Dangerous Atmosphere Created in Strip Mine Spoil

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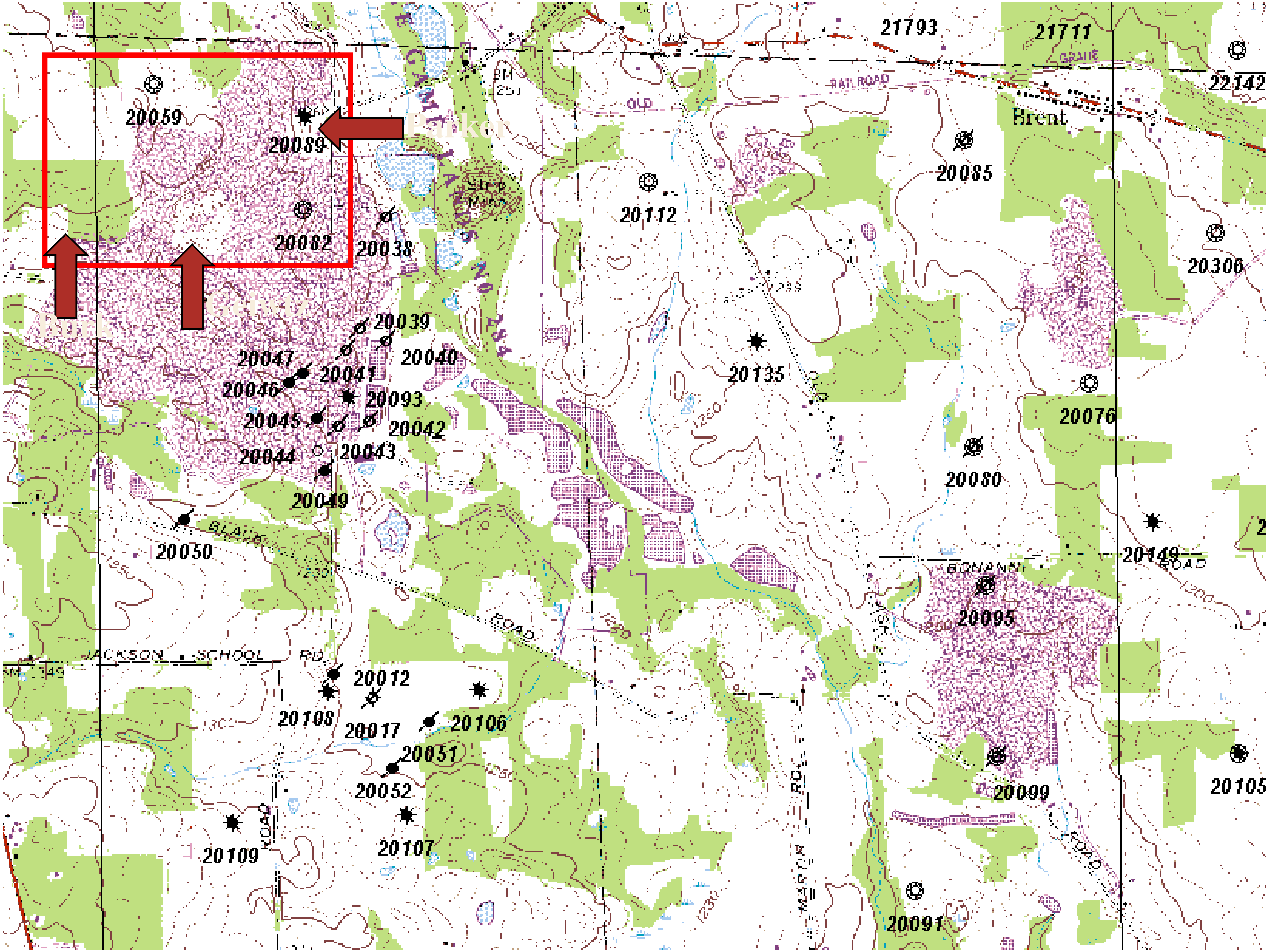
CO_2 Contamination Problems in Western Pennsylvania

- "Blackdamp"
- Usually associated with communication of shallow abandoned mine atmosphere with surface structures via old shafts & entries
- 12 – 15 % CO_2 in abandoned mine atmosphere
- CO_2 & Methane are natural products of coal

