

The release of dissolved inorganic carbon (DIC) and CO₂ from coal mine drainages

WVTF & IMWA Conference 2024

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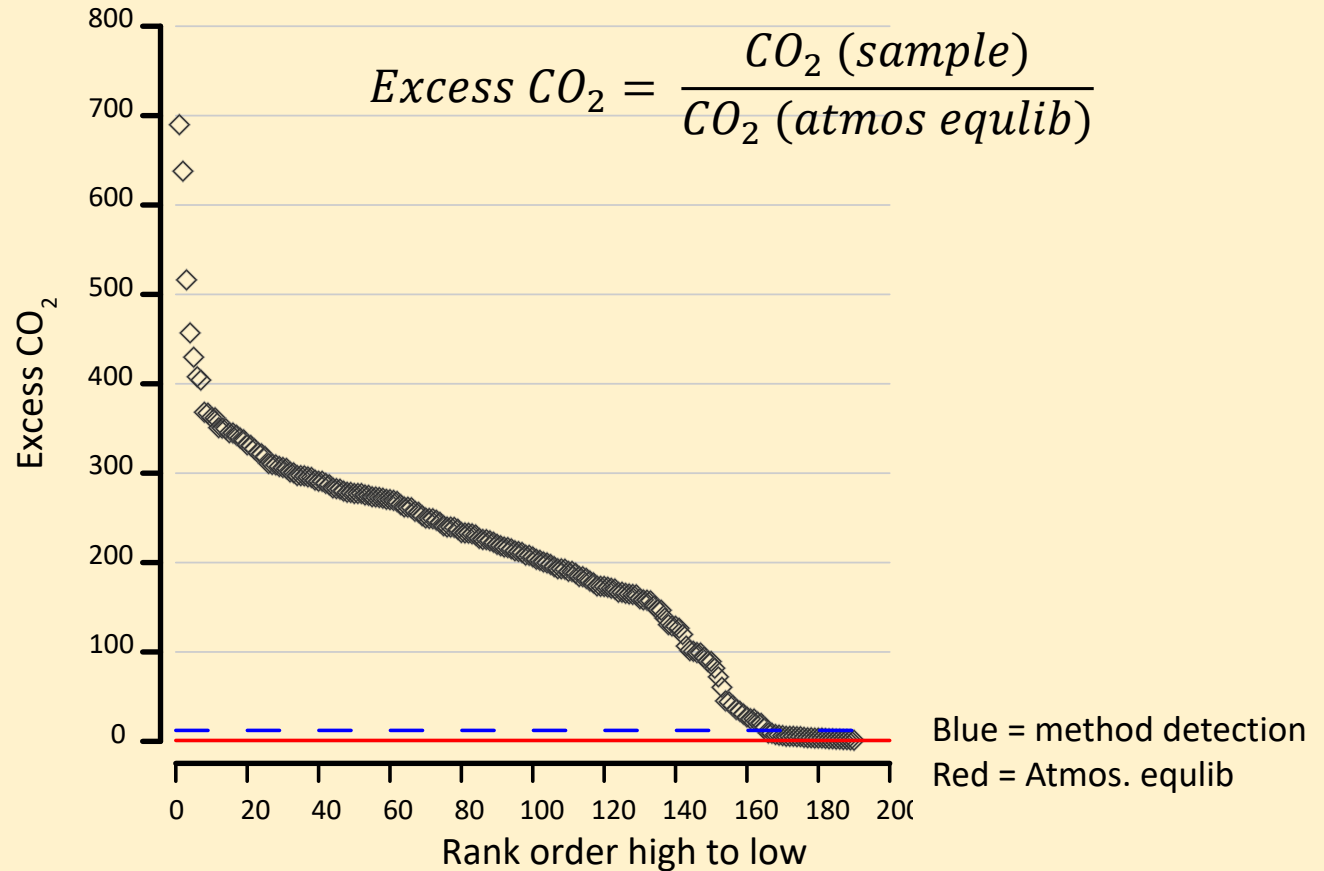


Acknowledgements

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- **UPITT:** the Office of Surface Mining Reclamation and Enforcement, Mine Drainage Technology Initiative (MDTI) program

First. The conclusion.

Data from 190 sites
in PA and WV
(2010 to 2024)

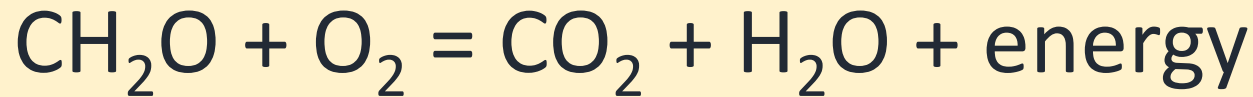


We've known about gasses in mines for a long time....

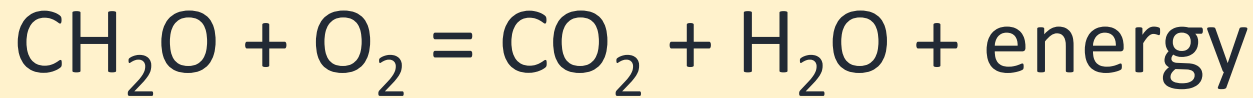


so why are we interested in this?

