Greenhouse Gas Removal Through Steel Slag Waste

-Romit Aggarwal (200470016); Newcastle University, Newcastle Upon Tyne, NE1 7RU

Newcastle University

AIM

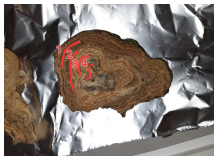
To observe the layers of calcium carbonate deposited in Howden Burn (H.B.) and identify variability in layering which could indicate variation in depositional conditions where the Consett Steel factory's steel slag waste was dumped.

Fig 1 (above right): OS map of Consett, Country Durham, England, from Digimap. The location of the field sampling site is Howden Burn (H.B.) – a tributary of the River Derwent – the red circle pointed to by a black arrow. Carbonate deposit is prevalent as semi-soft white substance seen at the surface.

METHODS

- Field Sampling from H.B. (Fig 1), Consett; extracting deposit from H.B. and a Stalactite from along H.B.
- Acid etching using 1.0 M HCL of samples done for physical observations under Stereomicroscope.
- Samples dried in furnace (used for Loss of Ignition – LOI – analysis) then powdered using mortar and pestle for XRD analysis.

Samples from – Howden Burn deposit (top left); Stalactite (right) found along H.B. site (1-4 indicating samples ST1-ST4).



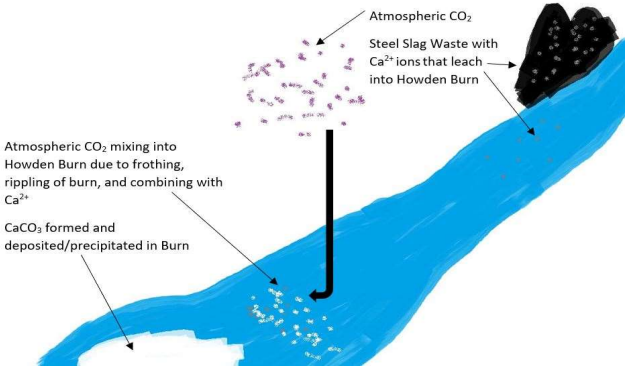


Fig 2 (above): Principle process for the formation of calcium carbonate in H.B., following the chemical reaction > Ca^{2+} (aq) + $2OH^-$ (aq) + CO_2 (g) ↔ Ca^{2+} (aq) + CO_3^{2-} (aq) + H_2O (l) ↔ $CaCO_3$ (s)+ H_2O (l)

RESULTS

- XRD patterns confirming major crystal composition to be Calcite (highest peak in graph being between 29.2*-29.5* for each layer) with varying traces of organic matter (Fig 3).

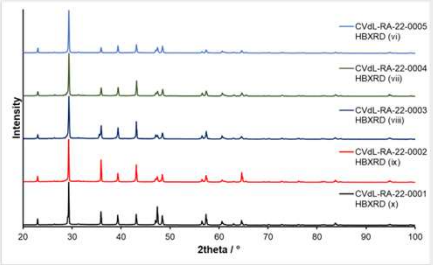


Fig 3: XRD graph of samples HBXRD (vi-x)

- Layers with relatively low calcite content have relatively higher weight loss % from LOI (Fig 5. (a) & (b) - HBXRD (iii),(iv),(v) for e.g.).
- Layers with relatively low calcite content appear to have higher organic matter content based off stereomicroscope analysis.

DISCUSSION

- A correlation between water content and organic matter content in certain layers of calcite to the proportion of calcite present is seen.
- Calcite variations similar to blocky, cluster shaped calcite, and clotted micrite visible + possible microbial rims (thin brown layers) – indicating variations in deposition conditions [1,2,3,5].
- Higher calcite content indicates higher energy water flow – to leach more Ca^{2+} from steel waste heaps + churn more CO_2 from atmosphere into water [5].
- Higher organic matter layers show periods of less water flow and more biological activity from surrounding ecology [3].
- Various calcite forms found at other sites in and around Consett possess different crystal growth rates, potentially indicating variability in deposition [2,4,5].

