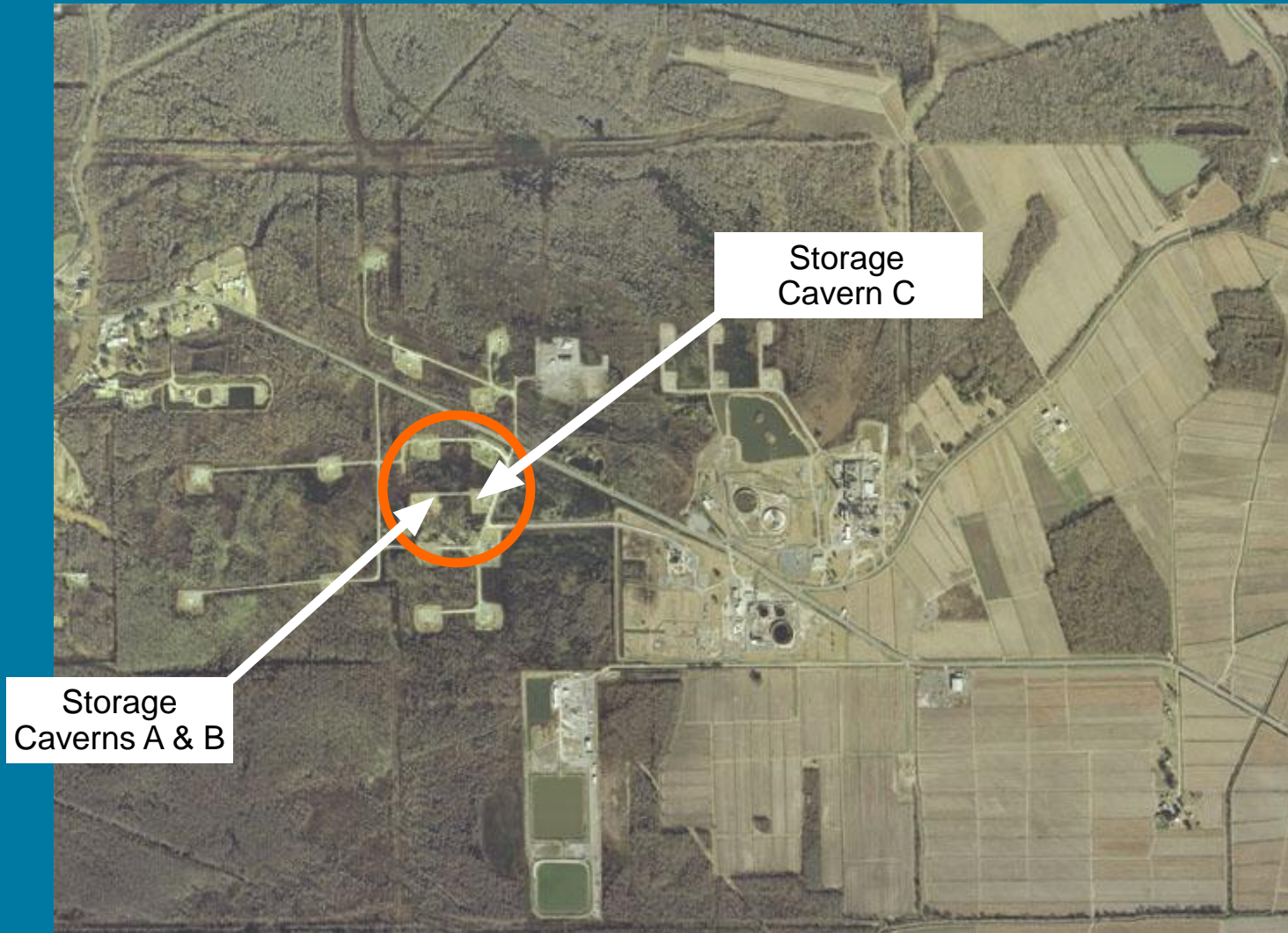
- Stable carbon and hydrogen isotopes of methane
- Carbon-14 ( $^{14}\text{C}$ ) of methane
- Other isotopic tracers, e.g.,  $^{87}\text{Sr}/^{86}\text{Sr}$ , H and O of water



