Impacts of hydraulic fracturing and surface mining on chemical and isotope compositions of shallow groundwater in the Central Appalachian Basin, Eastern United States

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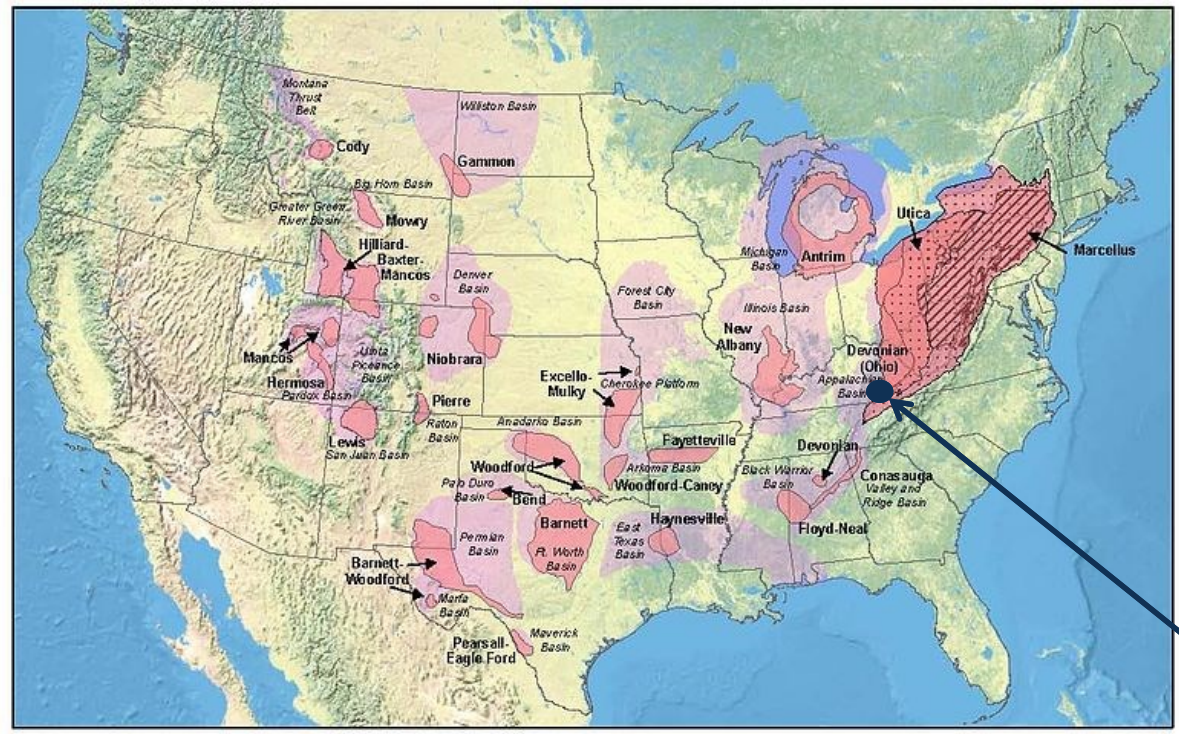
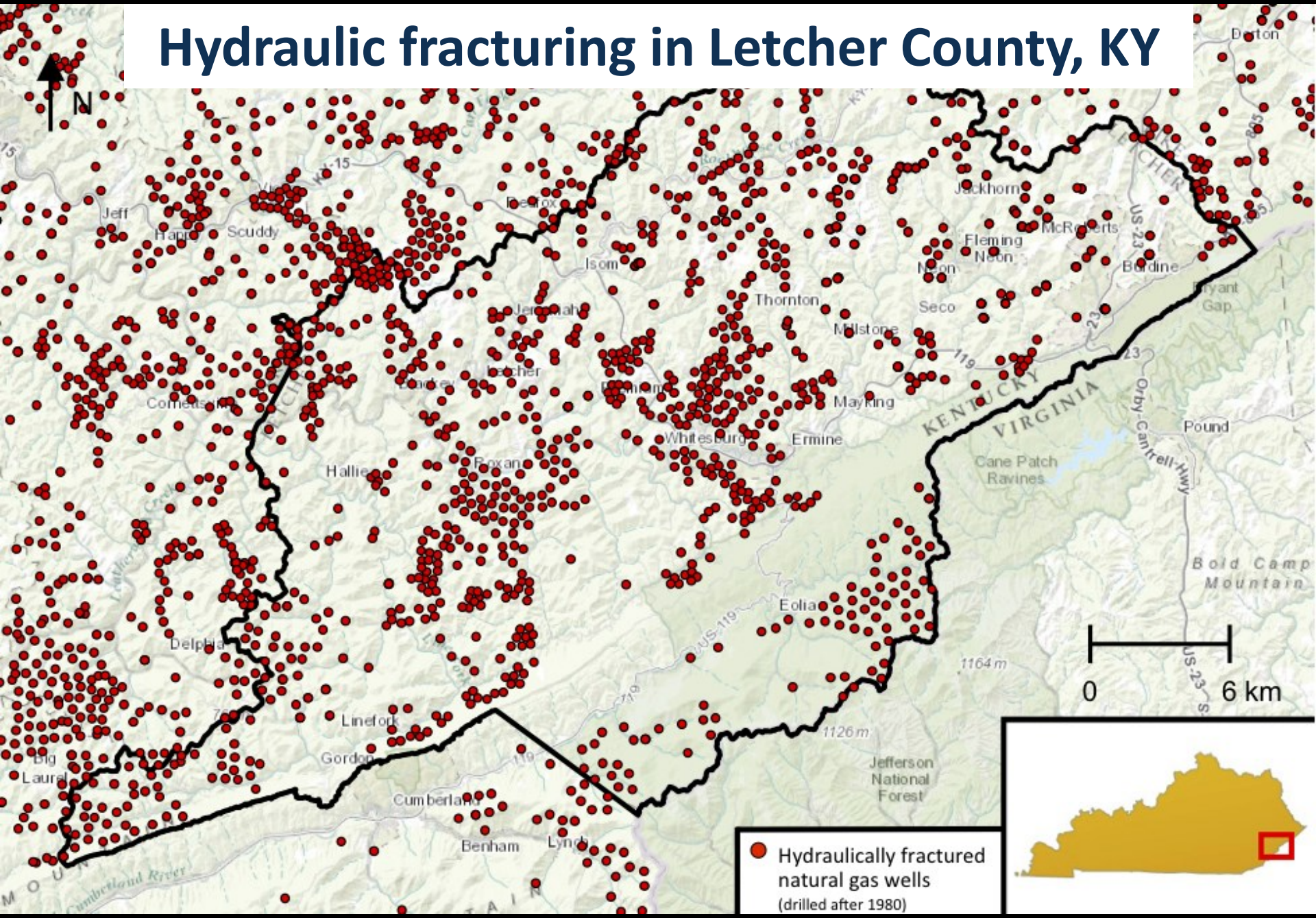
Major Goal