CONCLUSION

Variations in calcite layers indicate different depositional conditions on site, which could be associated with weather or climate cycles to produce a timeline of deposition, opening avenues for studies in carbon sequestration.

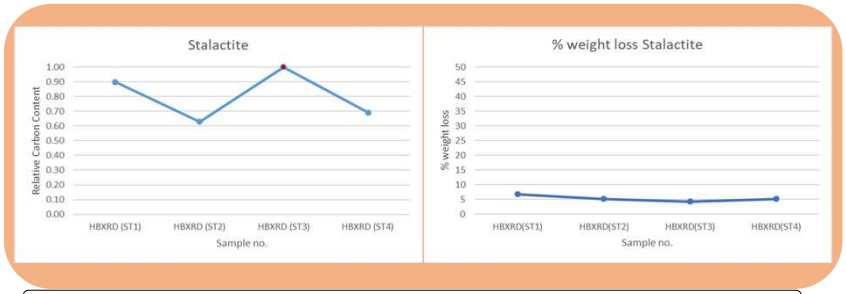


Fig 4: Stalactite (a - left) Relative Calcite content XRD; (b - right) % weight loss from LOI.

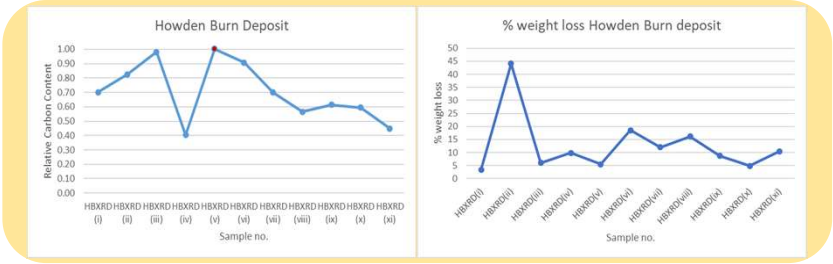


Fig 5: H.B. deposit (a - left) Relative Calcite content XRD; (b - right) % weight loss from LOI.

REFERENCES

1) Bastianini, L., Rogerson, M., Mercedes-Martin, R., Prior, T.J., Cesar, E.A. & Mayes, W.M. (2019) What Causes Carbonates to Form "Shrubby" Morphologies? An Anthropocene Limestone Case Study. *Frontiers in Earth Science*, **7(236)**. DOI: https://doi.org/10.3389/feart.2019.00236
2) Bastianini, L., Rogerson, M., Mercedes-Martin, R., Prior, T.J. & Mayes, W.M. (2021) What are the Different Styles of Calcite Precipitation within a Hyperalkaline Leachate? A Sedimentological Anthropocene Case Study. *The Depositional Record*, **00**, pp. 1-27. DOI: https://doi.org/10.1002/dep2.168
3) Dupraz, C., Reid, R.P., Braissant, O., Decho, A.W., Norman, R.S. & Visscher, P.T. (2009) Processes of Carbonate Precipitation in Modern Microbial Mats. *Earth Science Reviews*, **96**, pp. 141-162. DOI: http://dx.doi.org/10.1016/j.earscirev.2008.10.005
4) Mayes, W.M., Younger, P.L. & Aumonier, J. (2006) Buffering of Alkaline Steel Slag Leachate Across a Natural Wetland. *Environmental Science & Technology*, **40**, pp. 1237-1243. DOI: http://dx.doi.org/10.1021/es051304u
5) Mayes, W.M., Riley, A.L., Gomes, H.I., Brabham, P., Hamlyn, J., Pullin, H. & Renforth, P. (2018) Atmospheric CO_2 Sequestration in Iron and Steel Slag: Consett, Country Durham, United Kingdom. *Environmental Science & Technology*, **52**, pp. 7892-7900. DOI: http://dx.doi.org/10.1021/acs.est.8b01883