Carbon & fossil fuels: in the simplest reaction



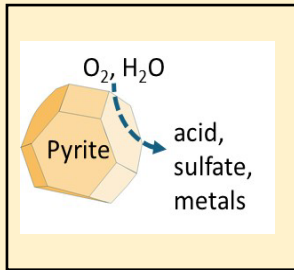
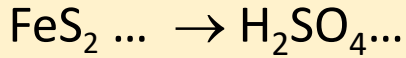
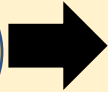
Carbon & fossil fuels: in the simplest reaction



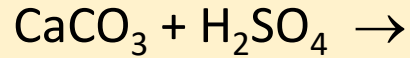
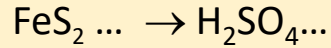
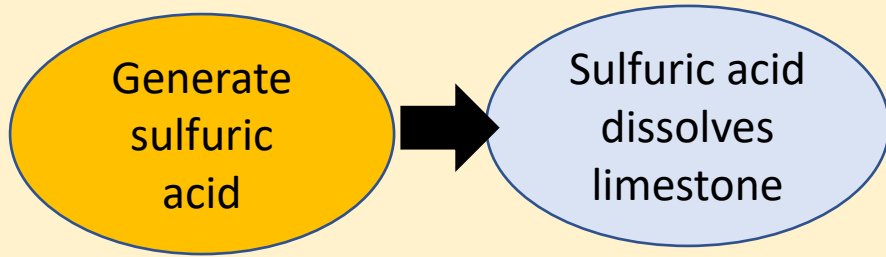
Combustion of fossil fuels, compost, lunch... 