Characterize sources of CH_4 in domestic groundwater of eastern Kentucky in relation to hydraulic fracturing

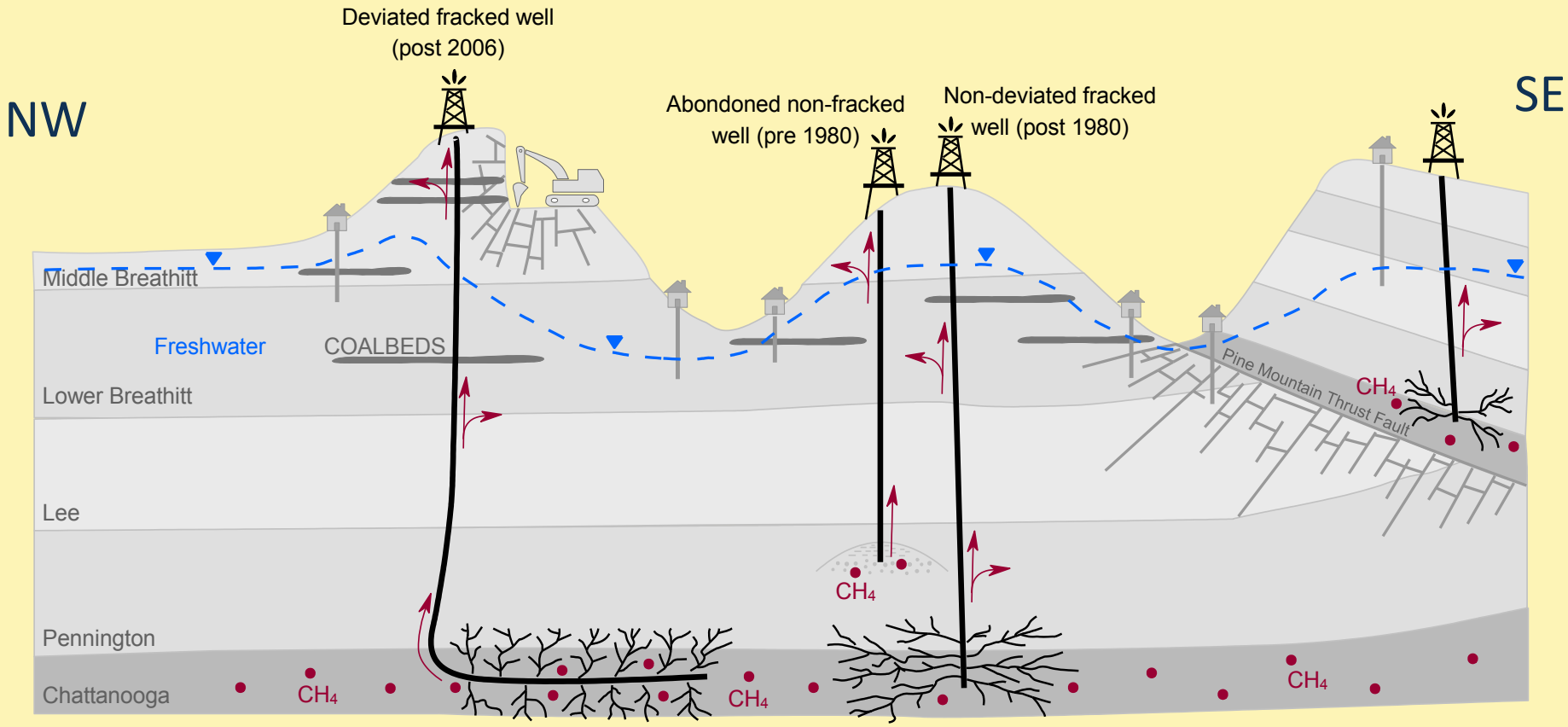


STUDY AREA

Hydraulic fracturing in Letcher County, KY



Bedrock Geology - Studied Area



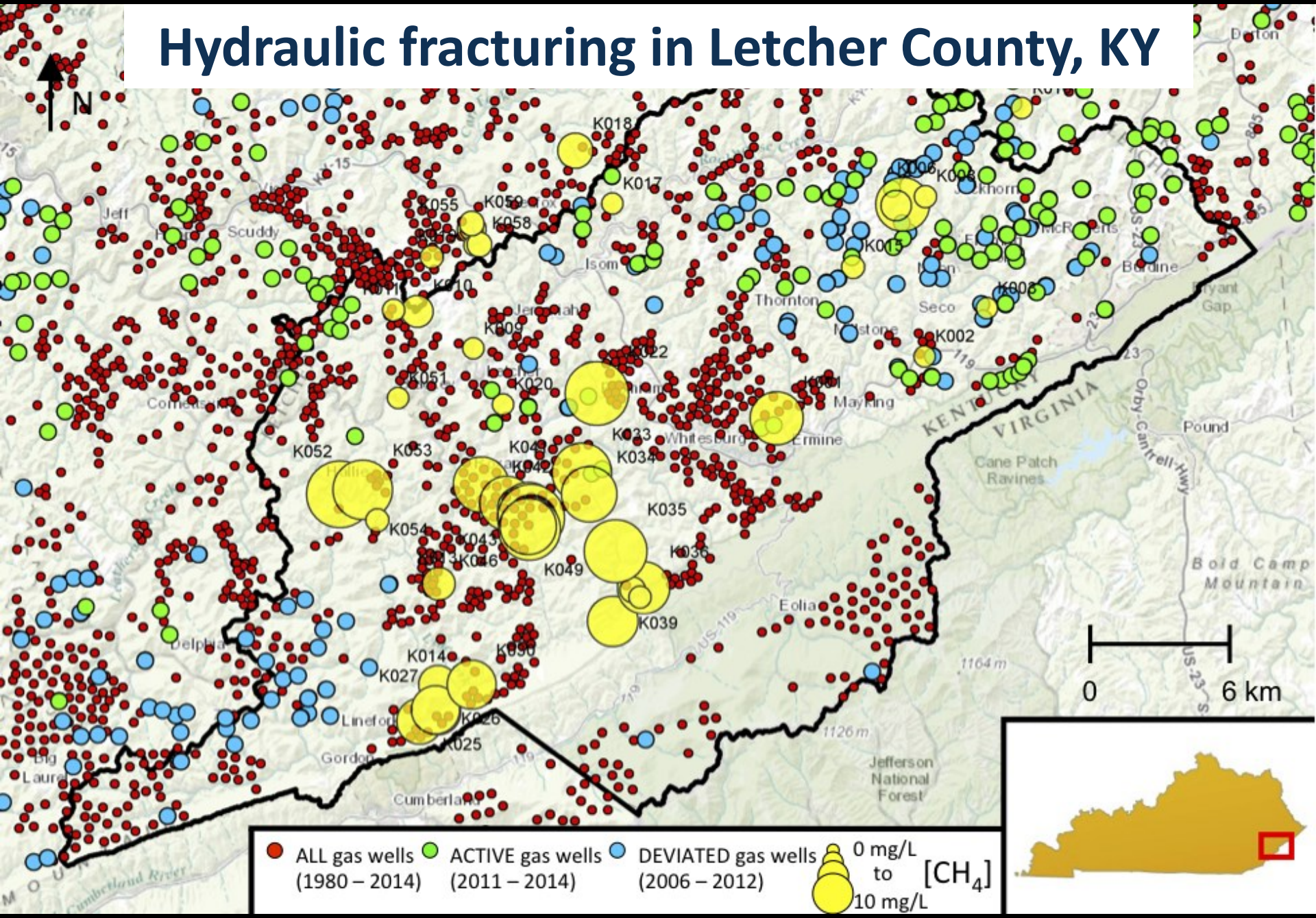
Groundwater Sampling

59 domestic wells were sampled in 2014/2015

Analyte	**Method**
pH, temp., TDS, DO, ORP, HCO_3, etc.	YSE Multimeter
Dissolved [CH_4]	GC
Dissolved cations/anions	ICP-OES/IC
$\delta^{13}C$ & $\delta^{2}H$ of CH_4	IRMS
$\delta^{2}H$ & $\delta^{18}O$ of H_2O	IRMS