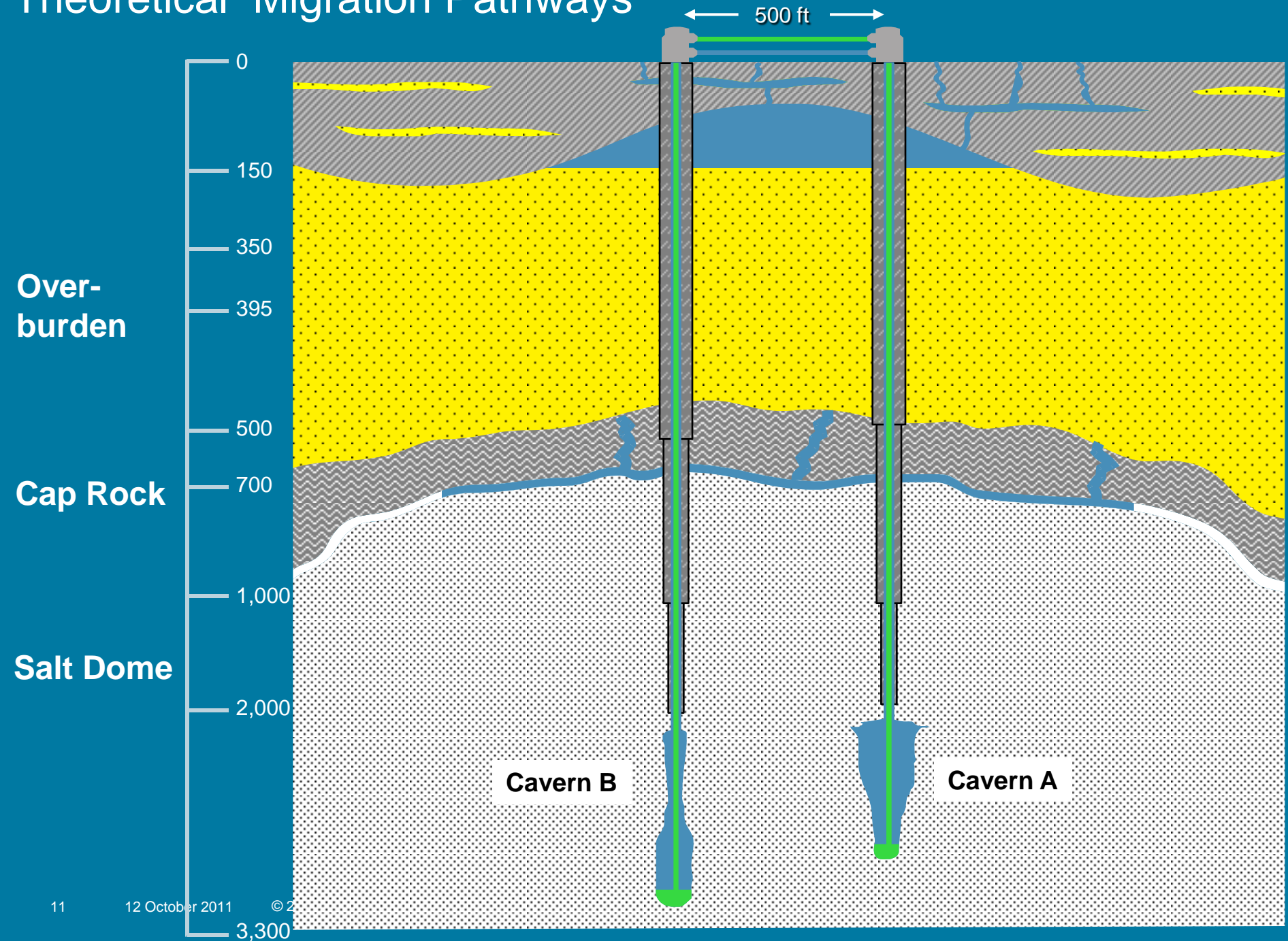
# Stable Isotope Signatures