But there's another pathway to generate CO₂ in the mine waters

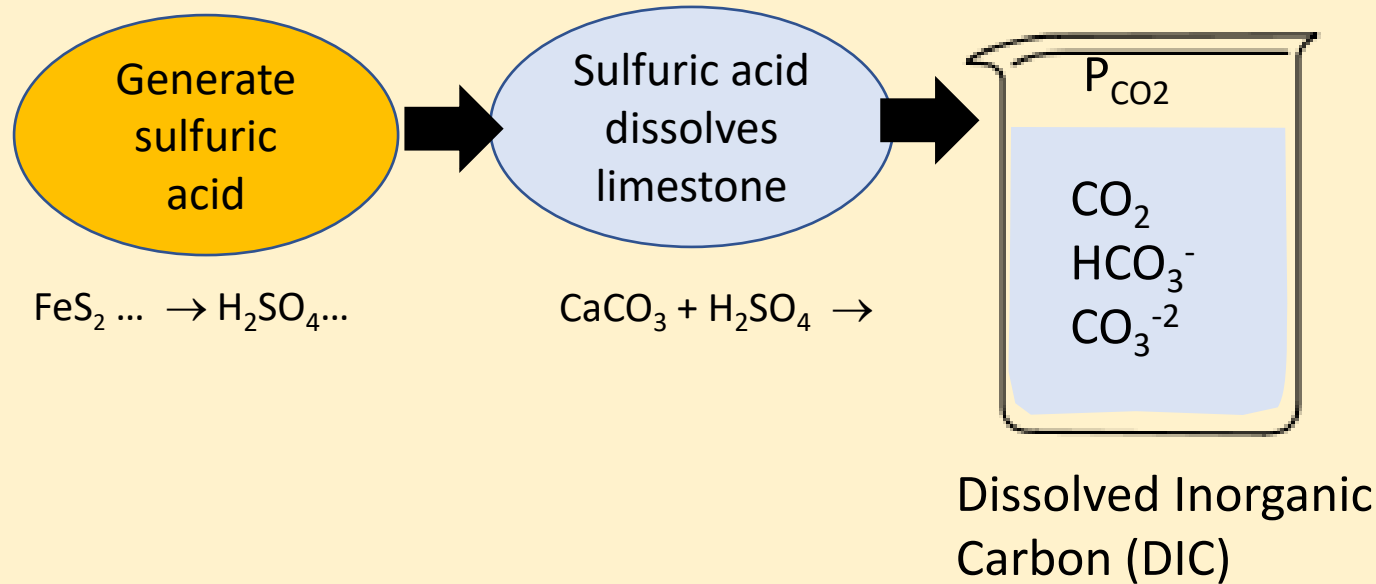
Generate
sulfuric
acid



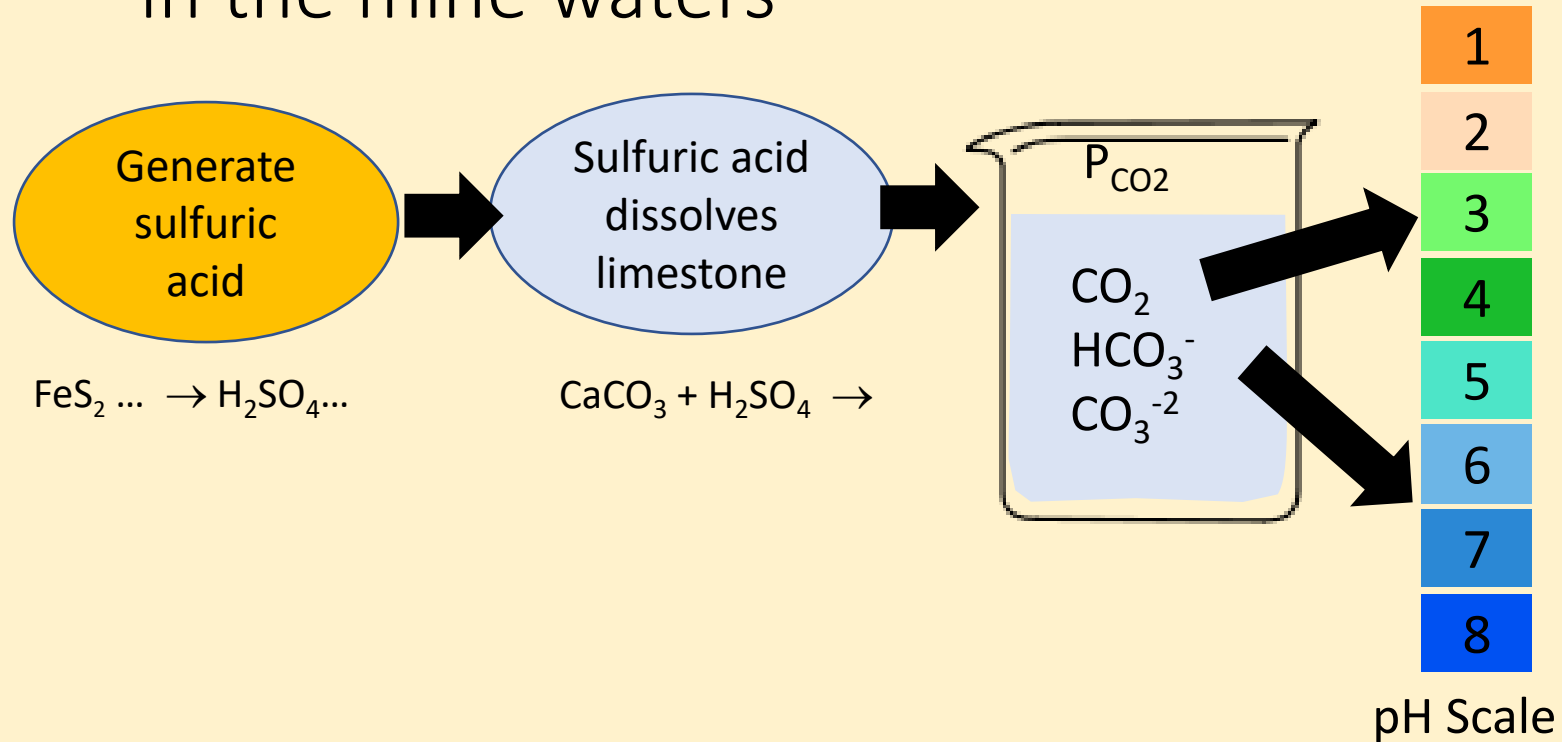
But there's another pathway to generate CO_2 in the mine waters



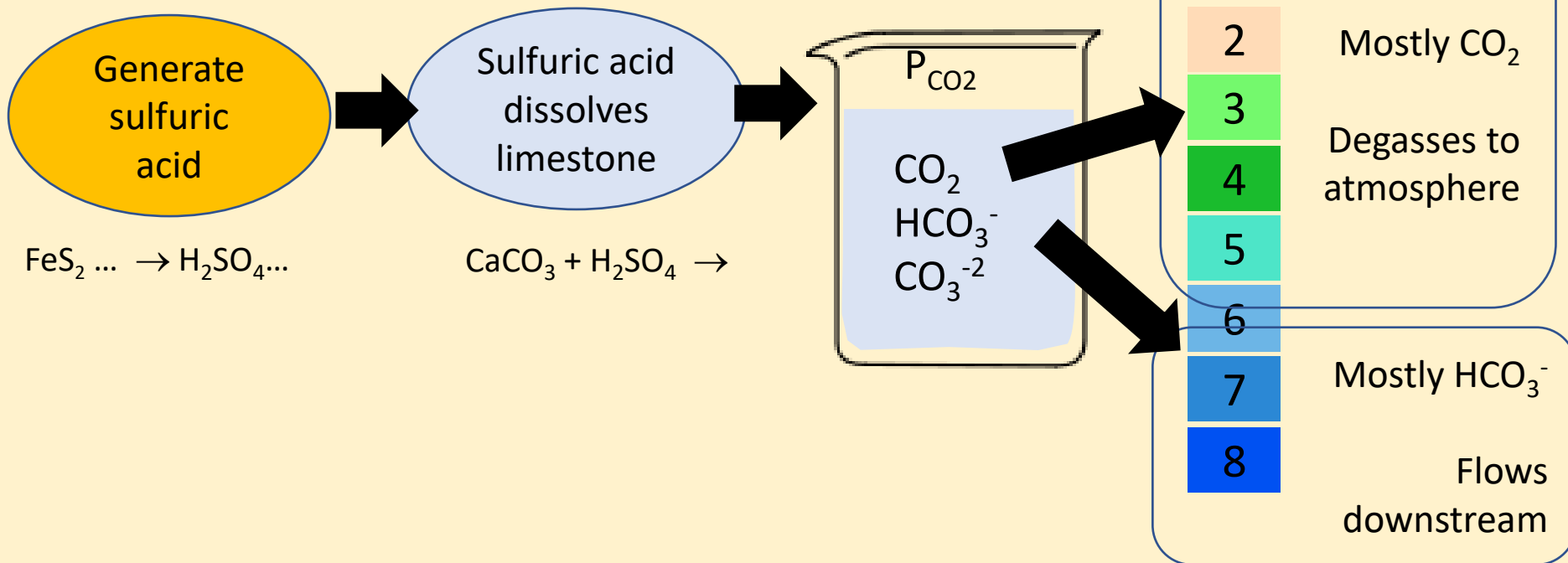
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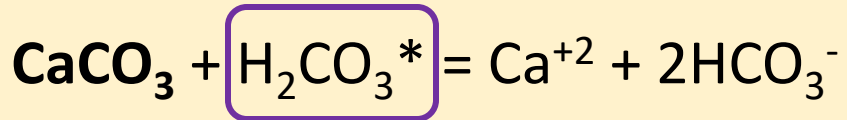


But there's another pathway to generate CO_2 in the mine waters



Why might we care about this CO₂ gas?

