Emissions of coalbed and natural gas methane from abandoned oil and gas wells in the United States

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Key Points:
- Abandoned wells are likely a minor source of methane in four production regions
- Plugging of inactive wells may be an effective means to reduce gas leakage
- Coalbed and natural gas methane both contribute to emissions from abandoned wells

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Background

- Legacy of oil and gas extraction means there are millions of abandoned oil and gas wells in the onshore United States
  - 2.3 million in state databases
  - May be up to 3 million (Brandt et al., 2014)
- Types of abandoned wells:
  - wells without recent production (terminology includes inactive, temporarily abandoned, shut in, and/or dormant)
  - wells without a responsible operator (orphaned or abandoned)
  - wells that have been plugged with a cement or mechanical plug to prevent migration of fluids (plugged)

Previous Work

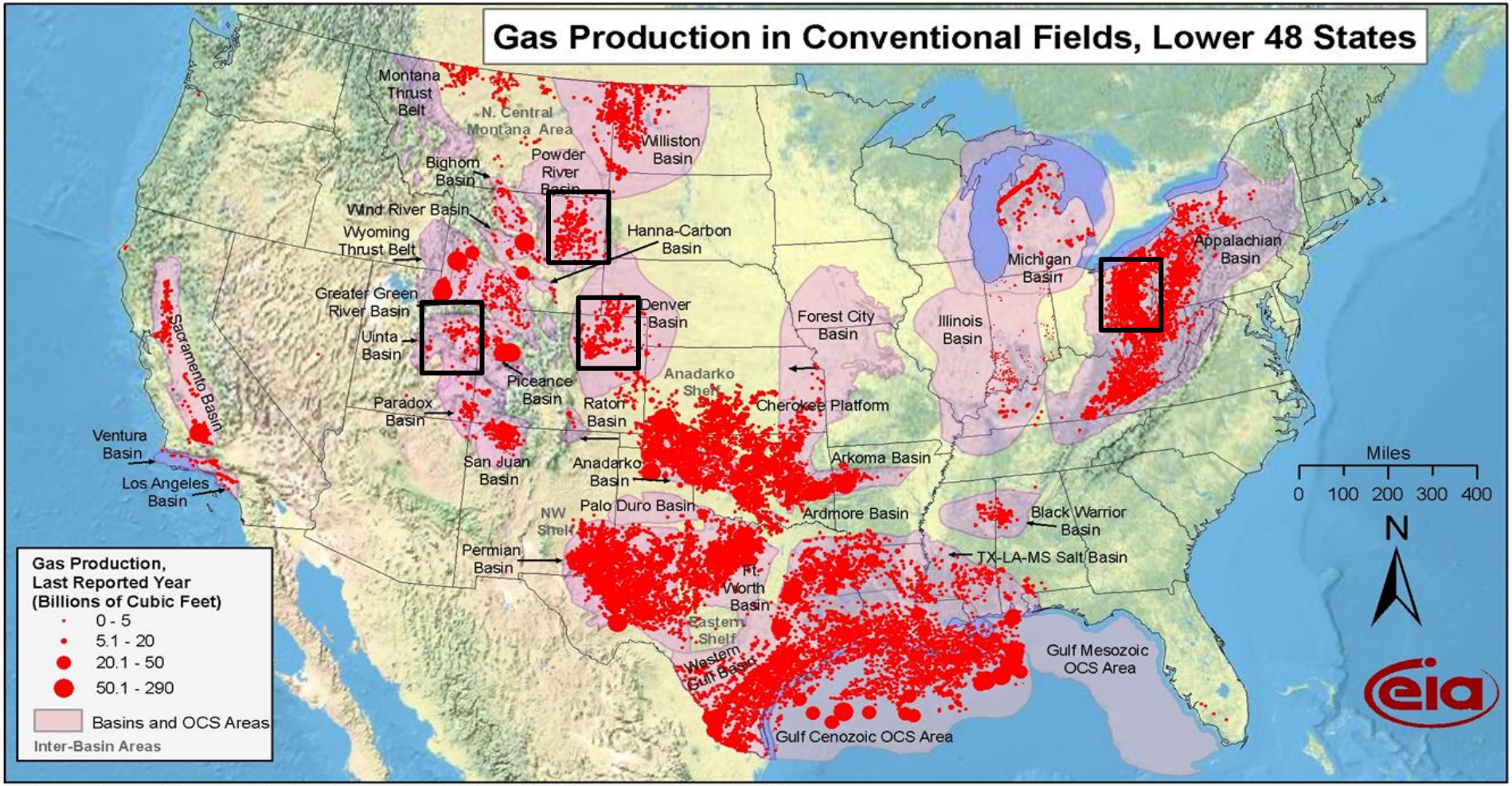
- Two studies of methane leakage from abandoned wells in Appalachian Basin implied they may be a regionally significant methane source (Etiope et al., 2013; Kang et al., 2014)
- Comparison of top-down and bottom-up methane inventories indicated a missing (possibly thermogenic) source – implicating abandoned wells (Brandt et al., 2014)