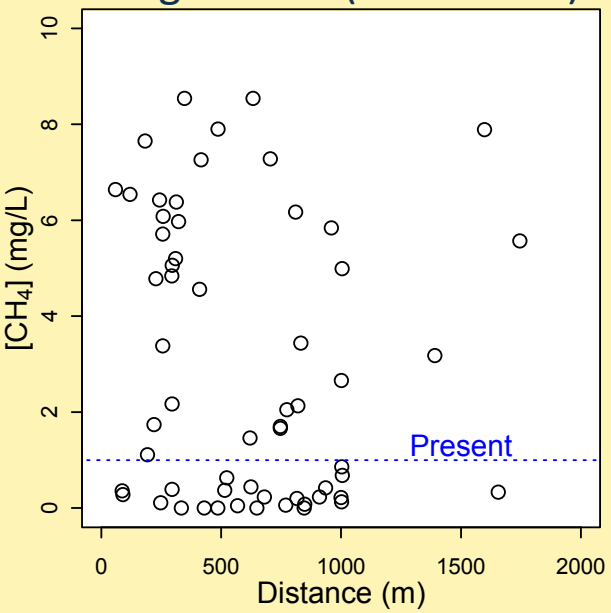
AGE	ROCK TYPE	THICKNESS	FORMATION
		0 to 350 m	**Middle Breathitt** sandstone (40%) shale (35%) siltstone (15%) coal(10%)
Pennsylvanian		600 to 800 m	**Domestic wells sampled** **Lower Breathitt** shale (45%) siltstone (40%) sandstone (15%) coal (5%)
Mississippian		250 to 600 m	**Lee** conglomerate (35%) sandstone (30%) siltstone (25%) shale (10%) coal (< 1%)
		50 to 200 m	**Pennington** Limestone/dolostone (90%) sandstone (5%) siltstone/shale (5%)
Devonian		15 m	**Chattanooga Shale**