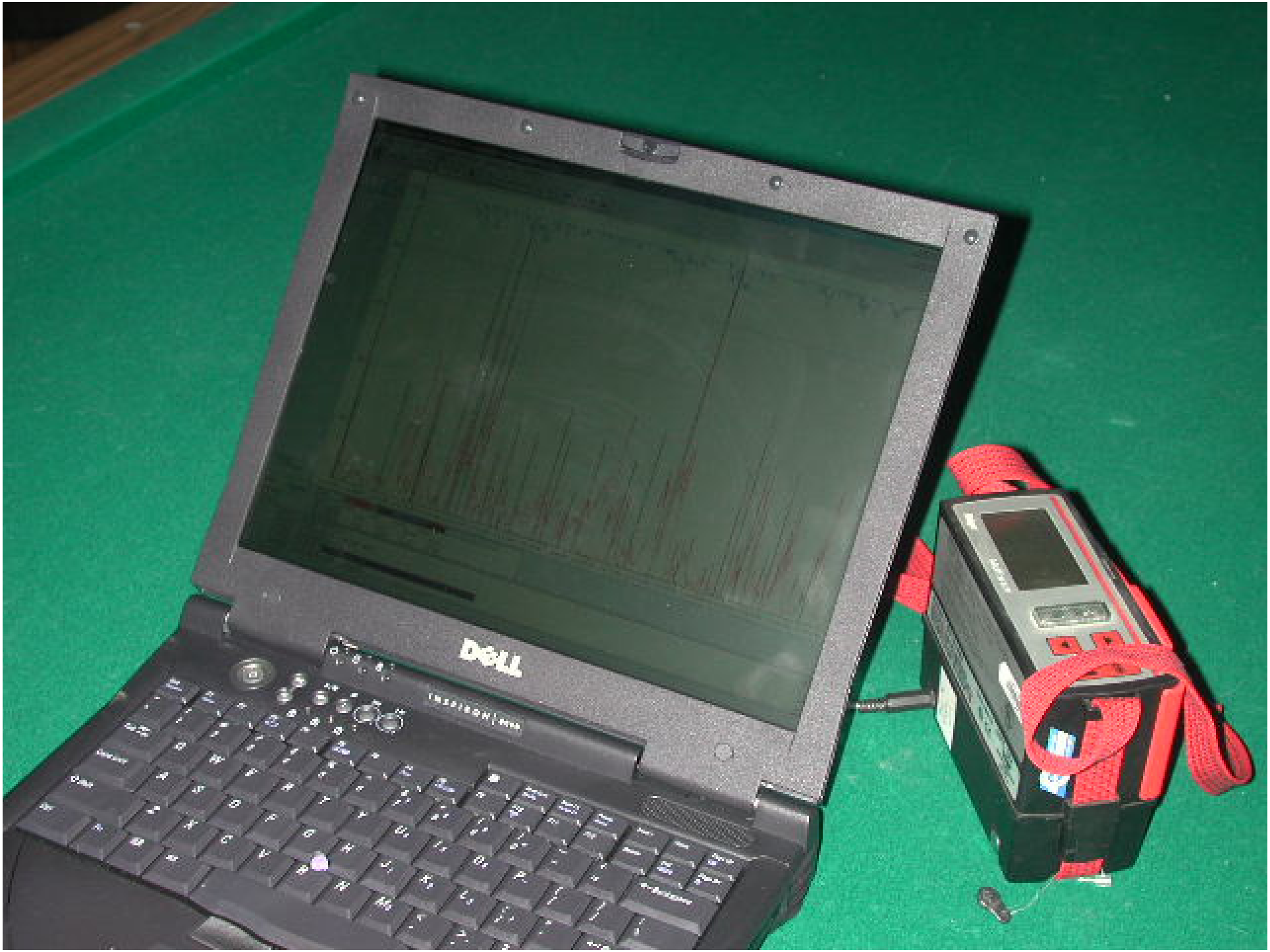
CO_2 Contamination Problems in Western Pennsylvania

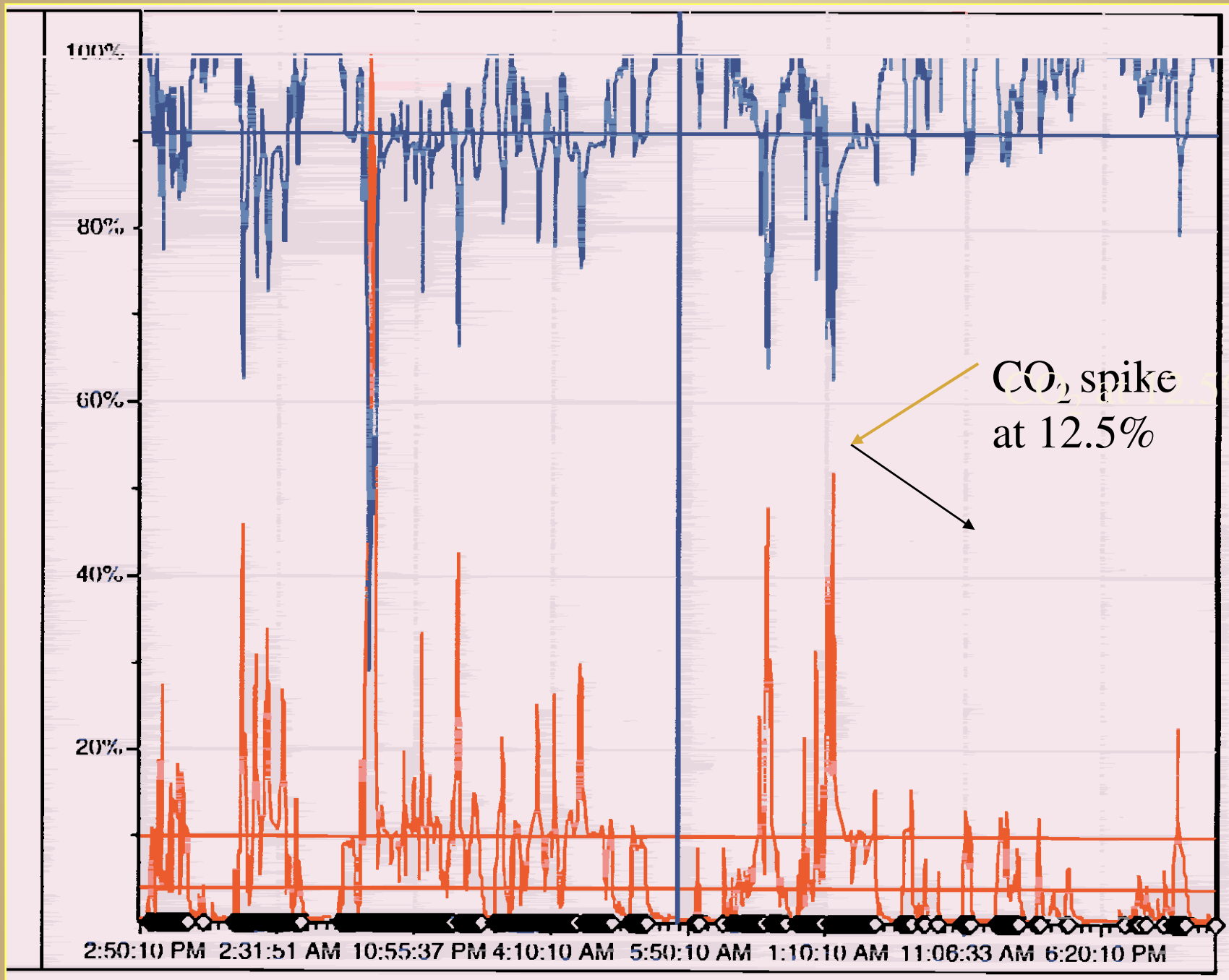
- **Residence, Latrobe, Westmoreland County 1998**
  - **CO_2 levels up to 6.3% measured inside the home**
  - **O_2 levels depressed as low as 16% inside the home**
  - **CO_2 levels up to 16.4% measured in monitoring wells around the home**
  - ***Low barometric pressure***