Most limestone dissolves because of carbonic acid:

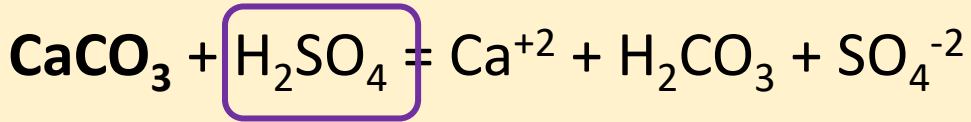


Young carbon

Old carbon

Why might we care about this CO₂ gas?

But when sulfuric acid is the driver, only old carbon is involved.



~~Young carbon~~

Old carbon

But... how we estimate CO_2 in mine waters doesn't always work.

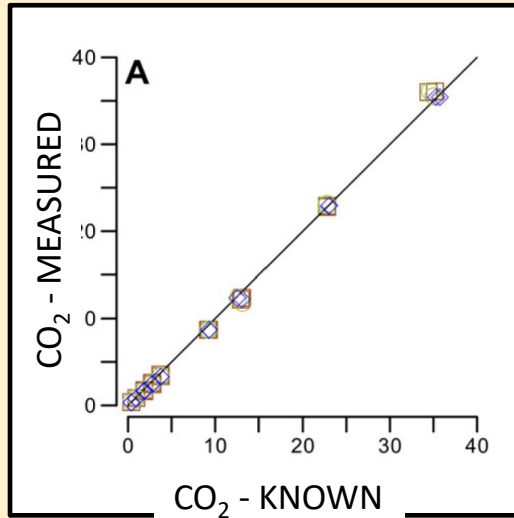
$$P_{\text{CO}_2} = \frac{a_{\text{H}} \boxed{a_{\text{HCO}_3}}}{(K_1 K_{\text{CO}_2})}$$

- Assumes that alkalinity is carbonate
- Samples must have measurable alkalinity
- DIC analyzers do not keep gas in
- Titrations can be challenging in chemically unstable waters



Anton Paar CarboQC Carbonation meter

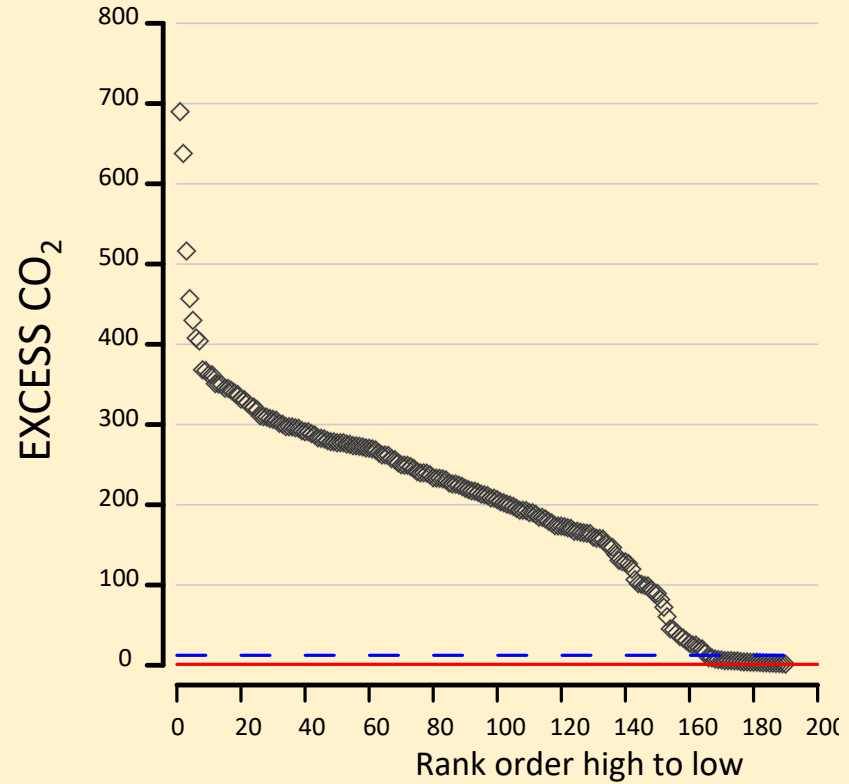
- Built for the soda & brewing industries
- CO₂ and DIC measured in field or in lab



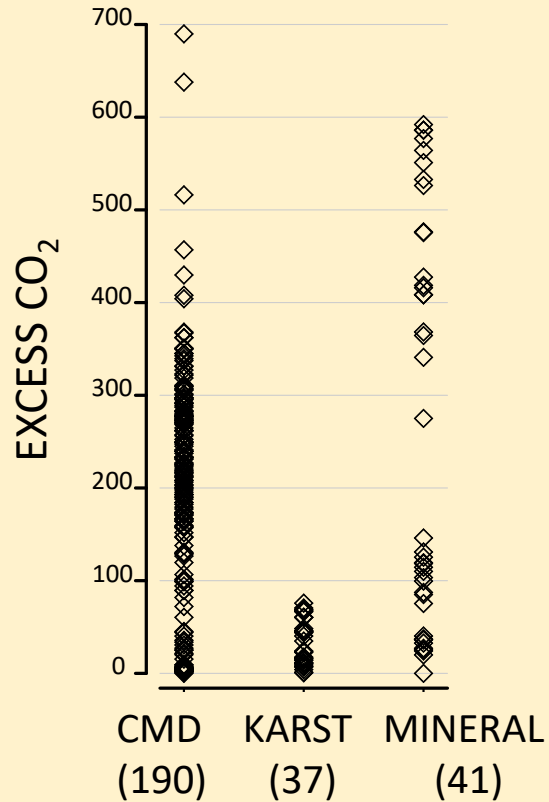
Vesper DJ, Edenborn HM (2012) Determination of free CO₂ in emergent groundwaters using a commercial beverage carbonation meter. *J Hydro* 438–439(0):148–155.

