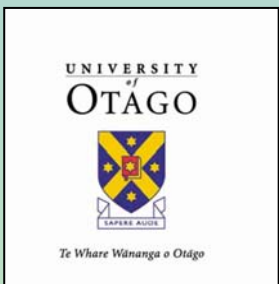




Objective 1



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

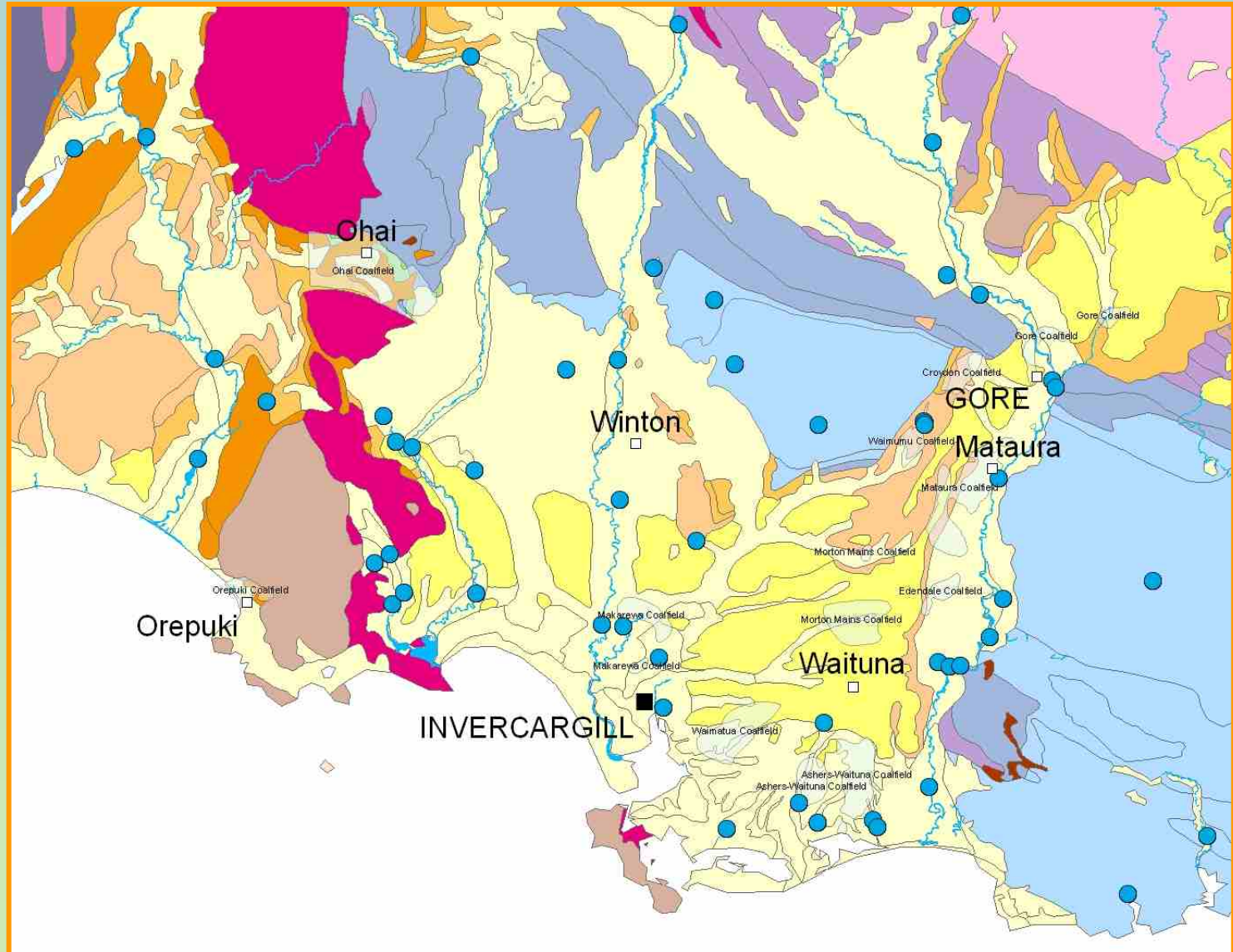
1 Aims

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

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



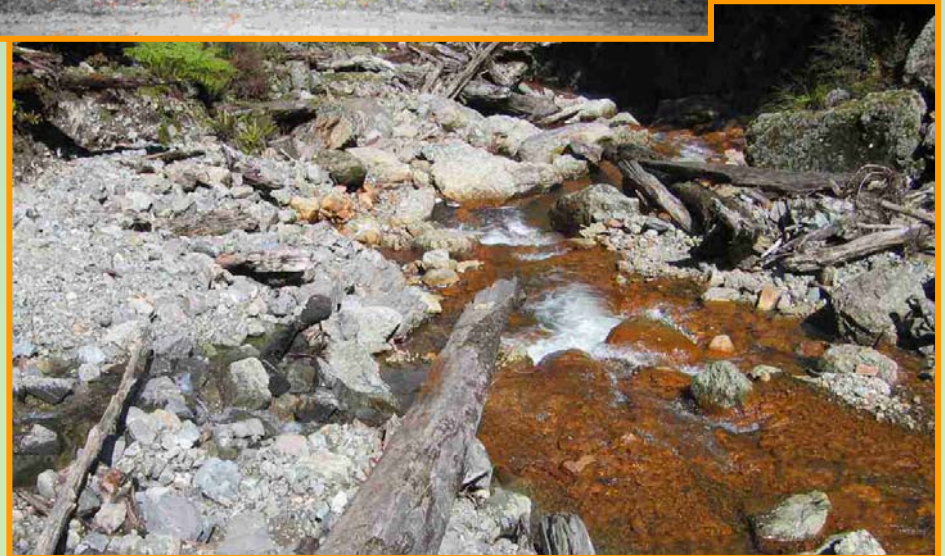
3 Mine Drainage Chemistry

- Highly variable
 - AMD, NMD, trace element enrichment
- Processes
 - Pyrite oxidation
 - $\text{FeS}_2 + 3.75\text{O}_2 + 3.5\text{H}_2\text{O} = 2\text{SO}_4^{2-} + 4\text{H}^+ + \text{Fe}(\text{OH})_3$
 - At Low pH Fe^{3+} is an oxidant
 - Other sulphide oxidation
 - $\text{ZnS} + 2\text{O}_2 = \text{Zn}^{2+} + \text{SO}_4^{2-}$
 - $\text{FeAsS} + 3.5\text{O}_2 + \text{H}_2\text{O} = \text{Fe}^{3+} + \text{HAsO}_4^{2-} + \text{SO}_4^{2-} + \text{H}^+$
 - Biologically catalysed

Mine Drainage Chemistry ctd.

- Reaction between AMD and host rock
 - Neutralisation
 - $\text{MCO}_3 + \text{H}^+ = \text{M}^{2+} + \text{HCO}_3^-$ (M = Ca or Mg)
 - Release of other components, Al
 - $\text{KAlSi}_3\text{O}_8 + 2\text{H}^+ + 6\text{H}_2\text{O} = \text{K}^+ + 3\text{H}_4\text{SiO}_4(\text{aq}) + \text{Al}^{3+} + 2\text{OH}^-$
- Trace elements usually controlled by sulphide mineral composition
- Acidity related to total sulphide content, rock mineralogy and other factors