Are emissions from abandoned wells significant at regional or national scales?

- Initial assessment of CH_4 emissions from abandoned wells in four active production areas across the country

- Also measured stable isotope ($\delta^{13}C$ and $\delta^{2}H$) signatures to elucidate sources of CH_4

Study basins: Appalachian, Powder River, Denver Julesburg, and Uintah. In total 138 wells were measured

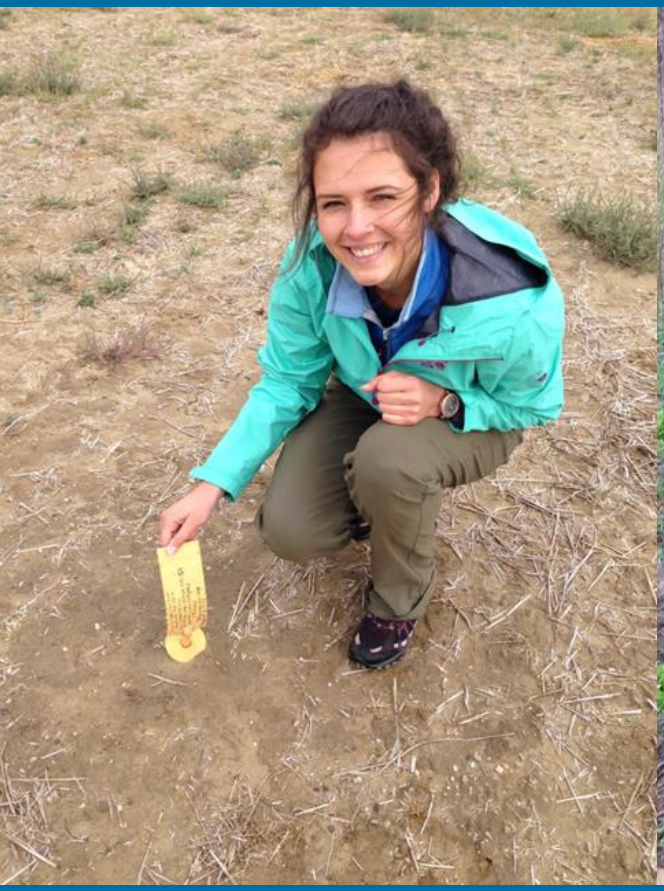


Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

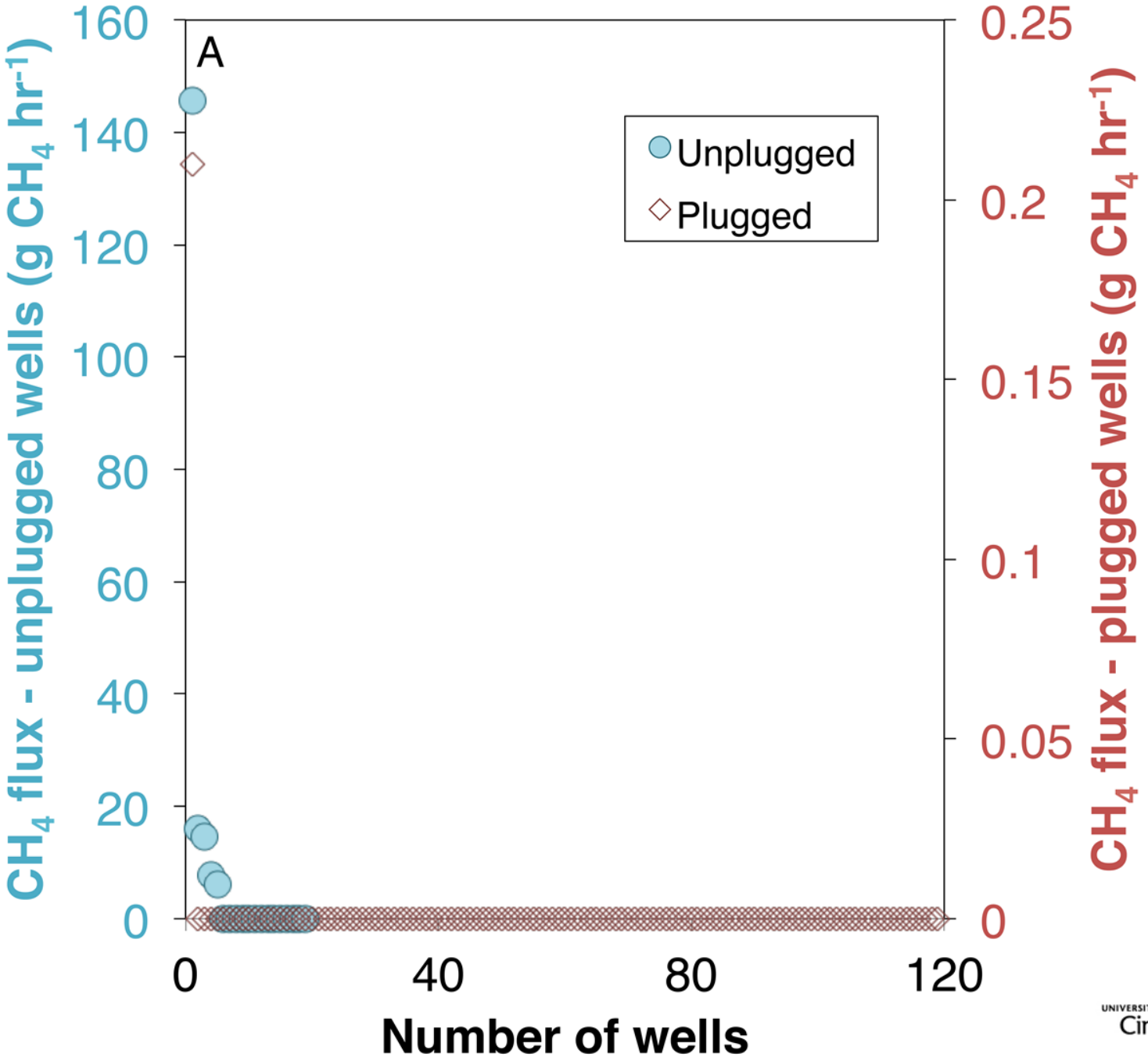
Approach

- Identify random selection of plugged and unplugged abandoned wells on public land
- Screening of methane concentrations on and around wellhead
- If screening value = 0, emission rate = 0
- If positive screening value, emission rate measured with hi-flow sampler or flux chamber with CRDS methane analyzer