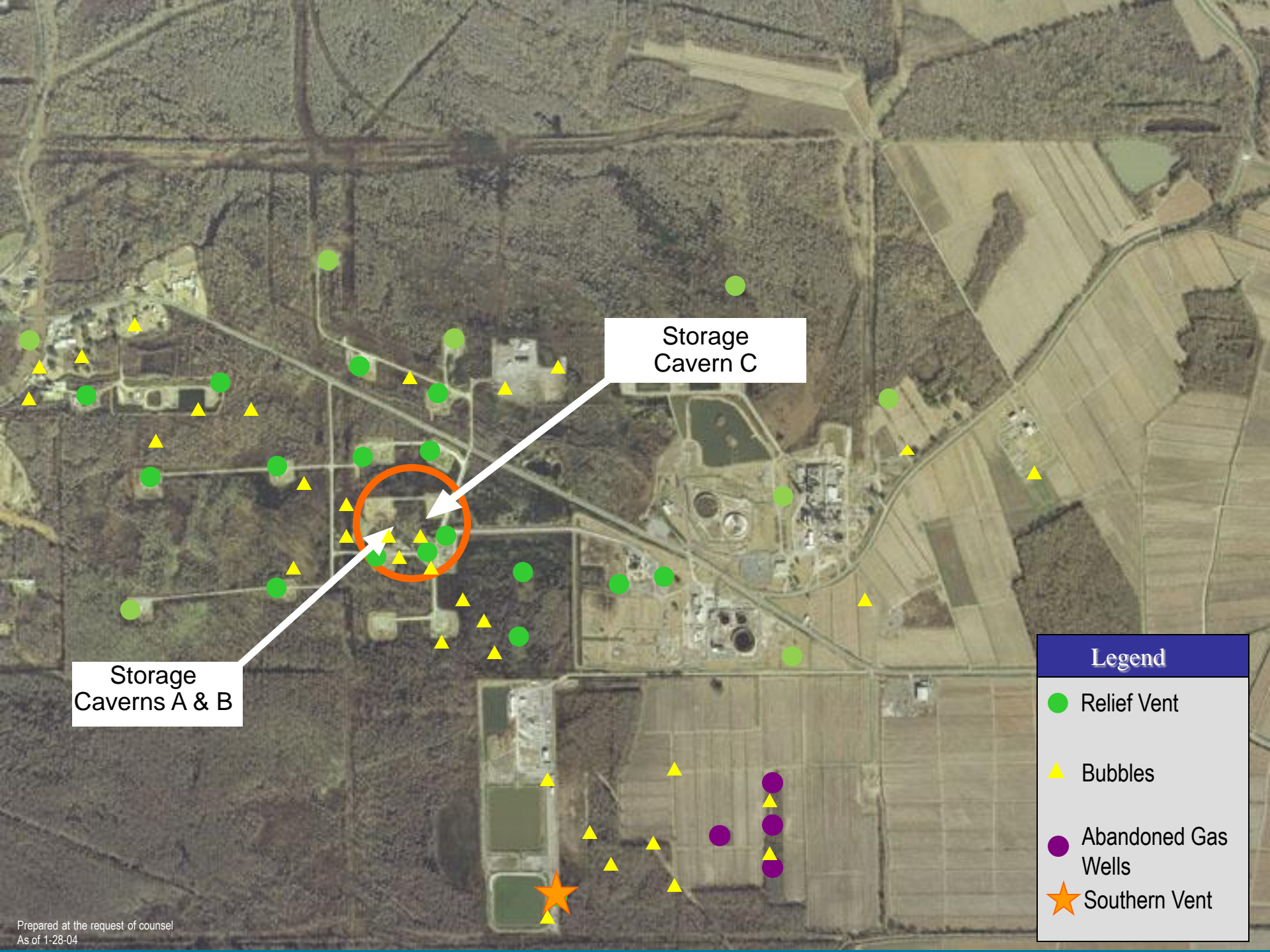


# Case Study





# Theoretical Migration Pathways