West Coast Mine Drainage



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

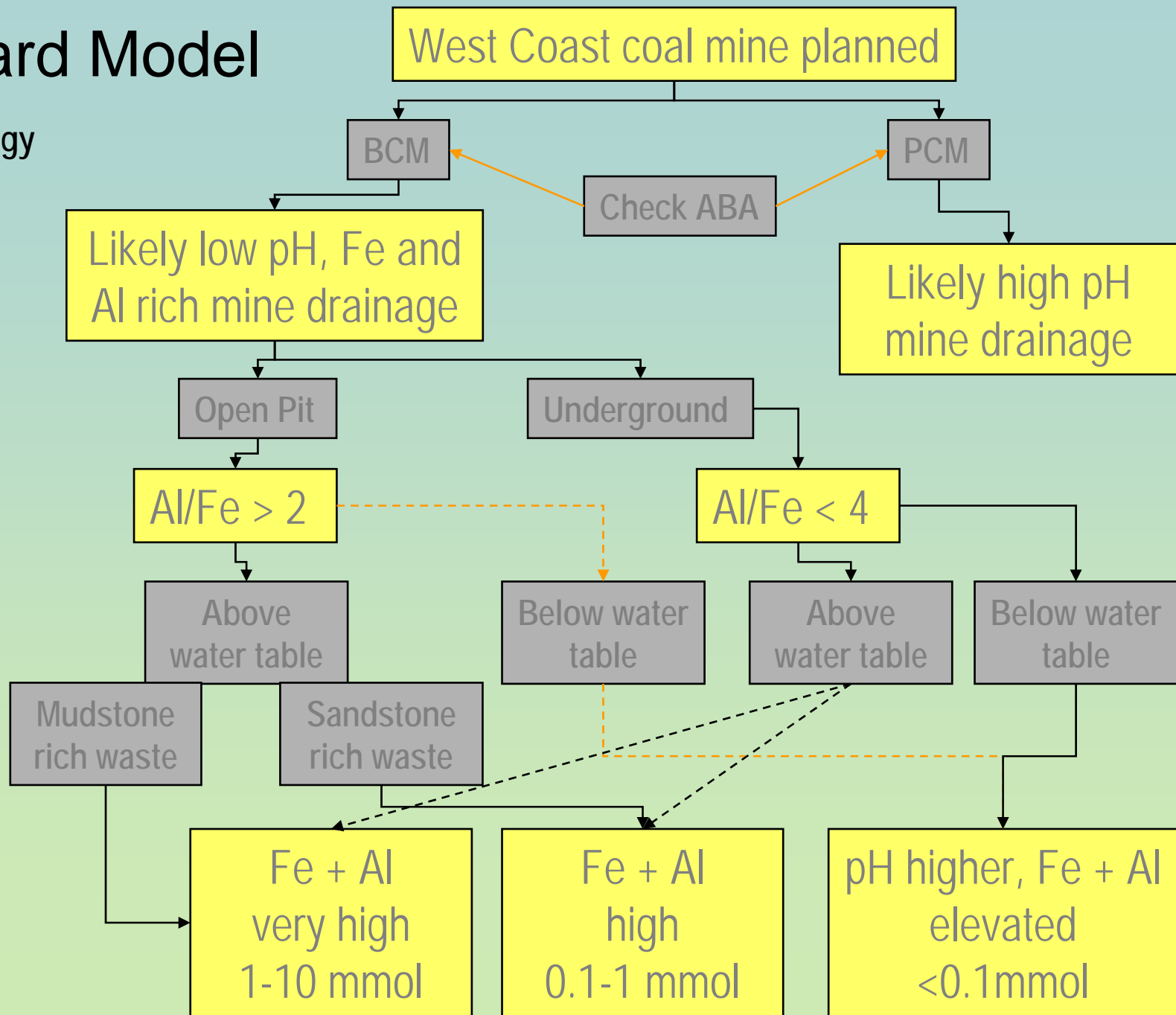
Hazard Model

Regional geology

Mine type

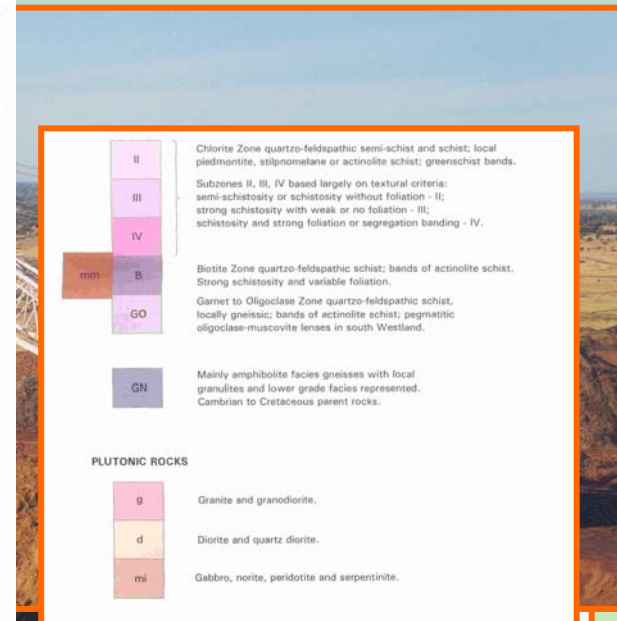
Hydro-geology

Local geology



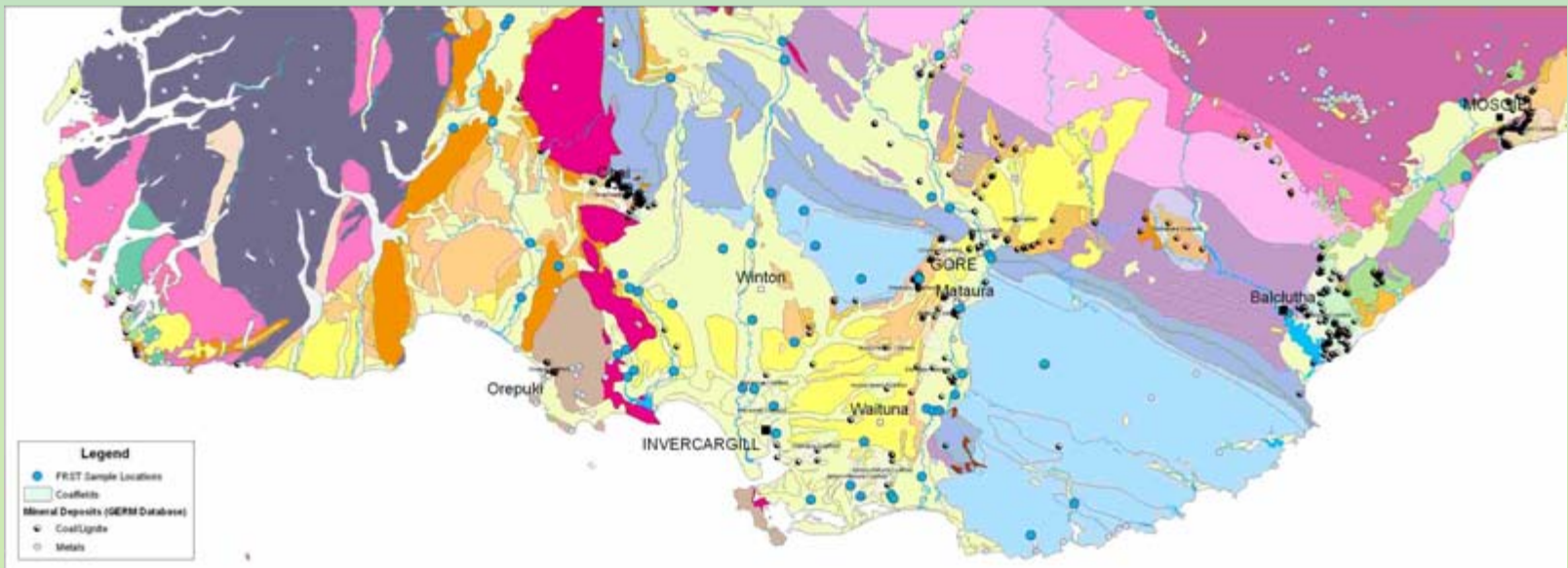
5 Preliminary Results from Southland