Hydraulic fracturing in Letcher County, KY

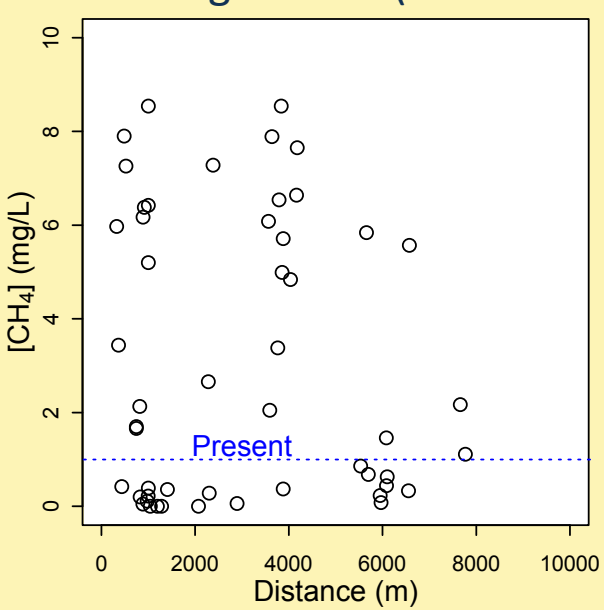


Concentrations of CH_4 with proximity to:

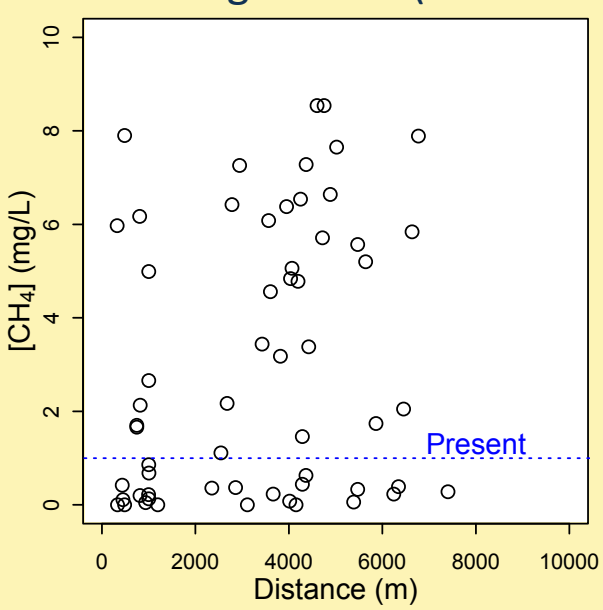
All gas wells (1980-2014)



Active gas wells (2011-2014)

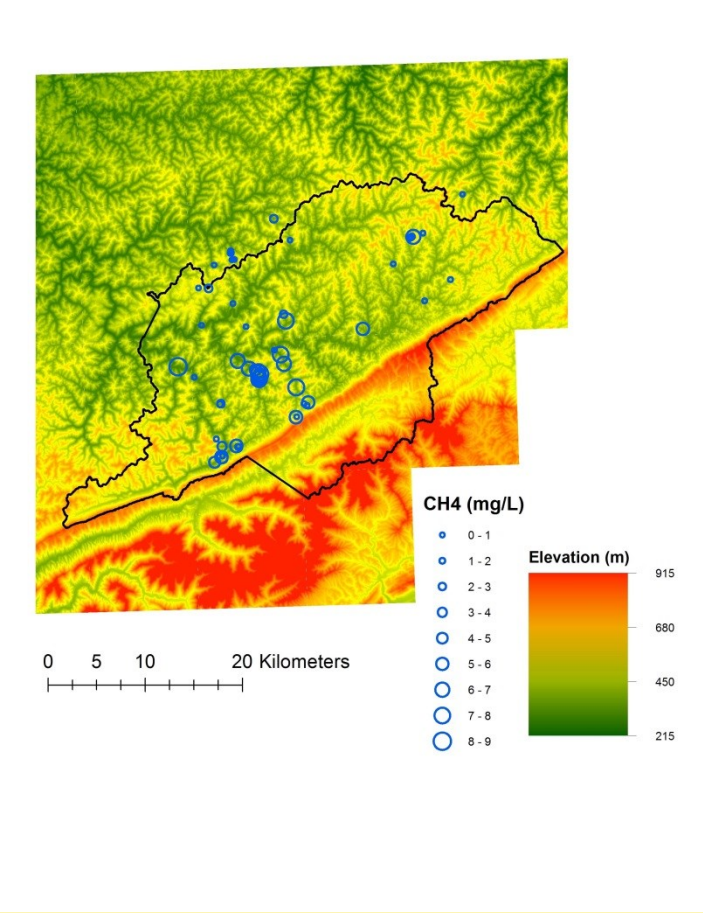


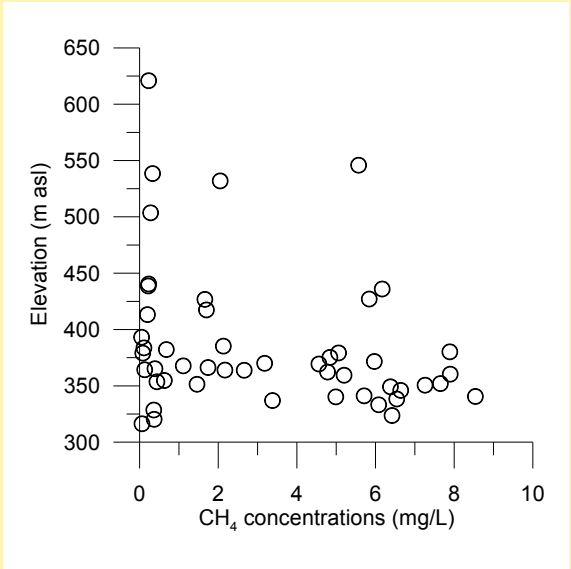
Deviated gas wells (2006-2012)



CH_4 concentrations ranged from **<0.5 to 10 mg/L in eastern Kentucky** and were lower compared to **groundwater from Pennsylvania, up to 50-70 mg/L** (near Marcellus Shale gas extraction)