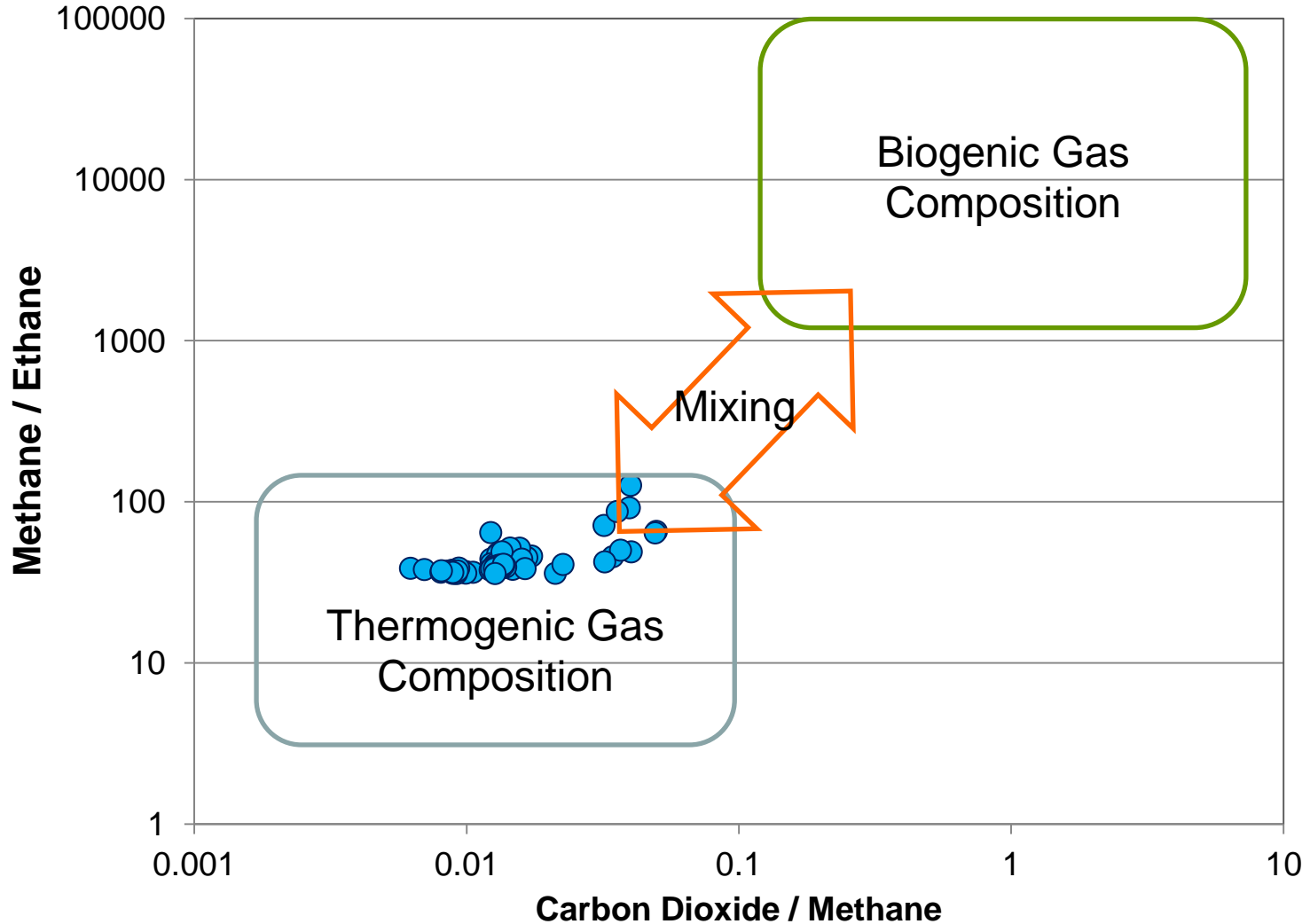


Storage Cavern C

Storage Caverns A & B