- Resources and Mining in Southland
 - Historic mining
 - Future mining
 - Rock types



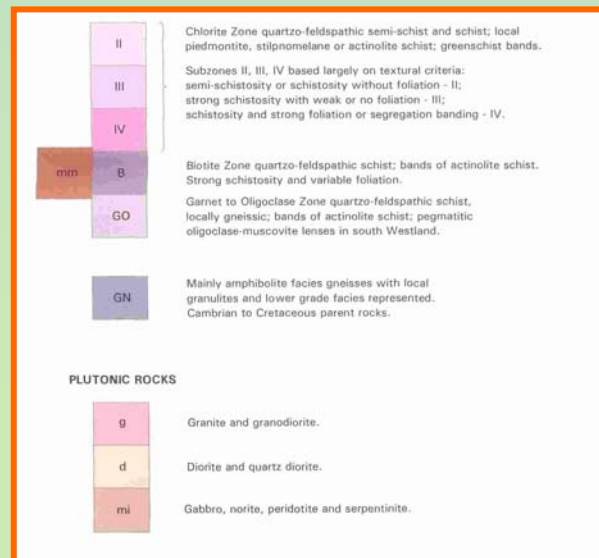
Data Compilation – Southland

- Water chemistry
 - Mostly focused on agriculture
 - ES
 - NIWA
 - Theses
 - Publications
 - This programme
 - Any additional data that you are aware of??