- **Northern Lawrence County**
  - **Three homes 2001**
  - **CO_2 levels > 25% measured inside the homes**
  - **Corresponding O_2 levels depressed as low as 10% inside the homes**
  - **CO_2 levels >25% measured in monitoring wells around the homes**
  - ***Low barometric pressure***

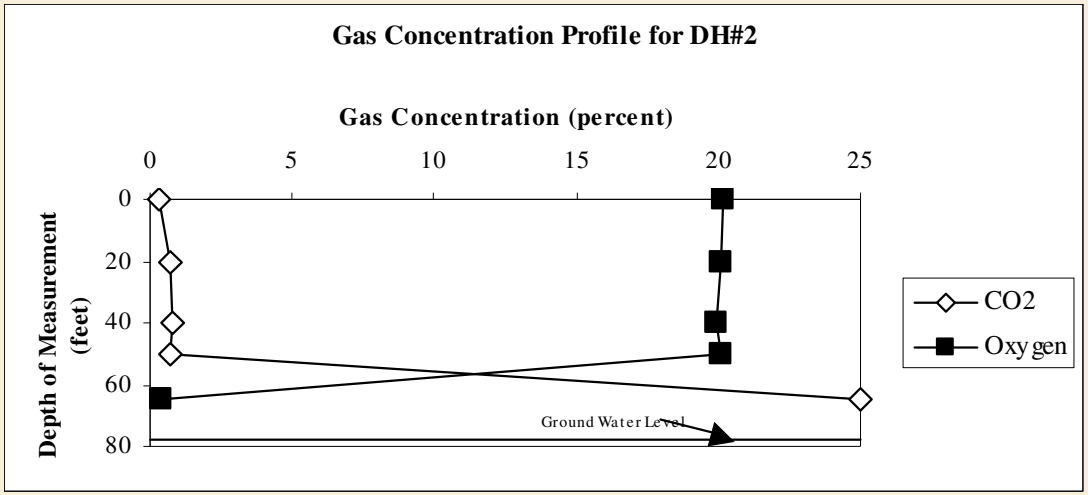


21793
21711
22142
20059
20089
20082
20038
20085
Brent
20112
20306
20039
20040
20047
20041
20046
20093
20045
20042
20044
20043
20049
20135
20076
20080
20050
20149
20095
JACKSON SCHOOL RD
BLAIR ROAD
BONANNI ROAD
20012
20108
20017
20106
20051
20052
20099
20105
20109
20107
20091


DELL


100%
80%
60%
40%
20%
CO_2 spike
at 12.5%
2:50:10 PM
2:31:51 AM
10:55:37 PM
4:10:10 AM
5:50:10 AM
1:10:10 AM
11:06:33 AM
6:20:10 PM

Monitoring Wells



Lawrence County Potential CO_2 Contamination Sources

- Deep Mine
- Strip Mines
  - Spoil gas
- Oil and Gas Fields
- Marsh Gas
- Drift Gas
- Subsurface Geology
  - Carbonate rocks?
  - Caves?