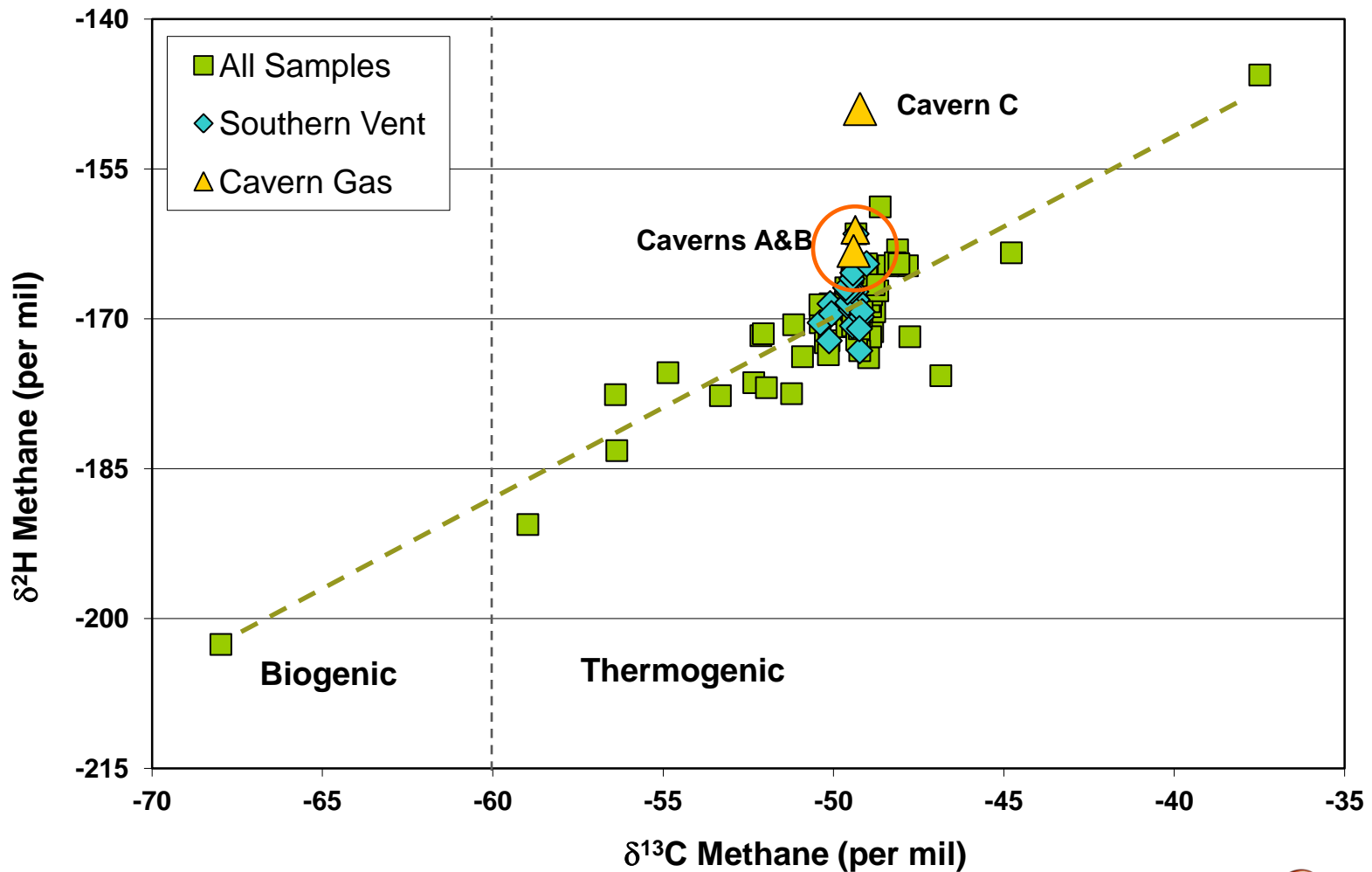
Legend	
	Relief Vent
	Bubbles
	Abandoned Gas Wells
	Southern Vent

