PRECIPITATION OF OCHRES FROM ACID MINE DRAINAGE TREATMENT: a computational and experimental approach

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Introduction

Neutralisation of acid mine drainage (AMD) results in the formation of high density sludge (HDS) which is usually discharged onto landfills with little repurposing, thus resulting in environmental challenges. In this study, neutralising agents such as NaOH, $CaCO_3$, and $MgCO_3$ were used to obtain selective precipitation of ochres from AMD. This way, formation of a bulky HDS is avoided so as to obtain potentially valuable precipitates. The study approach involved establishing an experimental design and parameter optimisation using geochemical modeling. Simulations of the neutralisation process were conducted using the PHREEQC geochemical modeling code. In the simulations, AMD and varying amounts of different neutralising agents were used as input while the output was the different Fe precipitates (ochres) and treated water. Selected simulations used to conduct the experimental studies were based on the yield of precipitated ochres and the chemistry of the treated water.

Aim

To precipitate ochres from AMD and assess their potential as pigments in paints and artwork.

Methods

Geochemical modelling approach

- Using PHREEQC (Phreeqc.dat database), the AMD's speciation and solubility was assessed and neutralisation of the affected water using a variety of neutralising agents was simulated, with precipitation of ochres.
- In these simulations, different parameters with different neutralising agents were assessed: varying pH values, equilibration with gases such as CO_2 and O_2 and varying temperatures.
- PHREEQC was also used for batch calculations that can be reacted or equilibrated with a gas (e.g., O_2 for fugacity).

```
TITLE RAW AMD WATER
SOLUTION 1
Temp      25
pH        2.8
pe        4
redox     pe
units     mg/l
density   1
Al        472.5
Ca        470
Cd        0.01
Fe        6051.3
K         1
Mg        0.03
Mn        125.9
S(6)      18000
Si        30
Zn        0.2
-water    1 # kg
```

```
Addition of neutralizing agent
REACTION 1
CaCO3     4
4 moles in 10 steps
END
```

```
Equilibration with O2
REACTION 1
MgO         4
NH4OH       4
4 moles in 10 steps
```

```
EQUILIBRIUM_PHASES 1
O2(g)       -0.5  8
END
```

```
Equilibration with CO2
REACTION 1
MgO         4
NH4OH       4
2 moles in 10 steps
```

```
EQUILIBRIUM_PHASES 1
CO2(g)      -2.0  8
END
```

```
Addition of neutralizing agent
REACTION 1
MgCO3       4
4 moles in 10 steps
END
```

```
Addition of neutralizing agent
REACTION 1
NaOH        4
4 moles in 10 steps
END
```

```
Combined neutralizing agent
REACTION 1
MgCO3       4
NaOH        4
4 moles in 10 steps
END
```

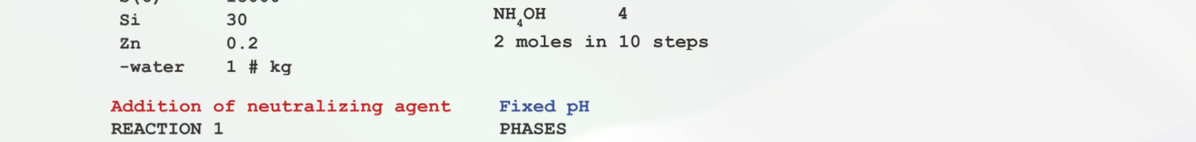
```
Fixed pH
PHASES
Fix_H+
H+=H+
log_k       0

EQUILIBRIUM_PHASES 1
Fix_H+      -9.0 MgCO3        10
END
```

Script for computational simulation of AMD neutralisation

Experimental approach

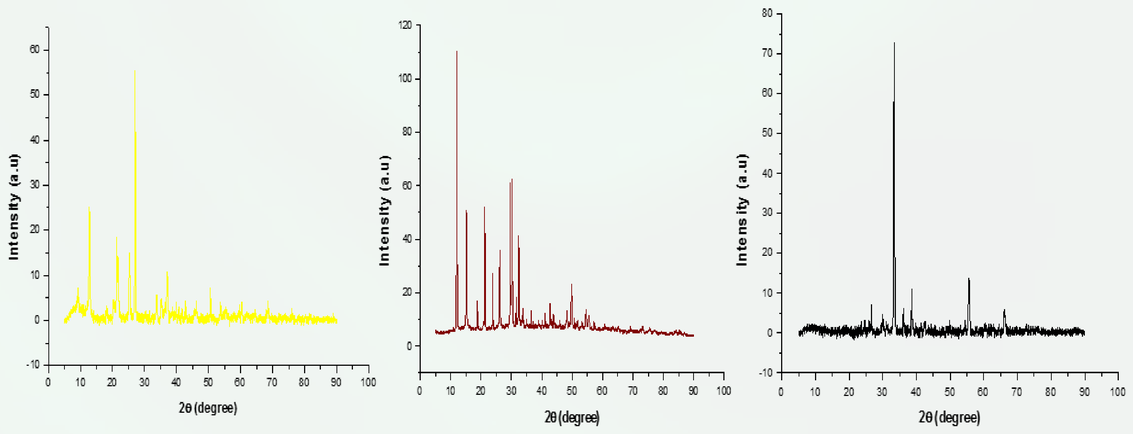
- Acid mine drainage (AMD) was collected in the Central Rand basin in Witwatersrand goldfields.
- Neutralising agents include NaOH, and $MgCO_3$ were used.
- Different pH values (pH 3 – 9) at 25°C.
- A stepwise selective precipitation mechanism was applied to assess the effect of parameters such as oxidation, pH adjustment, settlement rates and temperature (experiments conducted at room temperature).



Results

Ochres recovered from AMD

The pH values for precipitation was adjusted from pH 3 to 9. Filtered precipitates at 25 °C, Dried at 180 °C for 1 h, ground with pestle and mortar after drying.



X-ray diffractograms (from left to right) of the yellow (goethite), reddish-brown (hematite) and black precipitate (magnetite).

Art paintings from Fe precipitates recovered from AMD

Conclusions

- This study explored the possibility of beneficiating the AMD treatment process by forming Fe precipitates or ochres that can be useful for paint and artwork applications.
- Using conditions established in computational simulations, NaOH and $MgCO_3$ were found to be the best choices for neutralisation of AMD with the aim of precipitating desired ochres.
- Thus, the study has demonstrated that the treatment of AMD can enable more value to be derived in the form of treated water and precipitation of useful ochres.

References

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