Objective 1

Geochemistry

James Pope, Dave Craw, Tim Mulliner & Laura Haffert
Scope

Objective 1
1. Aims
2. Approach
3. Introduction to mine drainage chemistry
4. Summary of West Coast work
5. Preliminary results from Southland
6. A look forward
1 Aims

• Identification of the risks to water quality posed by mining in different areas
  – Targeted outcomes
    • Assessment of geological and other risks
      – Construction of risk module
      – Minimum analytical suite for impact assessment
    • Identification of factors that influence mine drainage chemistry
    • Assessment of our predictive ability
2 Approach

• Data compilation
  – DAME - Database for Assessment of Mine Environments
    • Water quality – many sources, many parameters
    • Rock geochemistry
    • Sediment geochemistry

• GIS Integration
  • Geology
  • Topography – Land use information
  • GERM

• Split into Coal and Gold mine drainage
Water Quality sites in Southland
3 Mine Drainage Chemistry

• Highly variable
  – AMD, NMD, trace element enrichment

• Processes
  – Pyrite oxidation
    • FeS$_2$ + 3.75O$_2$ + 3.5H$_2$O = 2SO$_4^{2-}$ + 4H$^+$ + Fe(OH)$_3$
    • At Low pH Fe$^{3+}$ is an oxidant
  – Other sulphide oxidation
    • ZnS + 2O$_2$ = Zn$^{2+}$ + SO$_4^{2-}$
    • FeAsS + 3.5O$_2$ + H$_2$O = Fe$^{3+}$ + HAsO$_4^{2-}$ + SO$_4^{2-}$ + H$^+$
    – Biologically catalysed
• Reaction between AMD and host rock
  – Neutralisation
  • $\text{MCO}_3 + \text{H}^+ = \text{M}^{2+} + \text{HCO}_3^-$  \(\text{M} = \text{Ca or Mg}\)
  – Release of other components, Al
  • $\text{KAISi}_3\text{O}_8 + 2\text{H}^+ + 6\text{H}_2\text{O} = \text{K}^+ + 3\text{H}_4\text{SiO}_4(\text{aq}) + \text{Al}^{3+} 2\text{OH}^-$

• Trace elements usually controlled by sulphide mineral composition

• Acidity related to total sulphide content, rock mineralogy and other factors
Predicting Mine Drainage Chemistry

- First Pass = Acid Base Accounting (ABA)
  - Total acid forming components – Total acid neutralising components
  
  - Maximum Potential Acidity (MPA)
  - Acid Neutralising Capacity (ANC)
  - Net Acid Production Potential (NAPP)
    - MPA – ANC = NAPP
  - Net Acid Generation (NAG)
Predicting Mine Drainage Chemistry

• Follow Up = Kinetic testing
  – If potentially acid forming rocks are identified
    • How much acid (pH, Fe, Al)
    • How quickly does it form
    • Trace element content
    • Changes in composition with time
  – Variety of leaching tests
  – Variety of scales, lab and field based
  – Trial management and remediation options
Mine Drainage Chemistry Summary

- Highly variable
- Reactions of mined rock with $O_2$ and $H_2O$ well understood
- Can predict some problems with analysis of rock disturbed by mines
- Environmental conditions make precise prediction of mine drainage chemistry difficult
- Difficult to manage and rehabilitate
4 Summary of West Coast Work

• Results of Data compilation – West Coast
  – Hotspot dataset
  – Can have low pH, Fe and Al rich coal mine drainage
  – Arsenic enrichment down stream of some gold mine sites

• Questions
  – How variable is coalmine drainage on the West Coast?
  – How much As from gold mining vs background?
  – How far downstream does it travel?
4 Summary of West Coast Work
West Coast Coal Mines

• Two very different mine drainage chemistries
  – Regional geology – Paparoa vs Brunner coal measures

• In the Brunner coal measures acid controlled by
  – Mine type
  – Hydrogeology
  – Local geology
West Coast Gold Mines

- Mines mostly related to Greenland Group Rocks
- Mine drainage typically near neutral
- Variably As enriched – controlled by
  - Presence of sulphides
  - Ore processing methods
  - Presence of secondary Fe
  - Hydrogeology of waste storage
Hazard Model

Regional geology

West Coast coal mine planned

Likely low pH, Fe and Al rich mine drainage

BCM

Check ABA

Likely high pH mine drainage

PCM

Mine type

Open Pit

Underground

Al/Fe > 2

Al/Fe < 4

Hydro-geology

Above water table

Below water table

Above water table

Below water table

Local geology

Mudstone rich waste

Sandstone rich waste

Fe + Al very high 1-10 mmol

Fe + Al high 0.1-1 mmol

pH higher, Fe + Al elevated <0.1mmol
5 Preliminary Results from Southland

- Resources and Mining in Southland
  - Historic mining
  - Future mining
  - Rock types
Data Compilation – Southland

• Water chemistry
  – Mostly focused on agriculture
    • ES
    • NIWA
    • Theses
    • Publications
    • This programme
  – Any additional data that you are aware of??
**Data compilation – Southland**

- **Rock Geochemistry**
  - Acid base accounting data from Ohai (small dataset ~12)
  - Sulphides observed in gravels
Results - Mine Drainage Chemistry

- Nine pits/mine drainage streams – additional data from Newvale
- Preliminary data relating turbidity to geology (Tim Mulliner MSc)
Results – Rock Geochemistry

• ABA preliminary dataset collected at Newvale (Tim Mulliner MSc)
  – Non acid producing
Gaps in Dataset

• Water chemistry issues
  – Belle-Brook AMD – extent of sulphides in gravels
  – Slight trace element enrichments As, Zn & B
  – Turbidity

• Additional mine drainage analyses

• ABA from remainder of rocks that could be disturbed by mining in Southland
  – Relate to stratigraphy

• Mining related turbidity
6 A Look Forward

- ABA (acid base accounting) data for rocks disturbed by lignite mining
Other areas in Southland
Summary

• Objective 1
  – Use mine drainage chemistry and rock geochemistry from current and historic mines to predict risk associated with future mines

• Predictive ability assessed – hazard models constructed for West Coast

• Few current/historic mine drainage chemistry problems in Southland

• Gaps identified
  – ABA data
  – Mine drainage chemistry and turbidity
Conclusion

A rare chance in Southland to be proactive with respect to environmental issues around mining