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Relating Recharge Mechanisms to Dissolved Inorganic Carbon Dynamics in an Updip Appalachian Coal Mine Discharge

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A Background & Study Rationale

Coal mine drainage (CMD) has been well studied throughout space and time, including the evolution of drainage chemistry over multiple years (Donovan et al., 2003), seasons (Kim and Kim, 2004; Burrows et al., 2015), and hours (Nimick et al., 2003; Gammons et al., 2005; Vesper and Smilley, 2010).

In addition to metals and acidity, CMD outflows export dissolved inorganic carbon (DIC) to receiving waterways. The export of DIC can be rapid relative to global carbon cycles if CO_2 is directly degassed to the atmosphere rather than transported to the ocean and eventually degassed. Widespread estimation of DIC from CMD outflows is difficult to constrain due to the large number of outflows in mined regions (Cravotta, 2008) and challenges accounting for CO_2 at low pH outflows and alkalinity measurements at high pH (Cravotta et al., 1999).

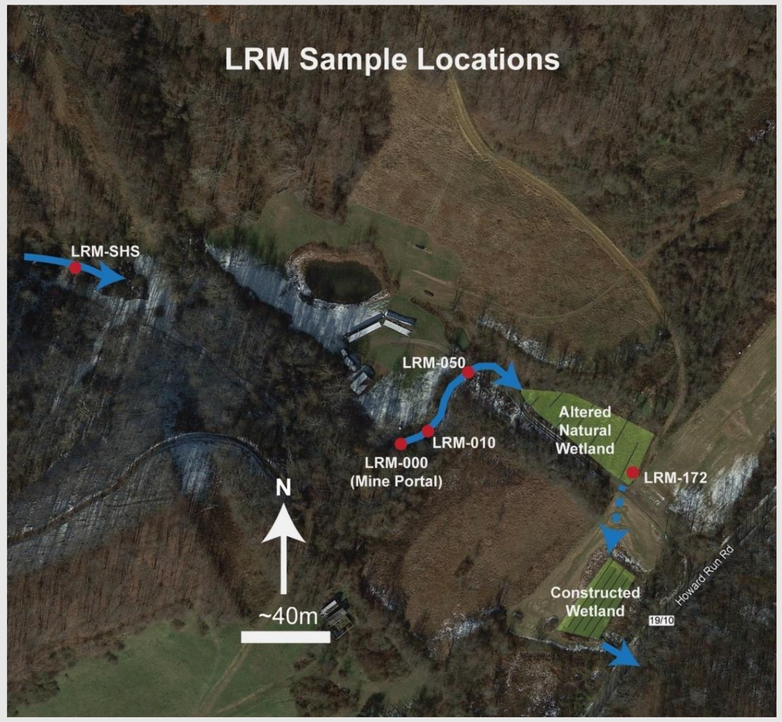
Literature addressing CO_2 emission from coal mine systems has comparatively few studies that directly measure CO_2 concentrations at the point of discharge (Raymond and Oh, 2009; Fox and Campbell, 2010; Vesper et al., 2016; Ross et al., 2018), even fewer address impacts of low pH outflows with excess CO_2 to contribute carbon on geologically rapid timescales.

Although this study does not attempt to extrapolate carbon flux to a global scale, it does demonstrate a case that should be considered further in global carbon balances.