Abandoned Deep Mine

CO_2 Migration From Subsurface Sources In Western Pennsylvania

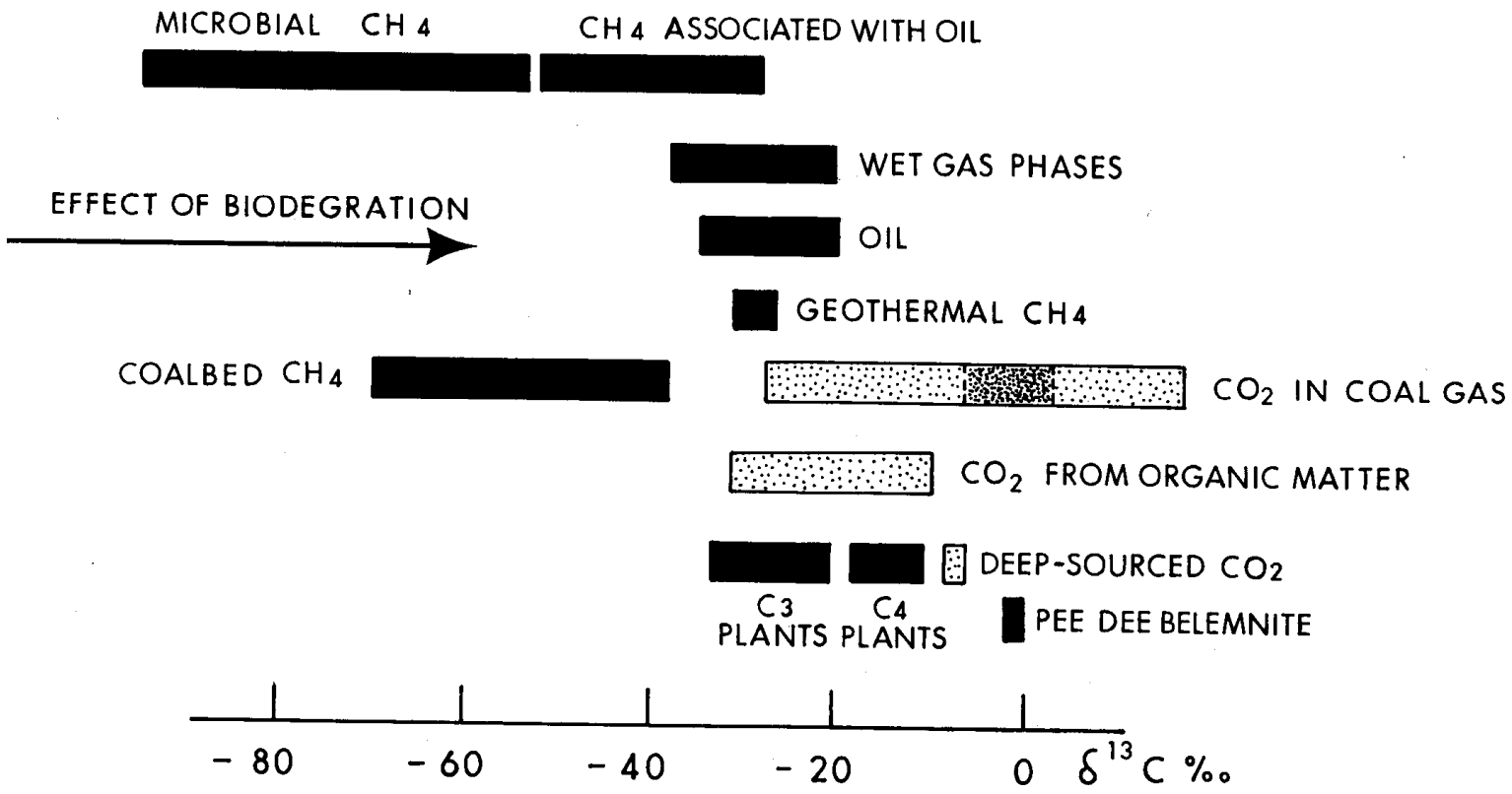
- Several possible sources of CO_2 in petroleum and coal fields

- Thermal degradation of organic matter in sediments
- Thermal dissolution of carbonate rocks
- Maturation of coal beds
- Microbial degradation of organic matter in sediments
- AMD reactions with carbonate in bedrock or spoil/fill

Stable Isotope Geochemistry

- Isotopic ranges of natural gases are large in range, specific, predictable, and capable of providing diagnostic information on their source.
- Differences in isotopic mass lead to subtle but significant differences in the behavior of an element during natural processes (*fractionation*)

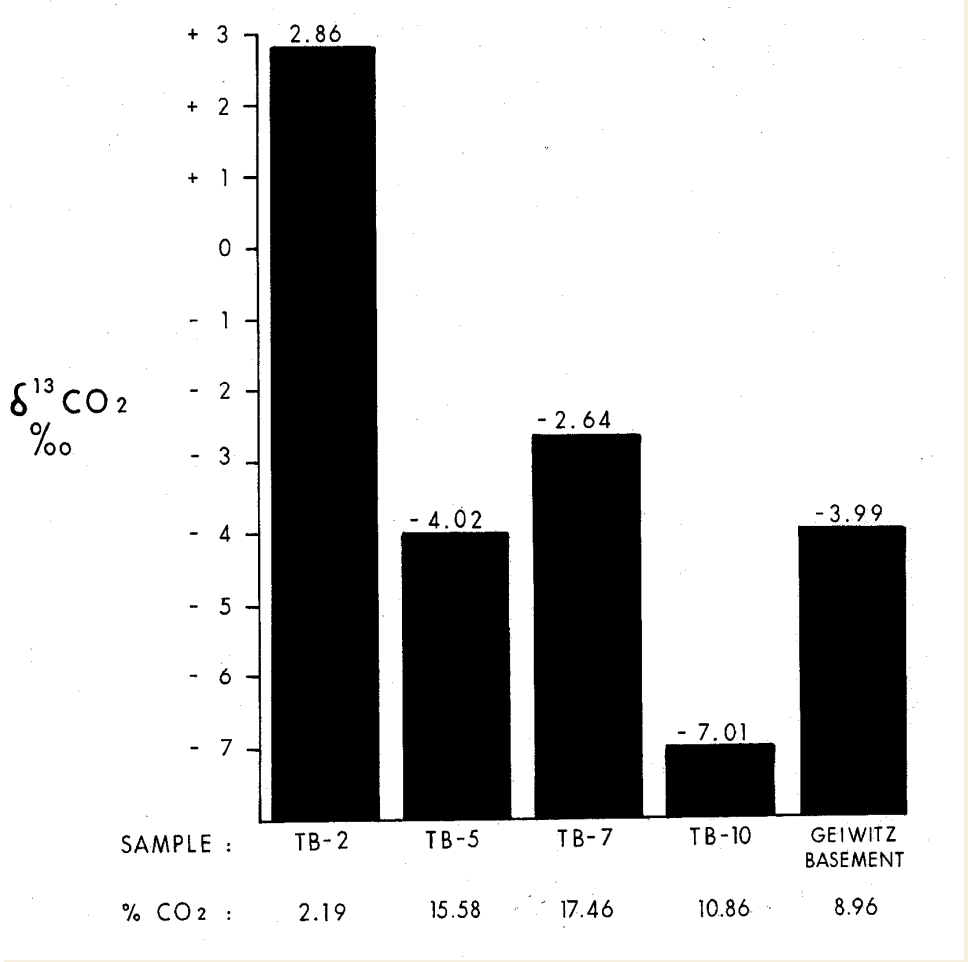
- $\delta\ ^{13}CO_2 = R_{sample} - R_{standard} * 1000$ (permil)