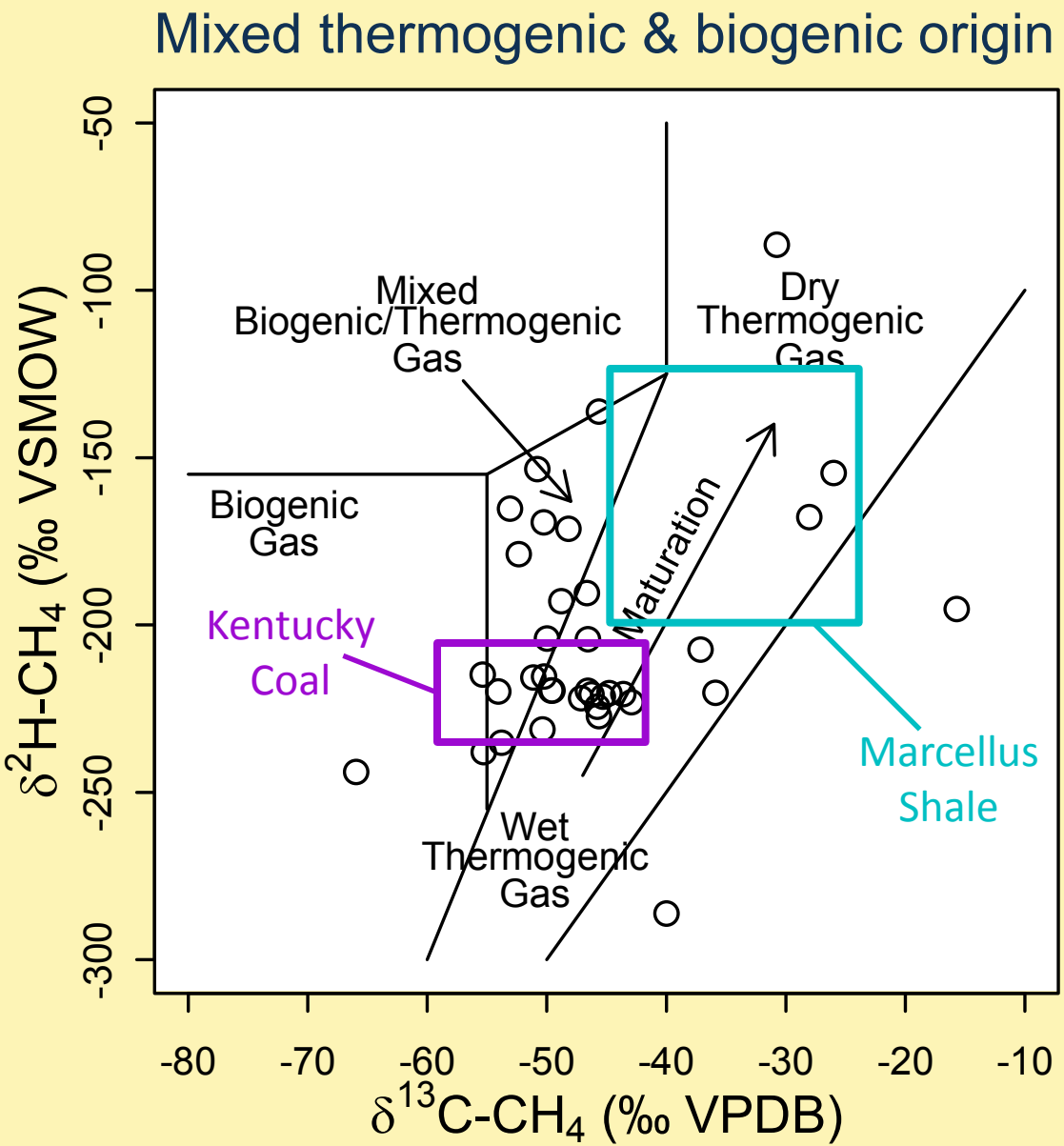
Concentrations of CH_4 and elevation:





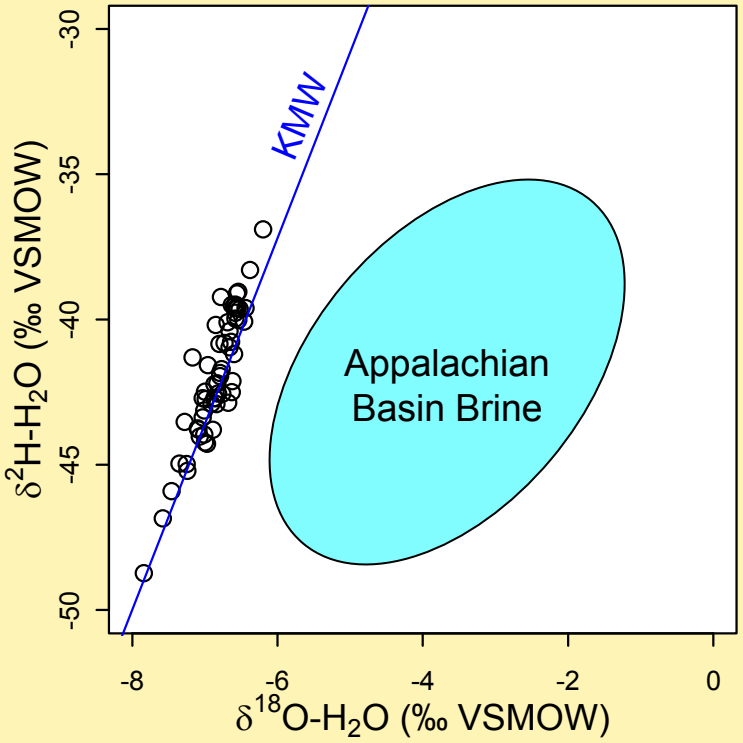
There was no correlation between CH_4 concentrations and elevation