Data compilation – Southland

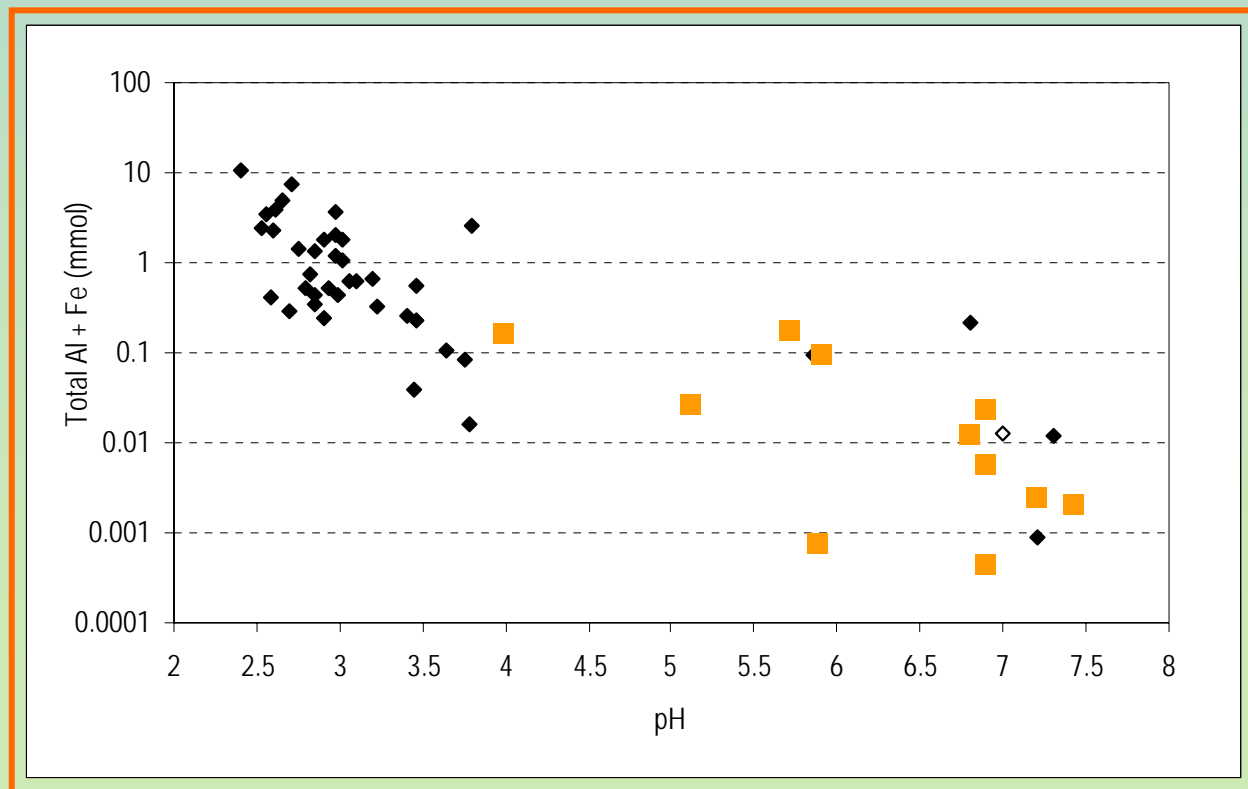
- Rock Geochemistry
 - Acid base accounting data from Ohai (small dataset ~12)
 - Sulphides observed in gravels



Qv	Q	Marine, estuarine and coastal lagoonal deposits. Dune sand, swamp deposits, peat and lake silt. Aggradation (mainly glacial) gravel and till. Thick loess on Banks Peninsula.	LATE QUATERNARY
Ql		Lahar deposits in Taranaki and central North Island.	
Qv	Q	Marine gravel, sand, silt, conglomerate and coquina limestone. Alluvial sand and gravel of high inland terraces. Aggradation gravel and local glacial deposits.	EARLY QUATERNARY
Pv	P	Marine sandstone, siltstone, conglomerate and coquina limestone. Non-marine conglomerate and sandstone.	PLIOCENE
Mv	M	Mainly sandstone, siltstone and limestone; pumiceous and andesitic tuff. Non-marine conglomerate and coal measures.	MIOCENE
Ov	O	Mainly limestone and calcareous siltstone, commonly glauconitic; sandstone and siltstone; conglomerate.	OLIGOCENE
Ev	E	Bentonitic mudstone, greensand, siliceous claystone and limestone. Quartzose coal measures.	EOCENE PALEOCENE
KEv			
Kv	K	Sandstone, siltstone, claystone, greensand, siliceous shale, conglomerate, dark argillite, minor splitic tuff and lava. Coal measures and conglomerate. Non-marine conglomerate and breccia in Otago and north Westland.	CRETACEOUS
Jv	J	Well bedded sandstone, mudstone and conglomerate in Southland and Waikato. Interbedded greywacke and argillite, with volcanics and chert, in Southern Alps, North Island axial ranges and Northland.	JURASSIC
	T	Well bedded tuffaceous sandstone, mudstone, tuff and conglomerate in Southland and Waikato. Structurally disturbed interbedded greywacke and argillite in Southern Alps, North Island axial ranges and Northland; grades into schist in Southern Alps. Sandstone and siltstone in Southland and Nelson. Volcaniclastic sandstone, grading into schist, in south and west Otago.	TRIASSIC
Ynm			
Yv	Y	Volcaniclastic sandstone, volcanics and conglomerate, grading into schist, in Southland and Nelson. Greywacke and argillite, grading into schist, in Otago and Canterbury. Limestone, siltstone and tuffaceous sandstone in Southland and east Nelson. Metaconglomerate, schist and quartzite in west Nelson.	PERMIAN
	C	Outcrops in Nelson, south Canterbury and north Otago too small to show on map.	CARBONIFEROUS
	D	Quartzite, calcareous argillite and limestone in west Nelson.	DEVONIAN
	S	Quartzite, argillite, biotite schist and amphibolite in west Nelson.	SILURIAN
	O	Limestone, graptolitic shale, argillite and quartzite; marble, hornfels, schist, greywacke and phyllite in west Nelson, Westland and Fiordland.	ORDOVICIAN
Ev	E	Volcaniclastic sandstone, argillite, limestone, conglomerate, chert, schist and amphibolite in west Nelson.	CAMBRIAN