# Geochemical Data



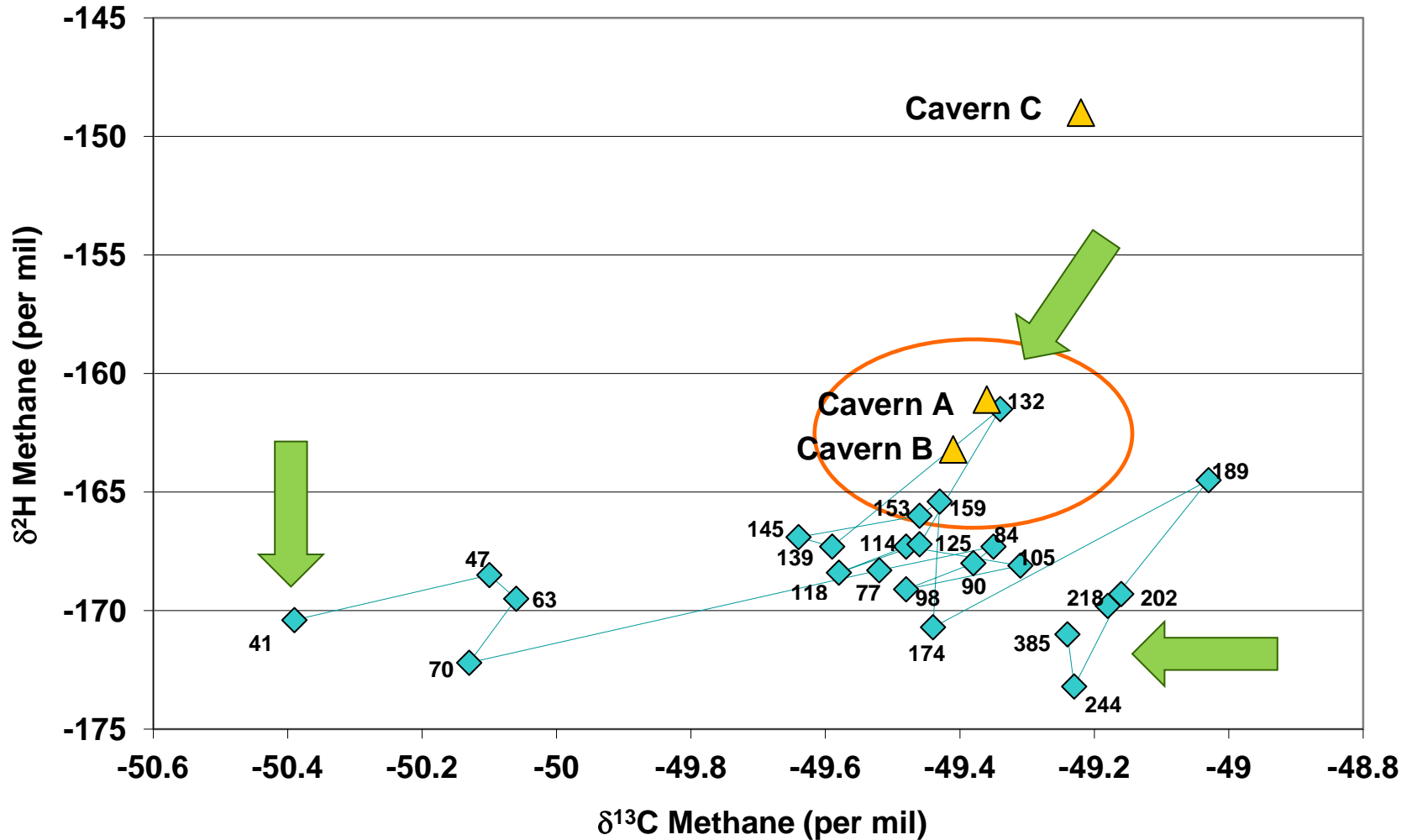
# Isotope Data – All Samples