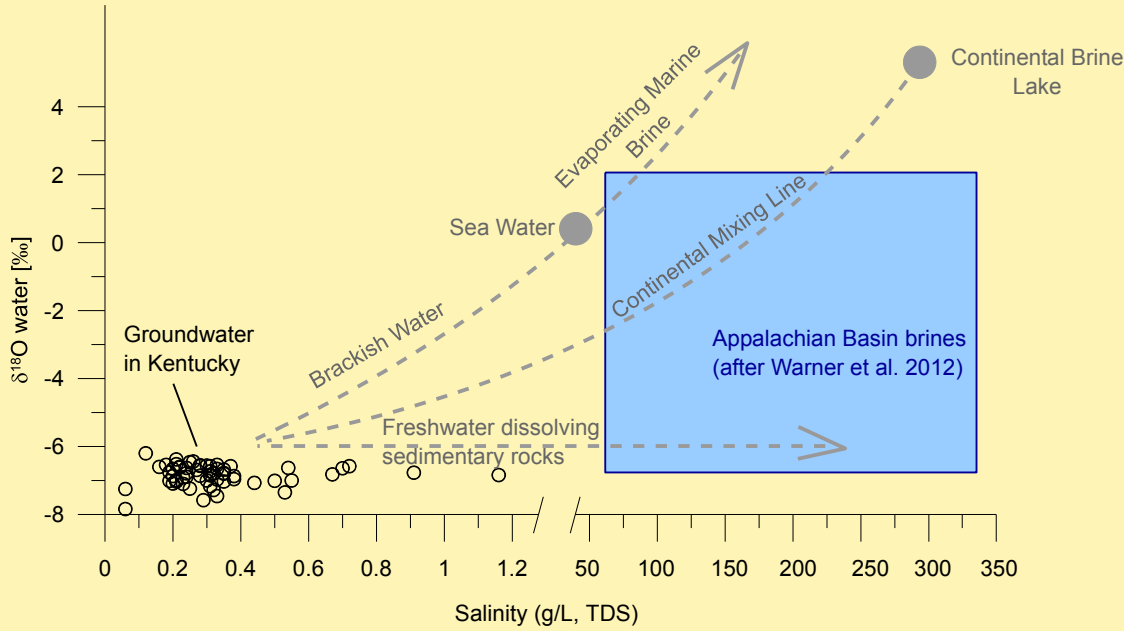
Isotope Composition of CH_4



Isotope Composition of Groundwater

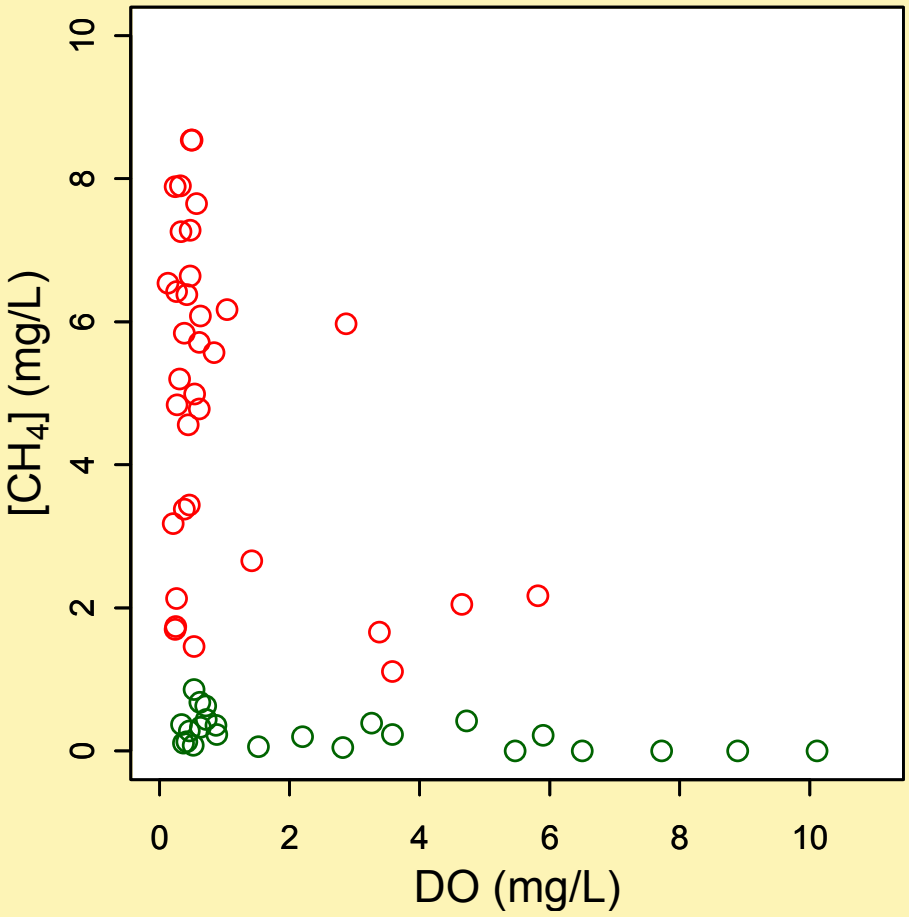
Increases of salinity mainly resulted from water-rock interaction