<https://doi.org/10.1016/j.jhydrol.2012.03.015>

Back to the data..
Is this a lot?



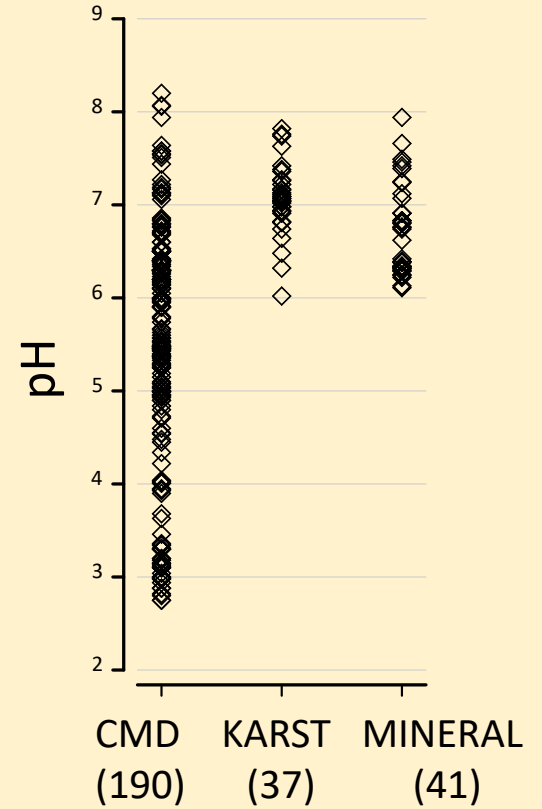
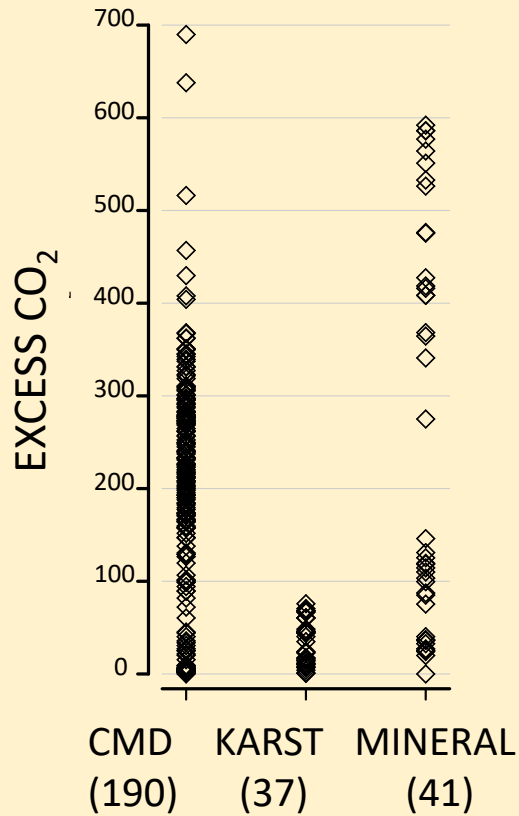
Compare with karst & mineral springs