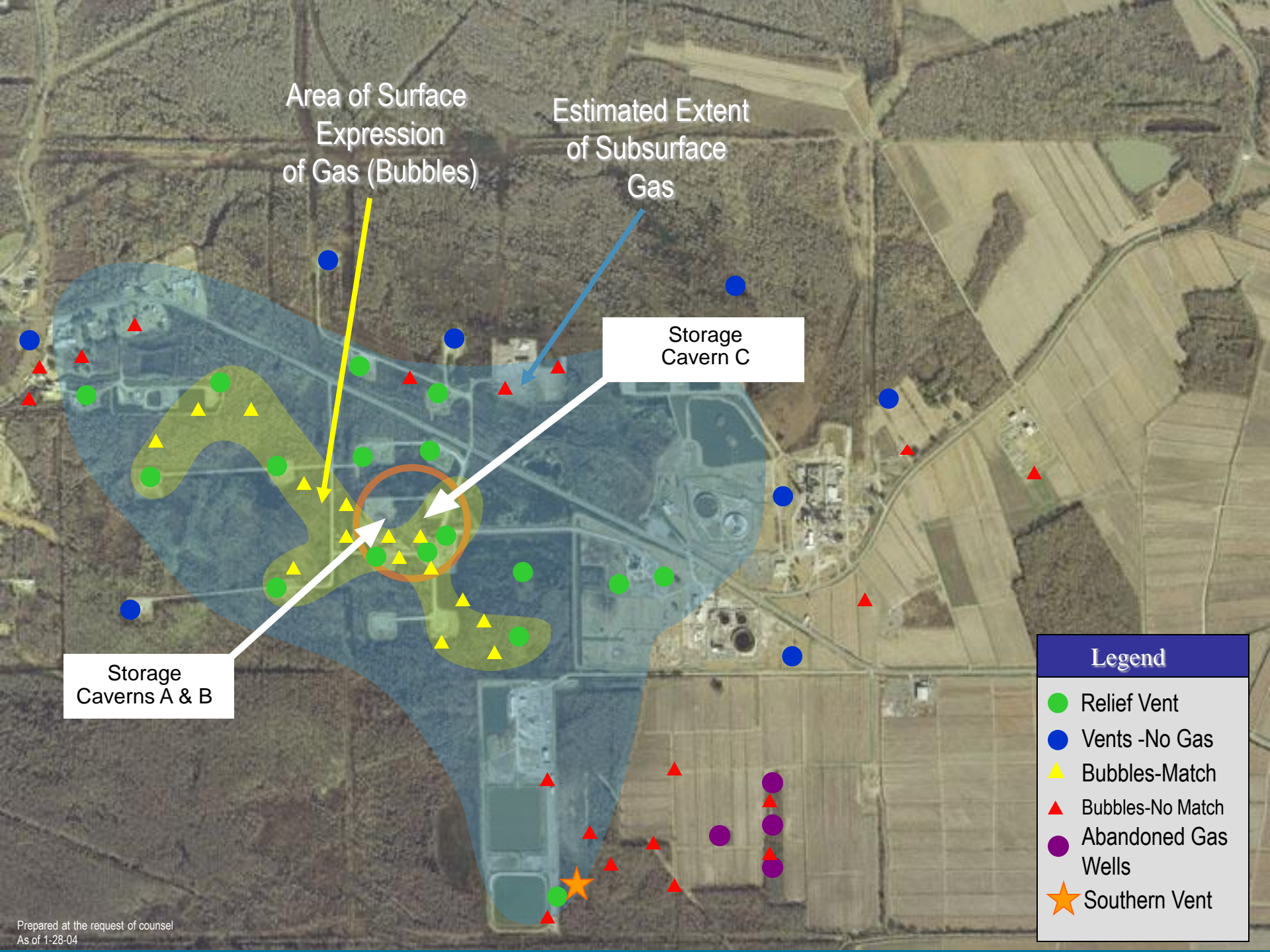
(up to one year of sample collection with several repeat locations)