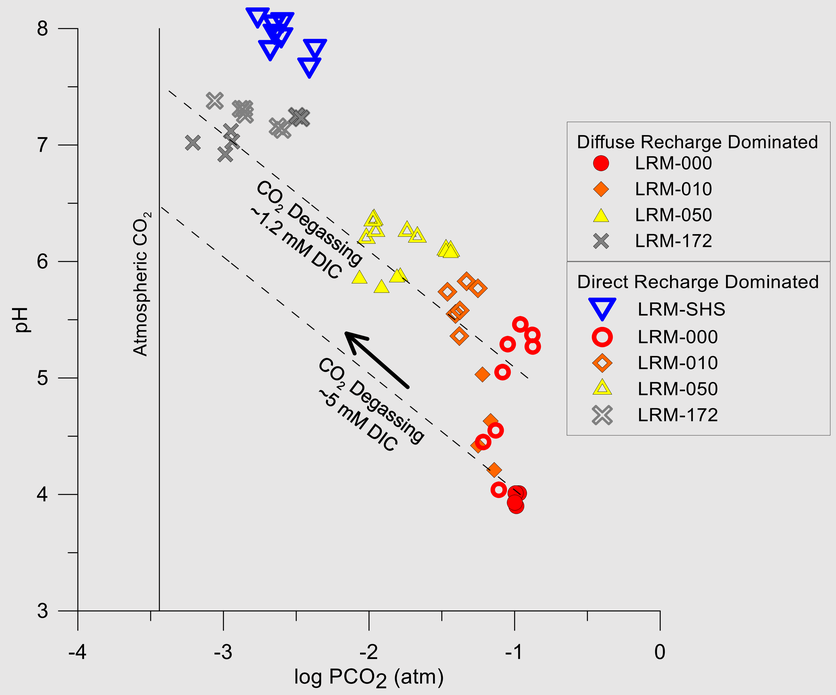
B Methods

To evaluate the variability of the DIC system relative to recharge mechanism, samples were collected along a passive treatment system flowpath (LRM) draining to Lambert Run in Harrison County, WV. The mine system was observed to have two distinct recharge mechanisms supplying water to the mine (a) direct recharge through a sinkhole feature (LRM-SHS sampling site) and (b) diffuse recharge through primary & fracture porosity.

DIC & CO_2 concentration, field parameters, cations and anions were measured every two weeks at the selected sampling locations. Sample dates were classified based on the dominant type of recharge entering the mine (diffuse vs direct).



Sample Location Code	Distance from Mine Portal	Location Description
LRM-SHS	N/A	Stream entering mine through swallow hole
LRM-000	0 m	Mine portal, samples collected at discharge pipe
LRM-010	10 m	Within limestone-lined channel
LRM-050	50 m	End of limestone-lined channel
LRM-172	172 m	End of altered natural wetland



C Results

Recharge Mechanism Trends

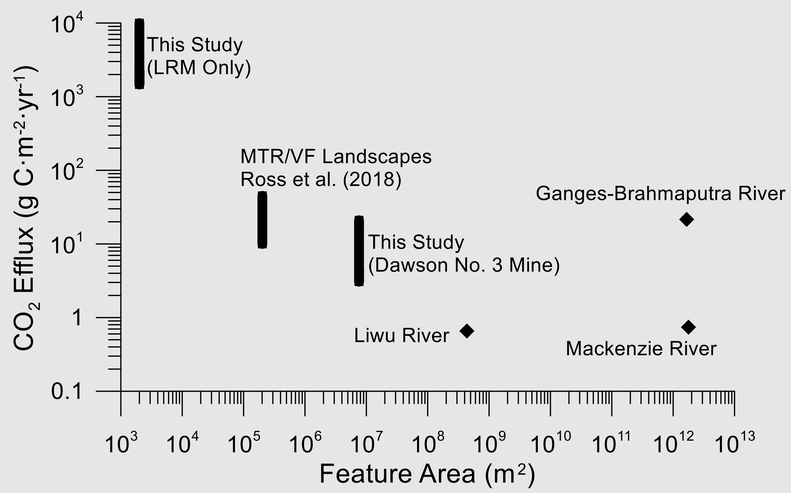
- Direct recharge = high pH, low SC water entering mine, causes higher pH at mine portal
  - Log PCO_2 vs pH approximates degassing trend (see figure to left)
- Diffuse recharge = lower pH at mine portal, more undersaturated with respect to calcite
  - Limestone dissolution evident within 10m of portal, then degassing

Trends along System Flowpath

- In mine, [DIC], [Ca2+] and [Mg2+] increase
- On average, 89% of DIC degassed as CO_2 before end of passive treatment system
  - Est. 23.2 metric tons CO_2/yr

D Conclusions

- Updip Appalachian coal mine discharges can produce similar CO_2 efflux as mountain top removal/valley fill mine operations (Ross et al., 2018) with a potential larger contributing area
- Scale is incredibly important when comparing areal CO_2 export estimates
  - i.e. LRM outflow export compared to entire Dawson mine workings export (highlighted in orange)
- Additional study can help constrain the contribution of abandoned coal mine drainage DIC to global carbon balances



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