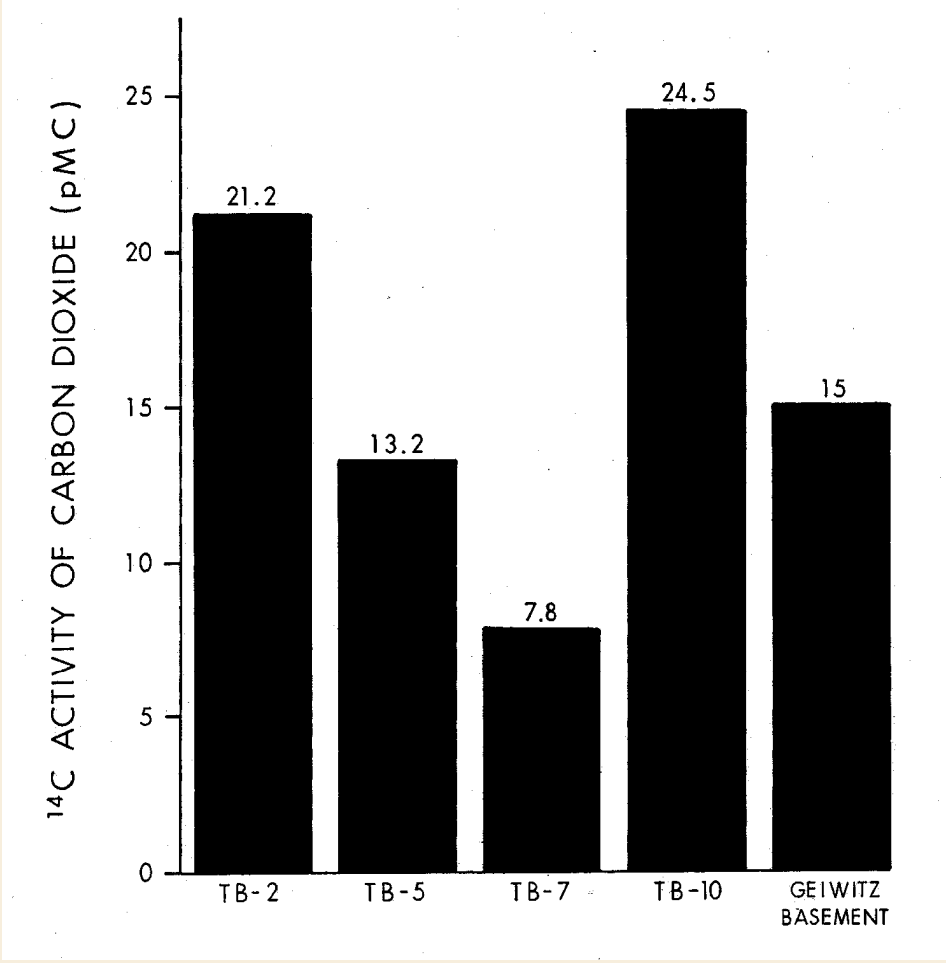

MICROBIAL CH 4
CH 4 ASSOCIATED WITH OIL
WET GAS PHASES
EFFECT OF BIODEGRATION
OIL
GEOTHERMAL CH4
COALBED CH4
CO2 IN COAL GAS
CO2 FROM ORGANIC MATTER
DEEP-SOURCED CO2
C3 PLANTS
C4 PLANTS
PEE DEE BELEMNITE
- 80
- 60
- 40
- 20
0
δ13C ‰