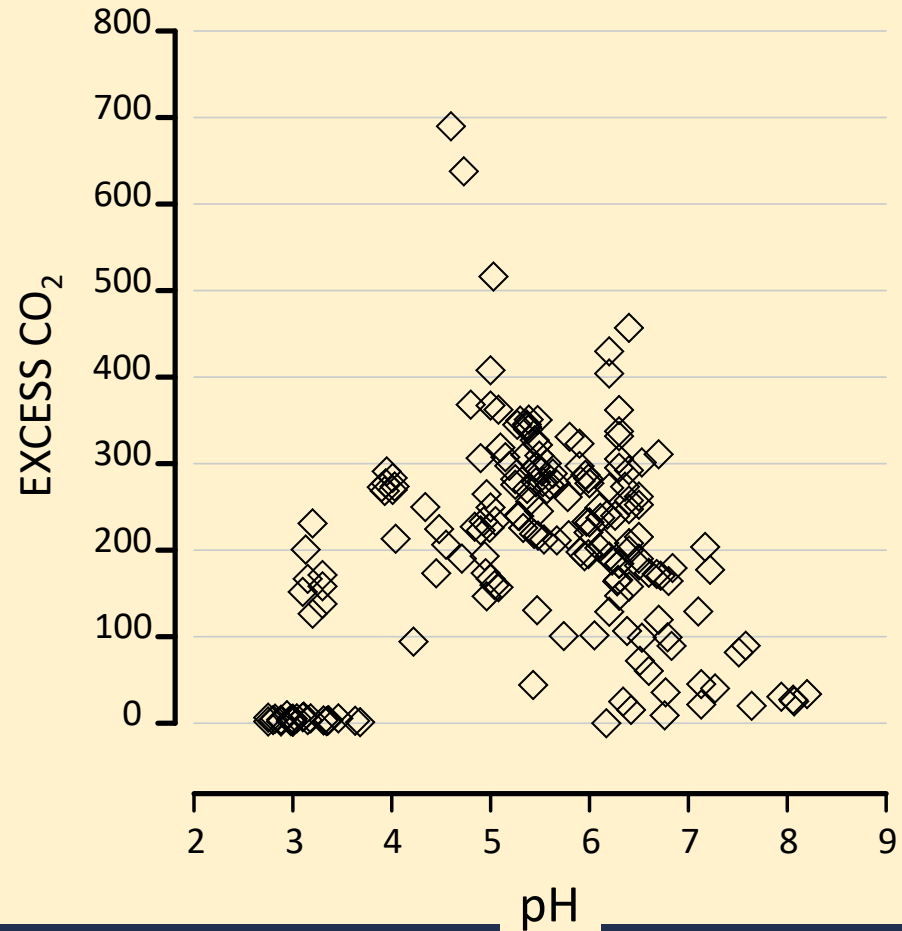
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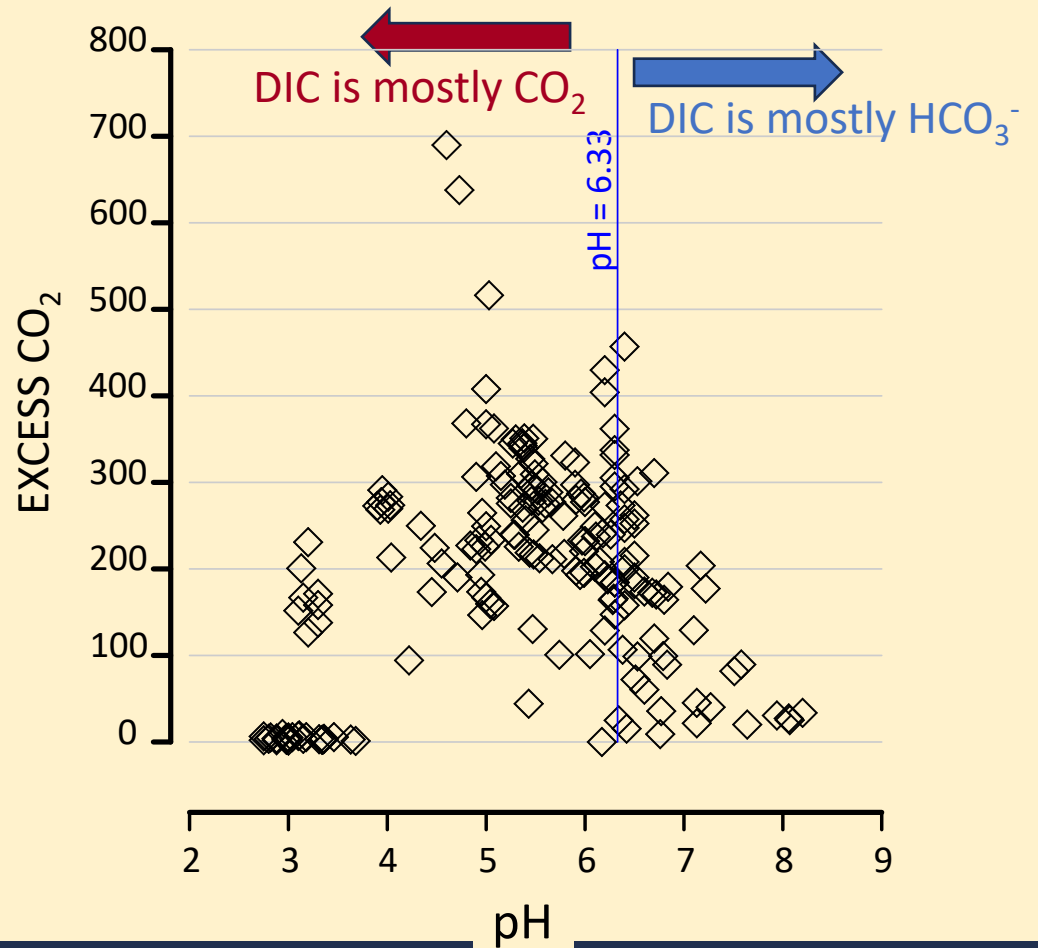
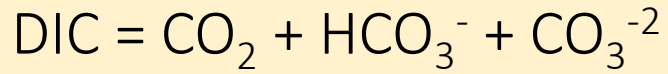
Old Sweet Spring, Monroe County, WV