KMW - Kentucky Meteoric Water

Oxidation of CH_4



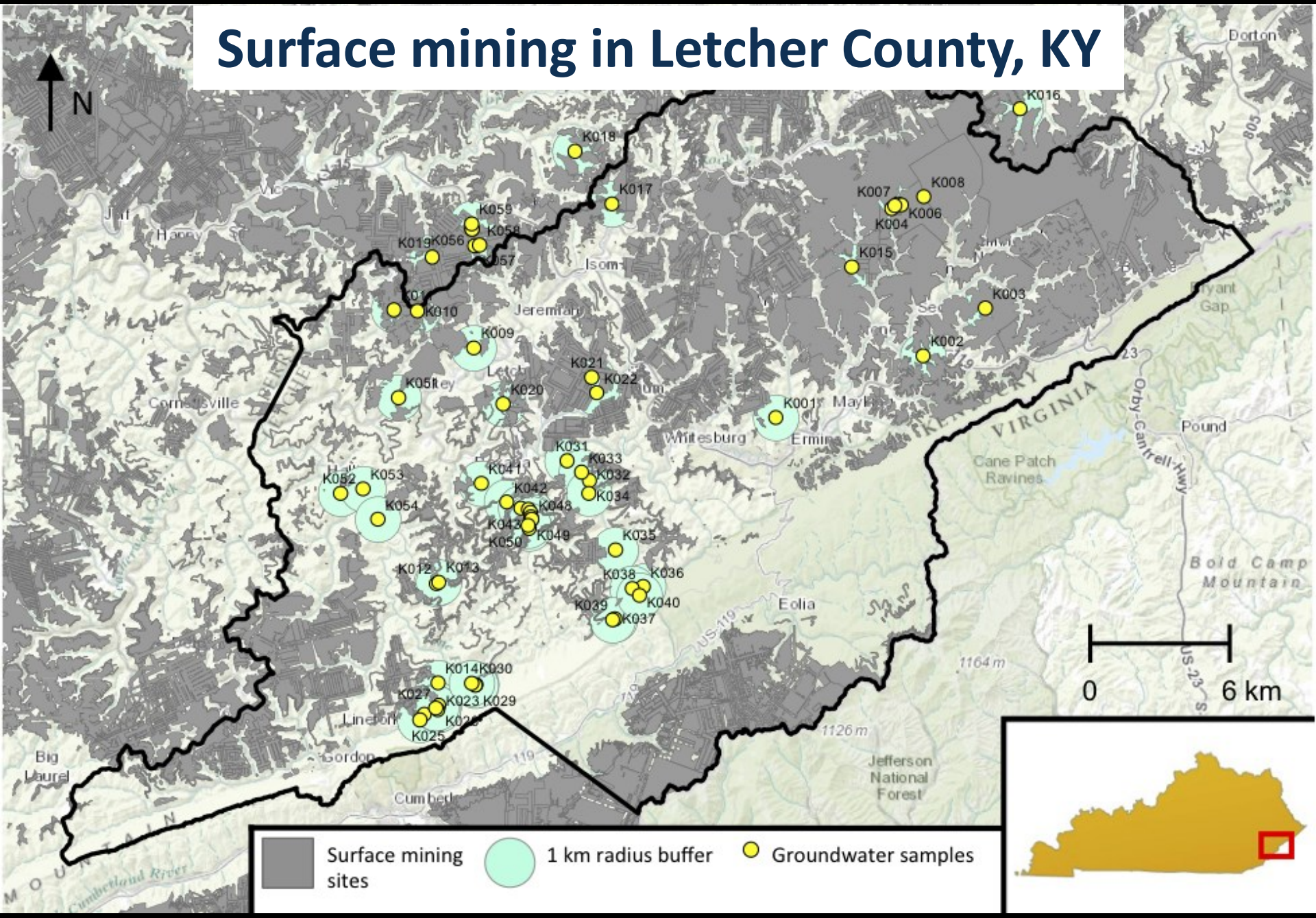
Water Type 1 (CH_4 = 1 to 10 mg/L)

Na-Cl-HCO_3-rich

Water Type 2 (CH_4 < 1 mg/L)