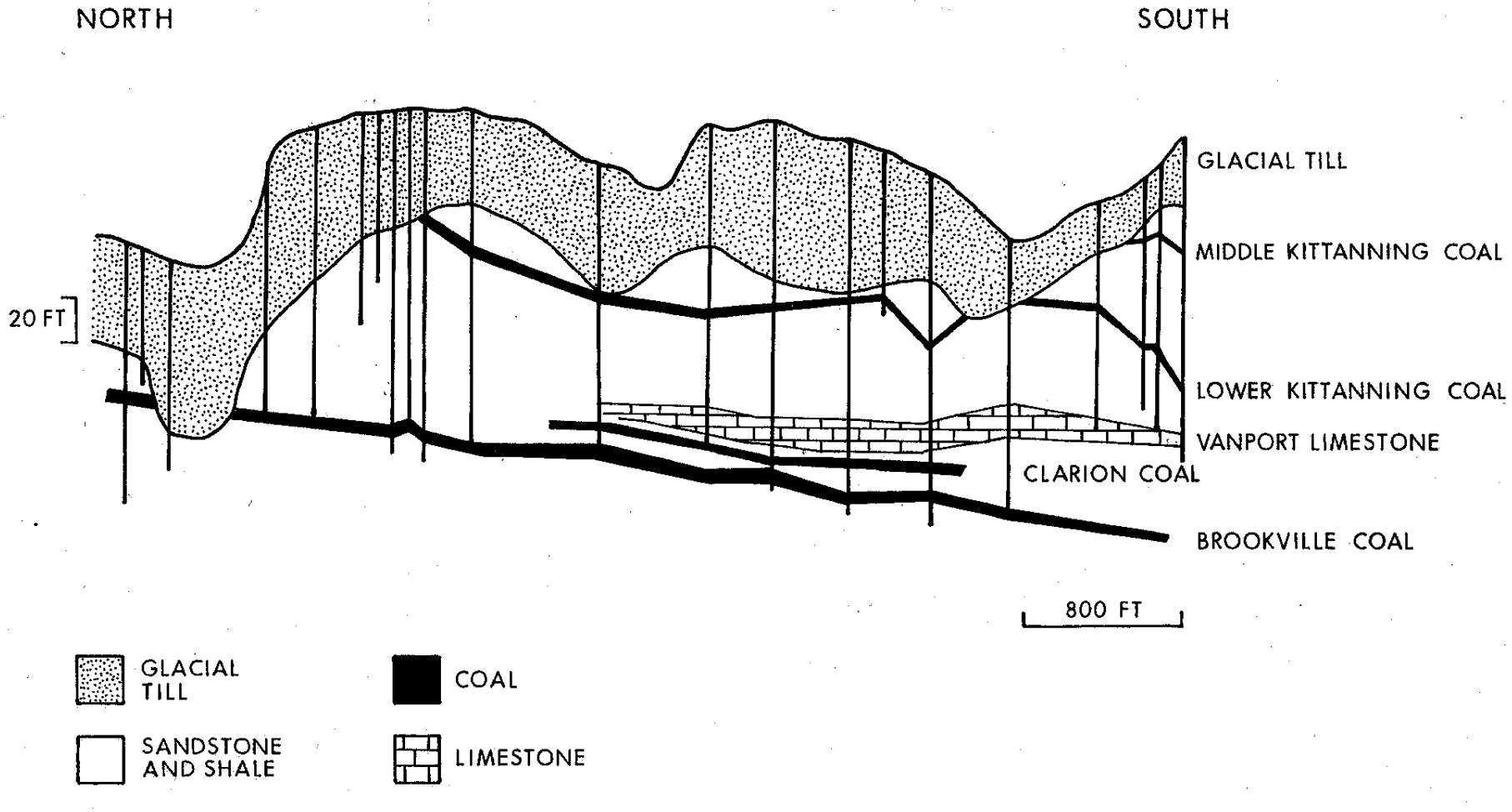
^{14}C Activity of CO_2

- Atmospheric testing of nuclear devices in the 1950's and 1960's produced substantial amounts of ^{14}C-enriched CO_2.
- All plant or animal material that has grown since approximately 1960 has ^{14}C concentrations above natural levels.
- This ^{14}C concentration can be used as a tracer for microbial gas.