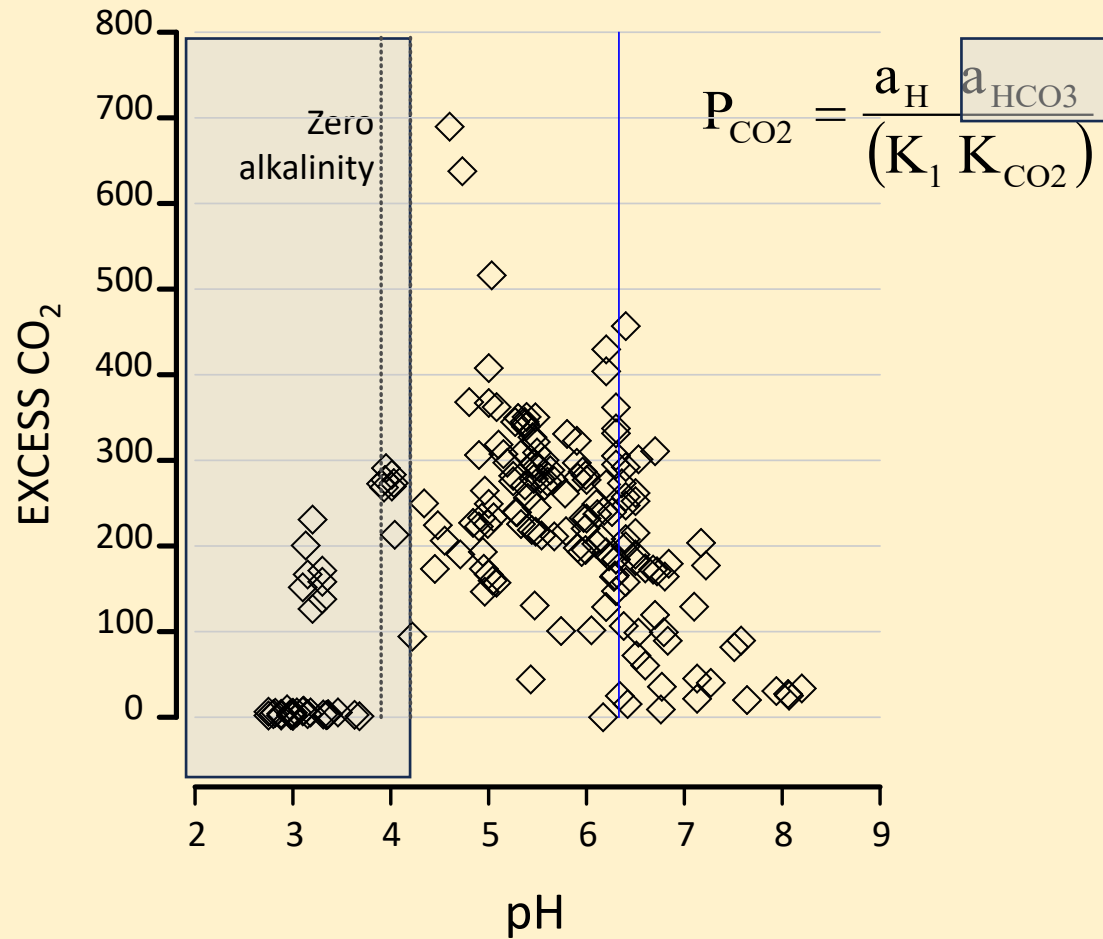
CO₂ can be present over a wide range of pH values



The species of DIC depends on the pH



At low pHs, no alkalinity exists, so P_{CO_2} can't be estimated from the bicarbonate. But there can still be CO_2 present.



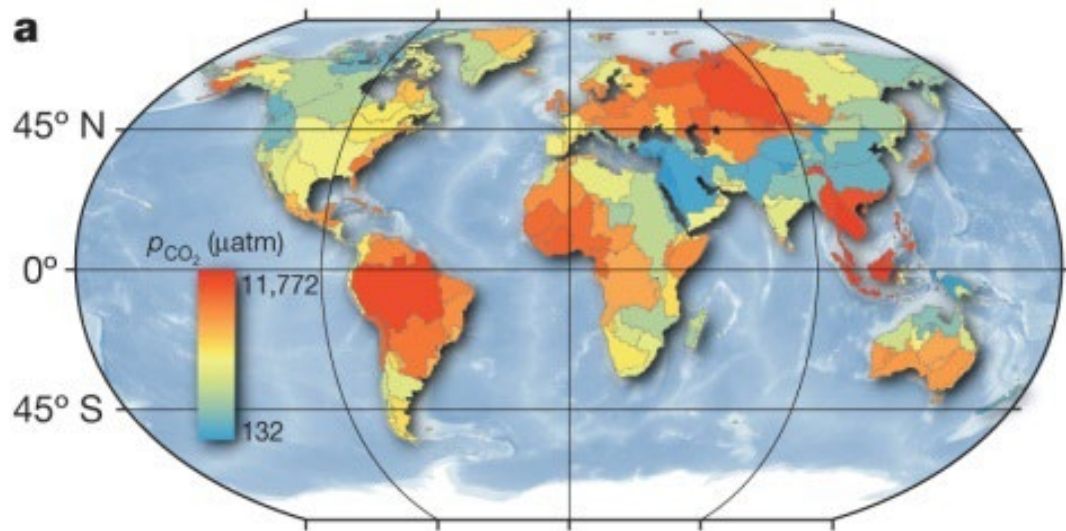
Is this important in the grander scheme of things?

CO₂ evasion – how much do mines contribute? And does that matter on a regional or global scale?

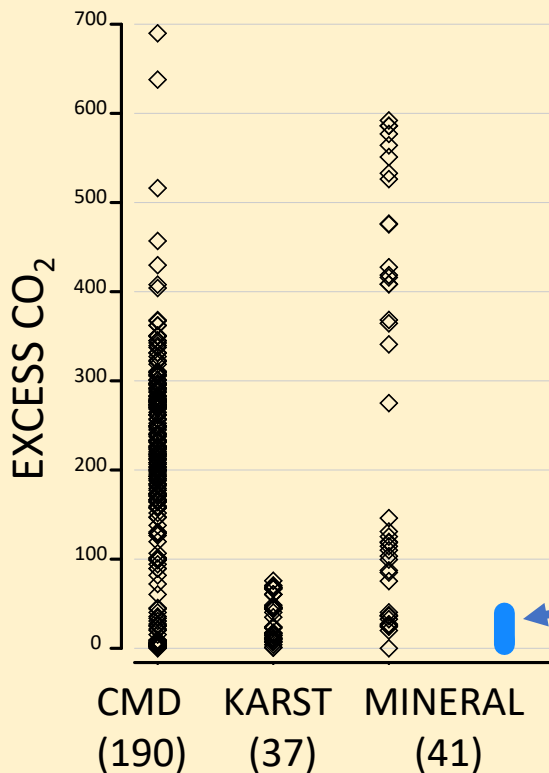
Our CO₂ numbers v. terrestrial freshwaters?