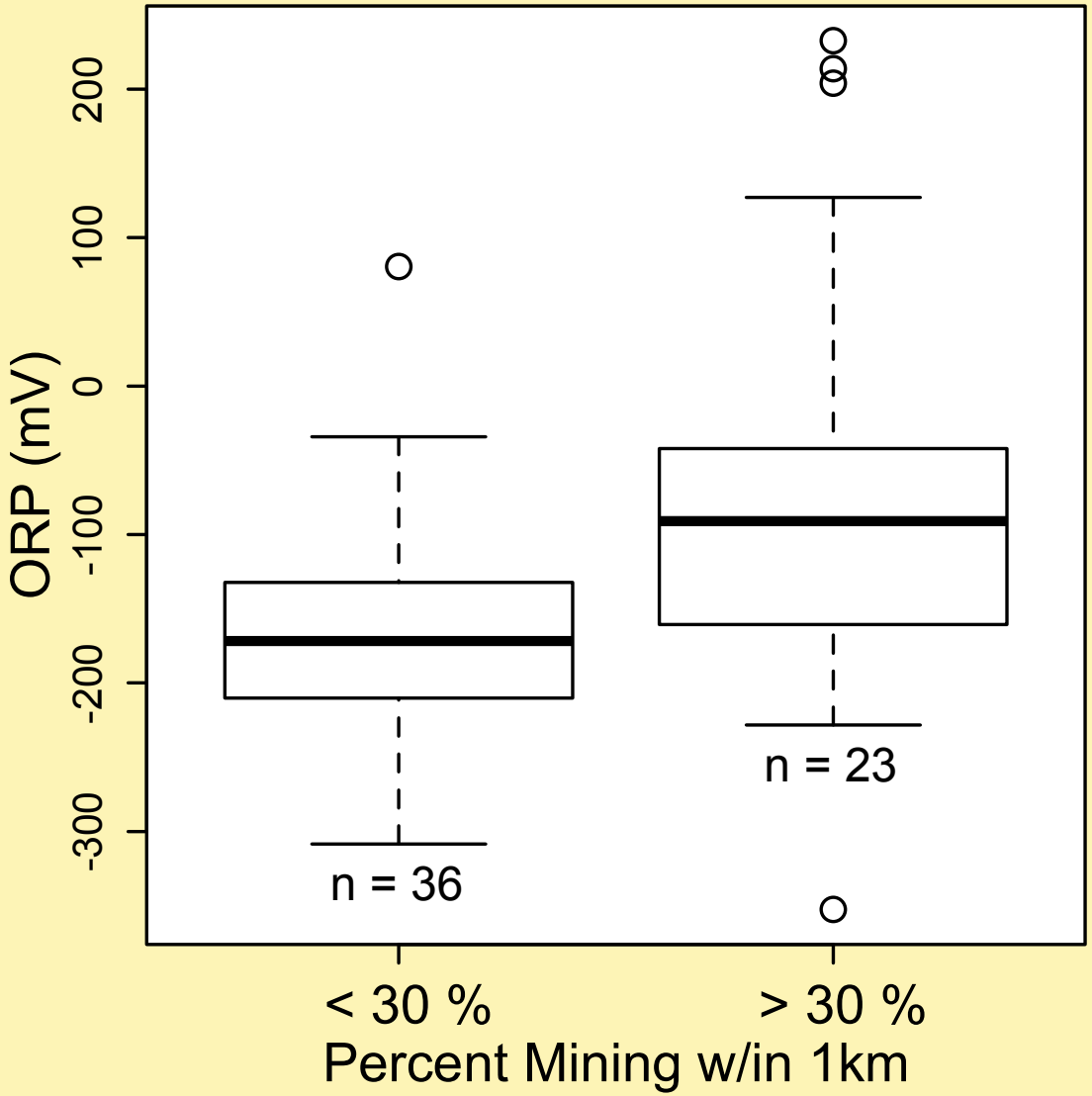
Ca-Mg-HCO_3-SO_4-rich

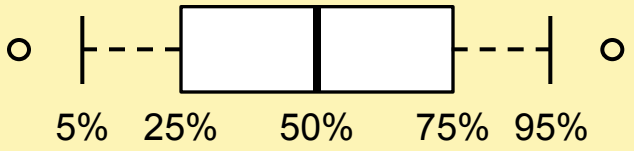
Surface mining in Letcher County, KY



ORP with proximity to mining

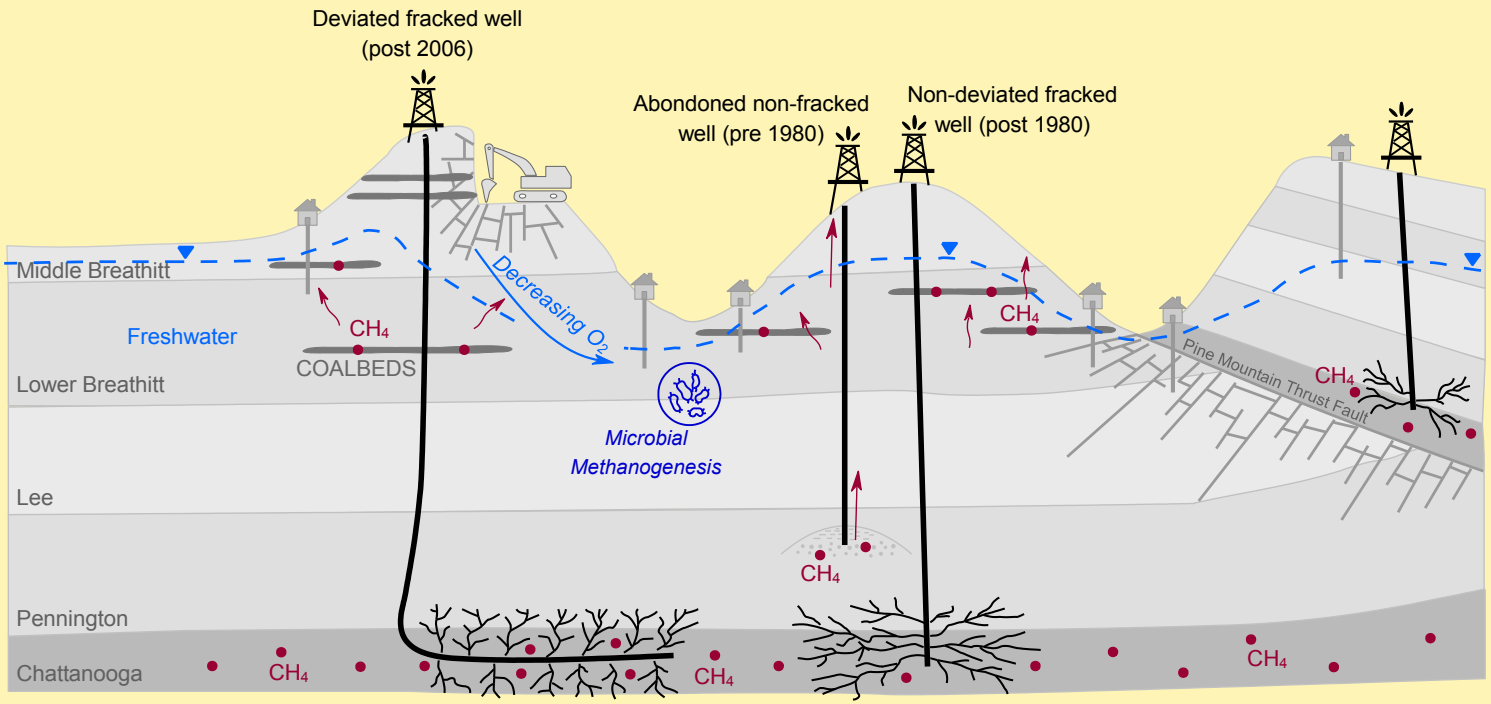
Evidence for groundwater oxidation





Conclusions

1. **Shallow sources of CH_4:** biogenic, coalbed, with plausible input from Chattanooga Shale
2. **No evidence** for direct contamination of domestic groundwater by CH_4 from fracked wells
3. **Mining activity increases likelihood of CH_4 oxidation in shallow environment**



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