Plugged Wells

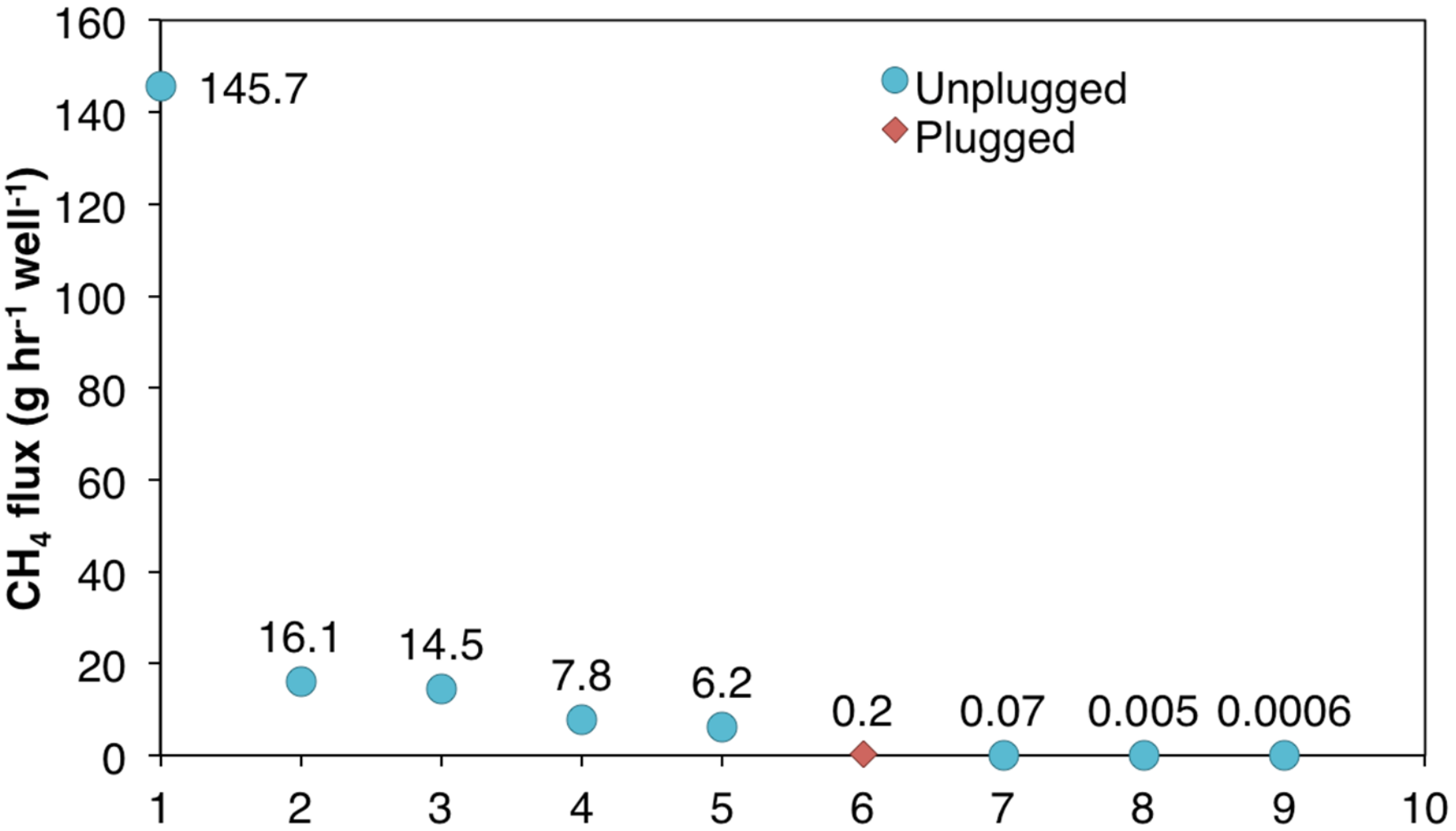


Unplugged Wells

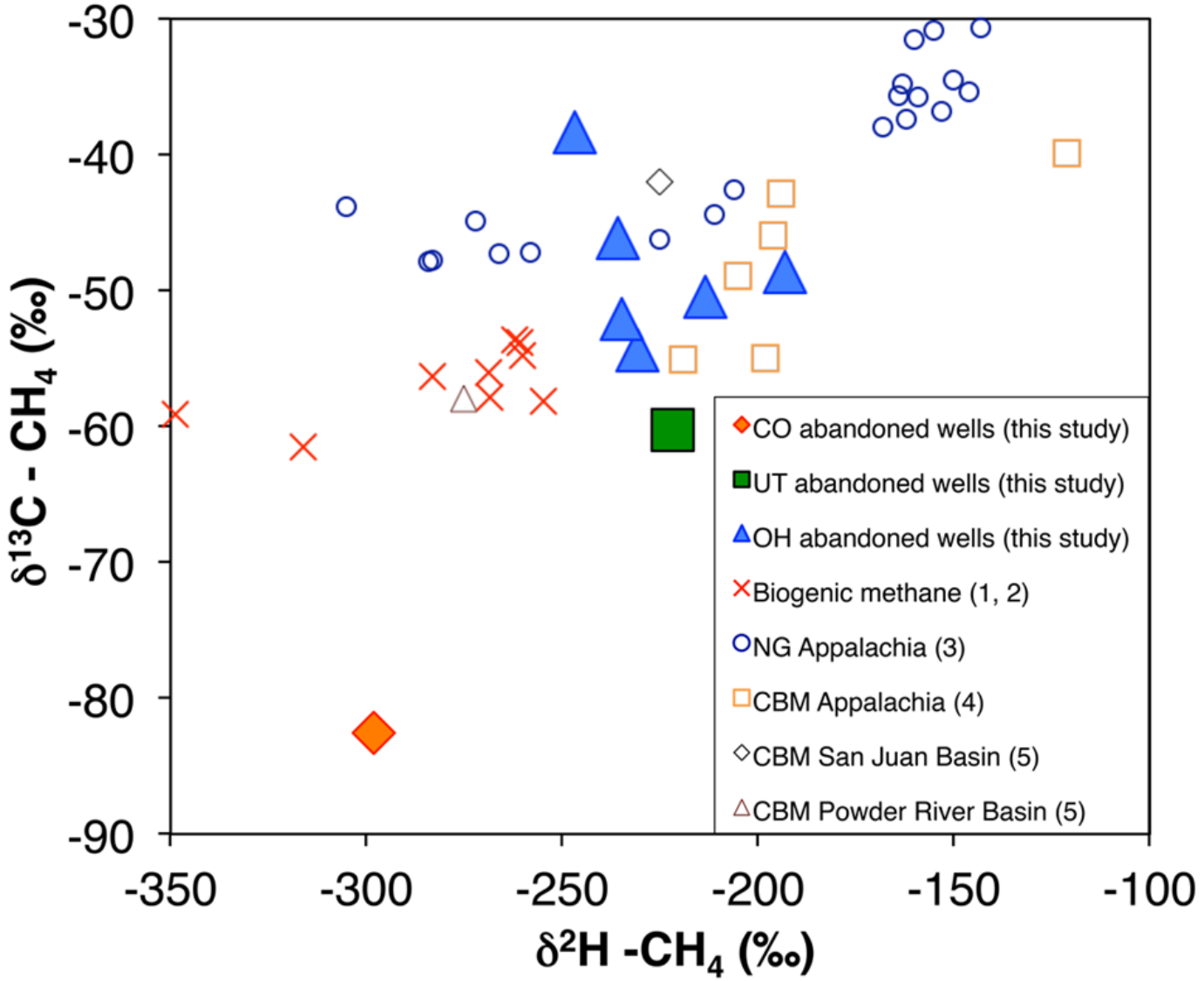

A
Unplugged
Plugged
160
140
120
100
80
60
40
20
0
0.25
0.2
0.15
0.1
0.05
0
0
40
80
120
Number of wells
CH4 flux - unplugged wells (g CH4 hr-1)
CH4 flux - plugged wells (g CH4 hr-1)

8 out of 20 unplugged wells were a positive source of atmospheric CH4 (mean = 10.0 g hr-1) (95% UCL: 22.5 g hr-1)

Only 1 out of 119 plugged wells was a positive source of CH4 (mean = 1.9 mg hr-1) (95% UCL: 4.9 mg hr-1)



Wells are a source of thermogenic and biogenic CH_4



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Are abandoned wells a significant CH_4 source?

- Preliminary results suggest that abandoned wells may account for
  - 0 – 0.2% of CH_4 emissions in the Uintah and Denver-Julesburg basins (as measured by top-down studies)
  - 0.1 – 0.3 % of CH_4 emissions in the NE Marcellus Basin
  - 1.6×10^4 kg CH_4 hr^{-1} nationally (2 – 4% of oil and gas CH_4 in the EPA emissions inventory)
- Proper plugging of abandoned wells is an effective strategy for reducing CH_4 emissions from legacy oil and gas operations
- Highest emissions were from wells in the Appalachian Basin – the oldest oil and gas producing region in the country (starting 1859)
  - This region also has poor record keeping of abandoned well status and location

Implications

- Abandoned wells may provide a conduit for generation and/or release of biogenic coal bed CH_4 in addition to natural gas
- State databases are lacking in accounting of abandoned wells, especially unplugged wells
- More work is needed to constrain the number of “super-emitters” regionally and nationally

Missing Information

- Texas did not have any accessible abandoned wells for this study

- Measurements of abandoned well emissions in California are currently under investigation at Stanford University (Rob Jackson's group)

Questions?

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