Raymond *et al.* (2013) *Nature* **503**: 355-359 doi:10.1038/nature12760

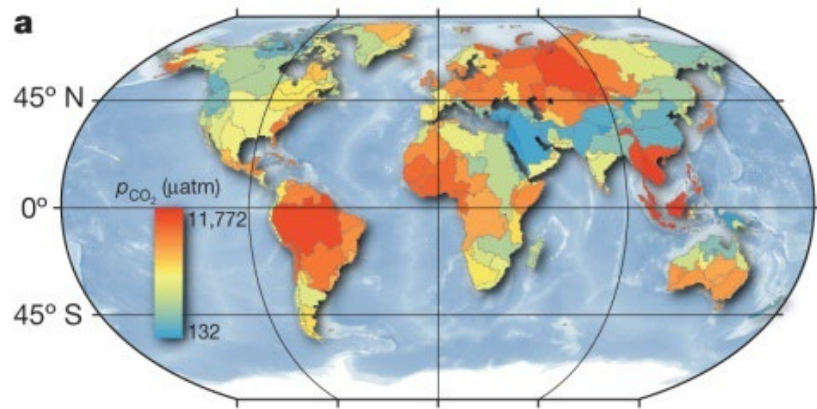
Global carbon dioxide emissions from inland waters



Our CO₂ numbers v. terrestrial freshwaters?



Raymond *et al.* (2013) *Nature* **503**: 355-359 doi:10.1038/nature12760

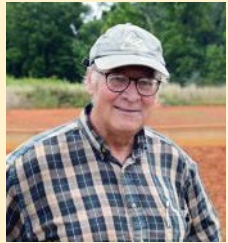


Is CMD important to CO₂ evasion? – *we don't even know if we are underestimating or overestimating the issue.*

- Number of mine discharges –chemistry & flow
- Low pH waters underrepresented in most datasets
- Non-point sources
- Degassing in mine or pipelines prior to discharge
- Seasonal & storm variability
- Do we degas to atmospheric levels

Is this important in the grander scheme of things?

- CO₂ evasion – how much do mines contribute? And does that matter on a regional or global scale?
- BUT... can we utilize the CO₂ for treatment?
 - Can we alter treatment systems to cut back on CO₂ evasion... dissolving more limestone... and even gain alkalinity?



Dr. Bob
Hedin

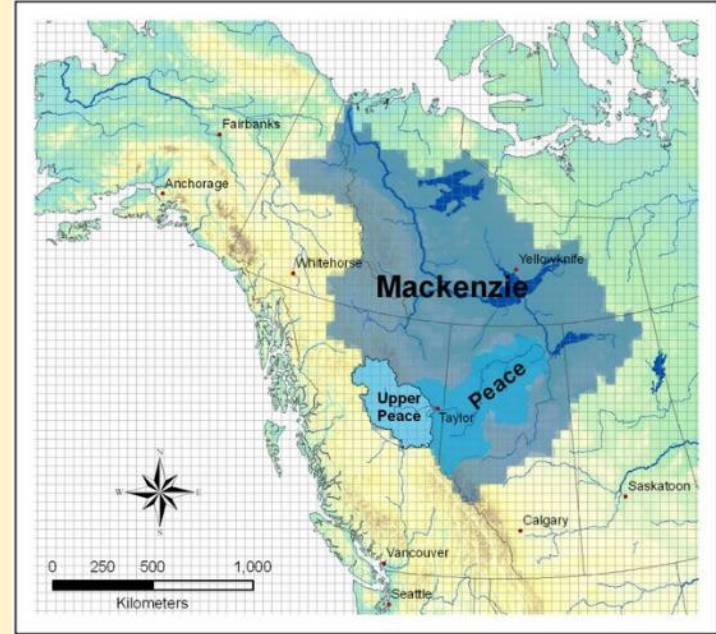
Top 3 take-away points

- Many mine waters have high concentrations of DIC which either degases (low pH) or is exported offsite as dissolved alkalinity
- CMD may be important in understanding terrestrial water CO₂ evasion (but we don't know for sure)
- Maybe the CO₂ can be harnessed in the CMD treatment process

The bigger picture – beyond mine waters



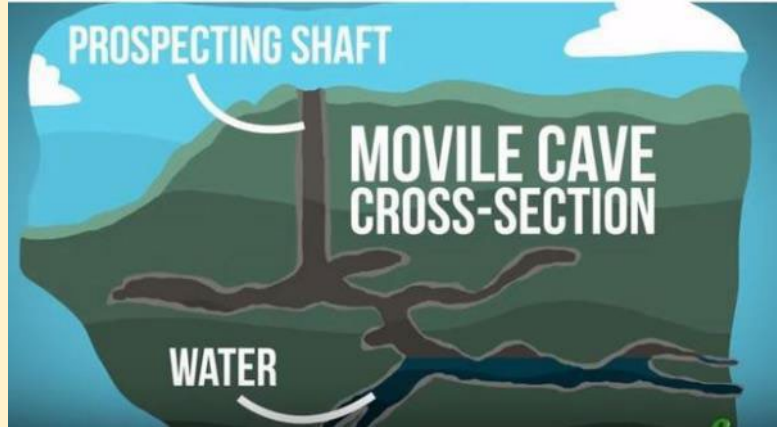
<https://wnpa.org/the-history-of-carlsbad-caverns-national-park/>



https://www.researchgate.net/publication/279532512_Climate_Diagnostics_of_Future_Water_Resources_in_BC_Watersheds/figures?lo=1

The bigger picture – beyond mine waters

1986.. Romania



Isolated for > 5 million years

Has more than 33 endemic species



Thanks for listening.



Frasassi Cave Italy

<https://www.hoteltermedifrasassi.it/en/discover-the-frasassi-caves.php>