# Isotope Data – Southern Vent

(one location, many samples)

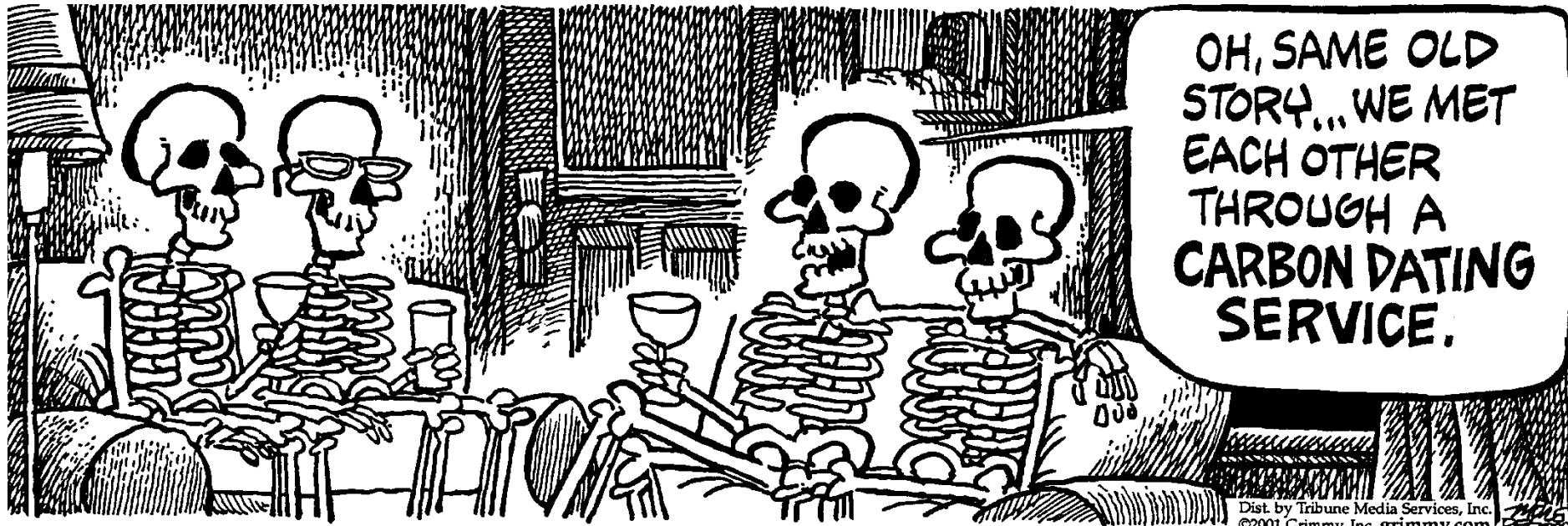




# Methane Forensic Techniques

- Cost effective and definitive investigation tool
- Highest standard of environmental forensics practice
- Establish baseline conditions
- Evaluate extent of gas migration

# Questions?



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# Imagine the Result

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