Isotope Geochemistry Data





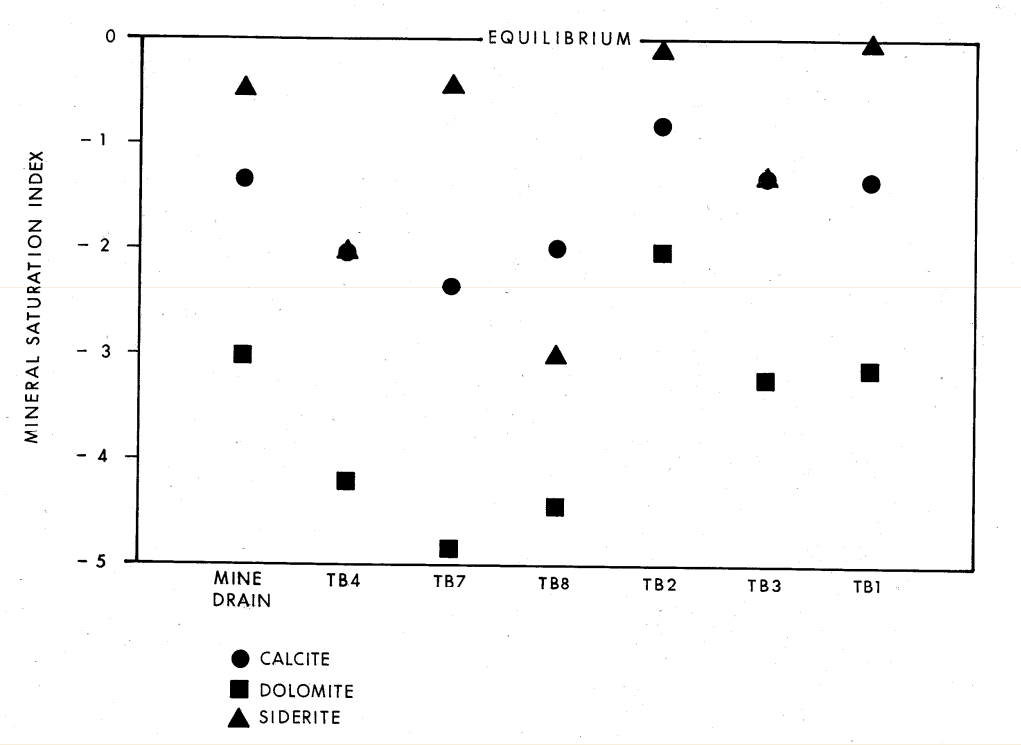

NORTH
SOUTH
20 FT
GLACIAL TILL
MIDDLE KITTANNING COAL
LOWER KITTANNING COAL
VANPORT LIMESTONE
CLARION COAL
BROOKVILLE COAL
800 FT
GLACIAL TILL
COAL
SANDSTONE AND SHALE
LIMESTONE

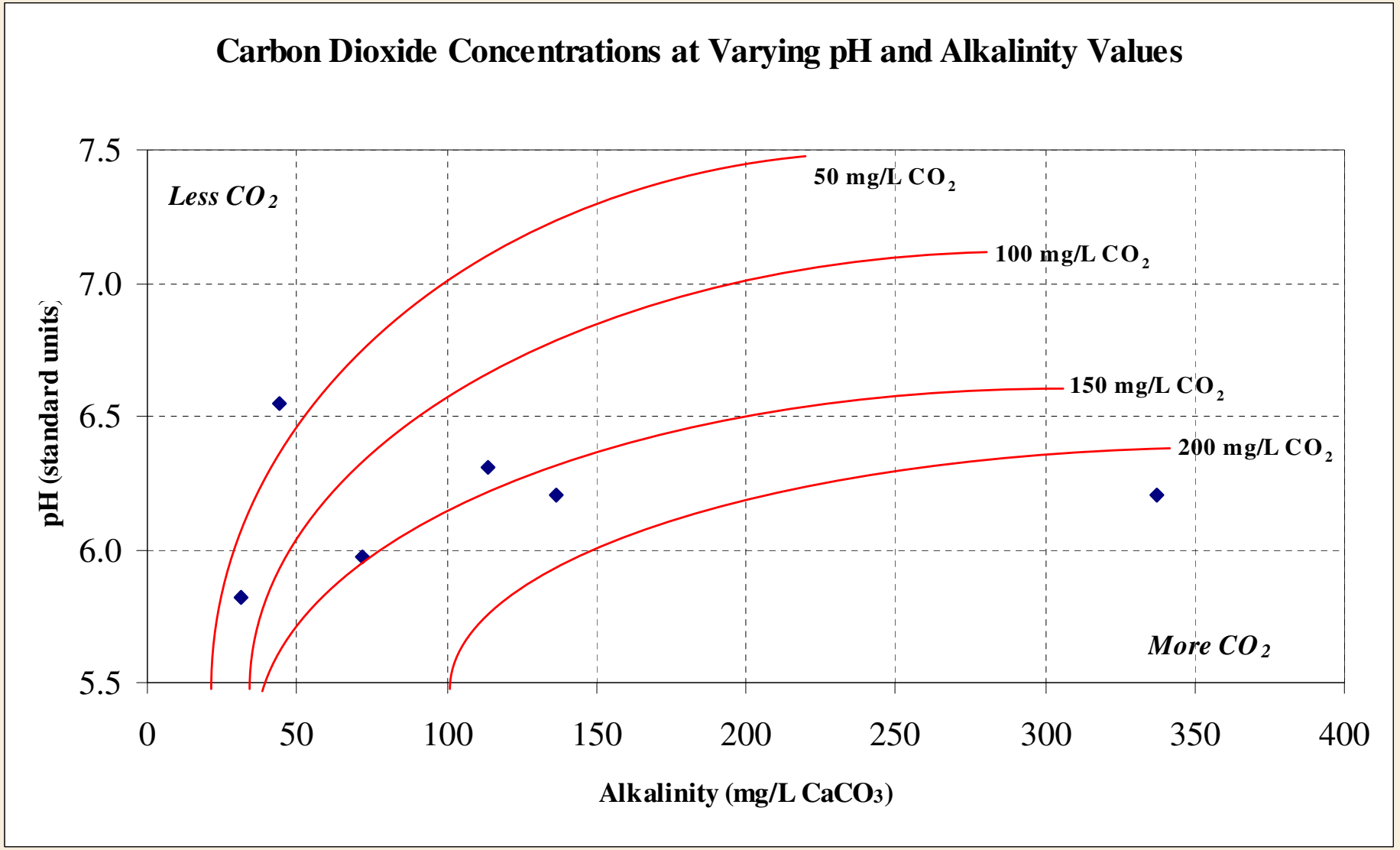
Carbonate Source?

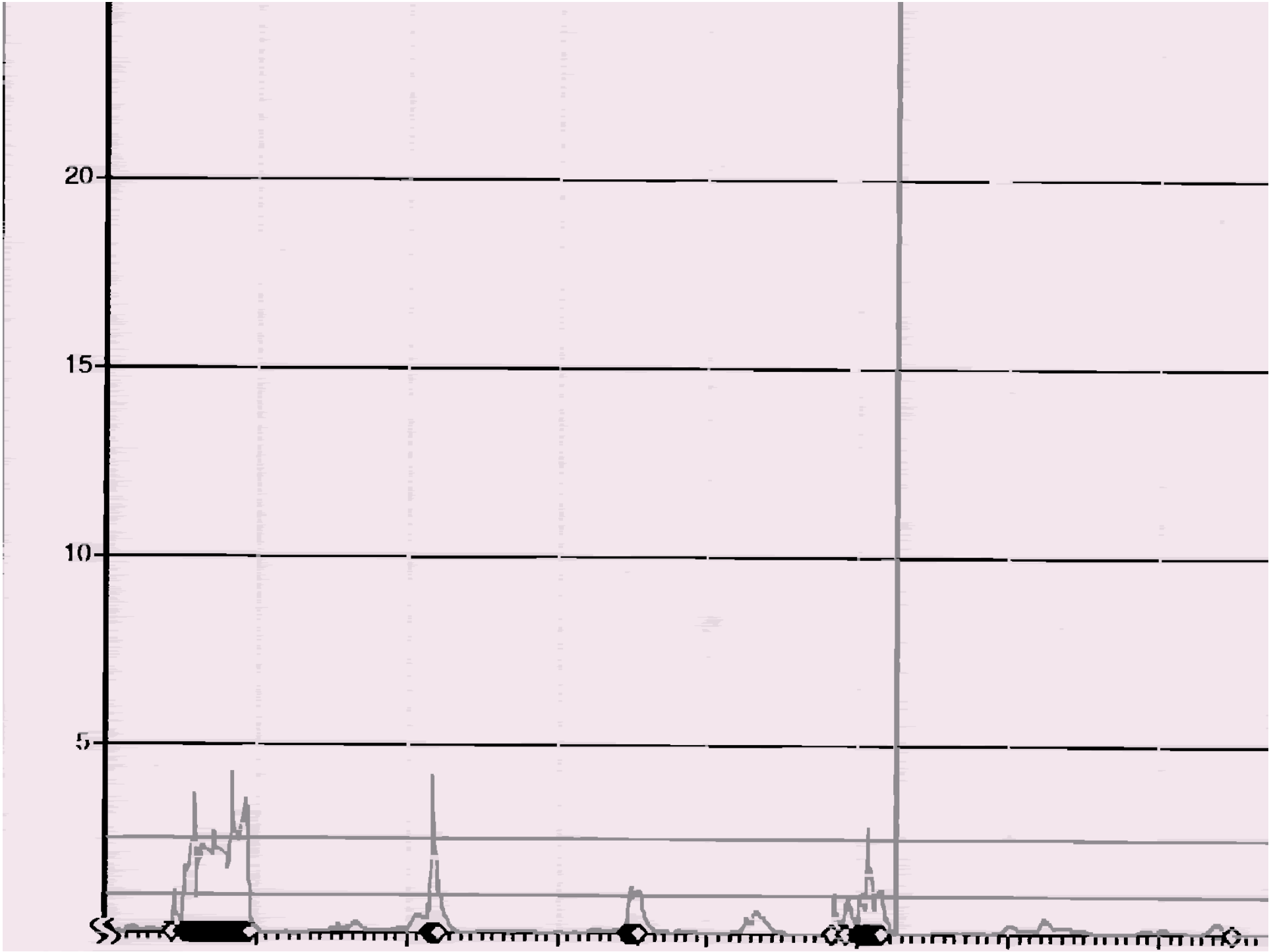
- No Vanport Limestone beneath the study area
- Other bedrock units lack carbonate minerals
- Glacial till contains 4 – 8% $CaCO_3$
- Glacial till was used as fill (high neutralization potential)

Groundwater Chemistry

- The groundwater onsite is under saturated with respect to calcite and dolomite. Groundwater can react with reported carbonate in the fill to produce the observed volumes of CO_2.
- **Alkalinity:** 31.36 – 136.84 mg/l
- **pH:** 5.82 – 6.55
- **PCO_2:** 0.01 – 0.2 atm; groundwater PCO_2 ranged from 0.5 - 0.2 atm during low barometric pressure events.
- Local pockets of tipple refuse in fill allow areas of more acidic water and enhance carbonate dissolution.




Carbon Dioxide Concentrations at Varying pH and Alkalinity Values
7.5
7.0
6.5
6.0
5.5
pH (standard units)
Less CO2
50 mg/L CO2
100 mg/L CO2
150 mg/L CO2
200 mg/L CO2
More CO2
0
50
100
150
200
250
300
350
400
Alkalinity (mg/L CaCO3)


20
15
10
5

Conclusions

- In Lawrence County, Pennsylvania, three homes near and on a reclaimed strip mine were contaminated with dangerous amounts of CO_2 (up to 25%) and correspondingly low levels of O_2 (as low as 10%).
- There was no evident association of the CO_2 contamination from underground mining.

Conclusions

- $\delta\,^{13}CO_2$ of gases collected from the homes and monitoring wells indicates a carbonate source.
- Groundwater at the site is under saturated with respect to calcite and dolomite and PCO_2 is adequate to produce the observed gas volumes.
- Glacial till used for strip mine fill contains enough carbonate to react with AMD from an abandoned deep mine to produce the observed volumes of CO_2.

Conclusions

- Remediation involved making the foundations as impermeable to gas as possible and installing a system to create positive pressure in the sub-base material (fresh atmosphere buffer between basement and CO_2.
- This one project cost taxpayers $120,000.
- Abatement is energy - consuming and this cost will be borne by the home owners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