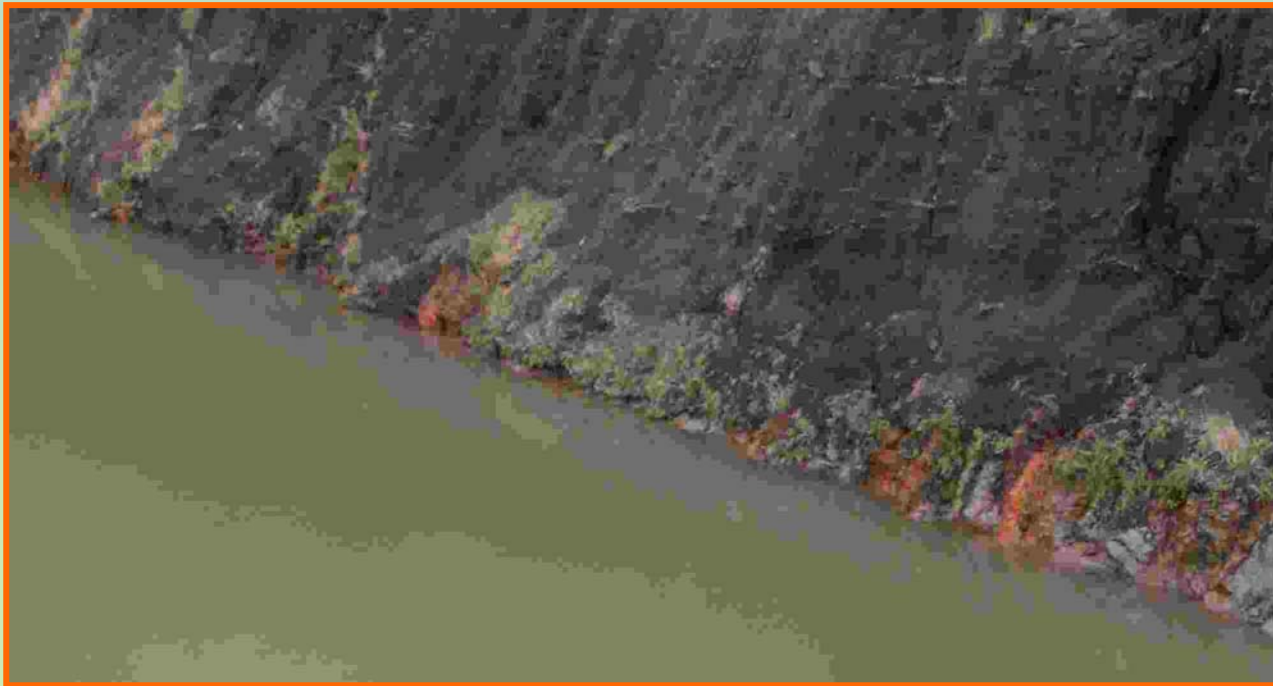
Results - Mine Drainage Chemistry

- 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

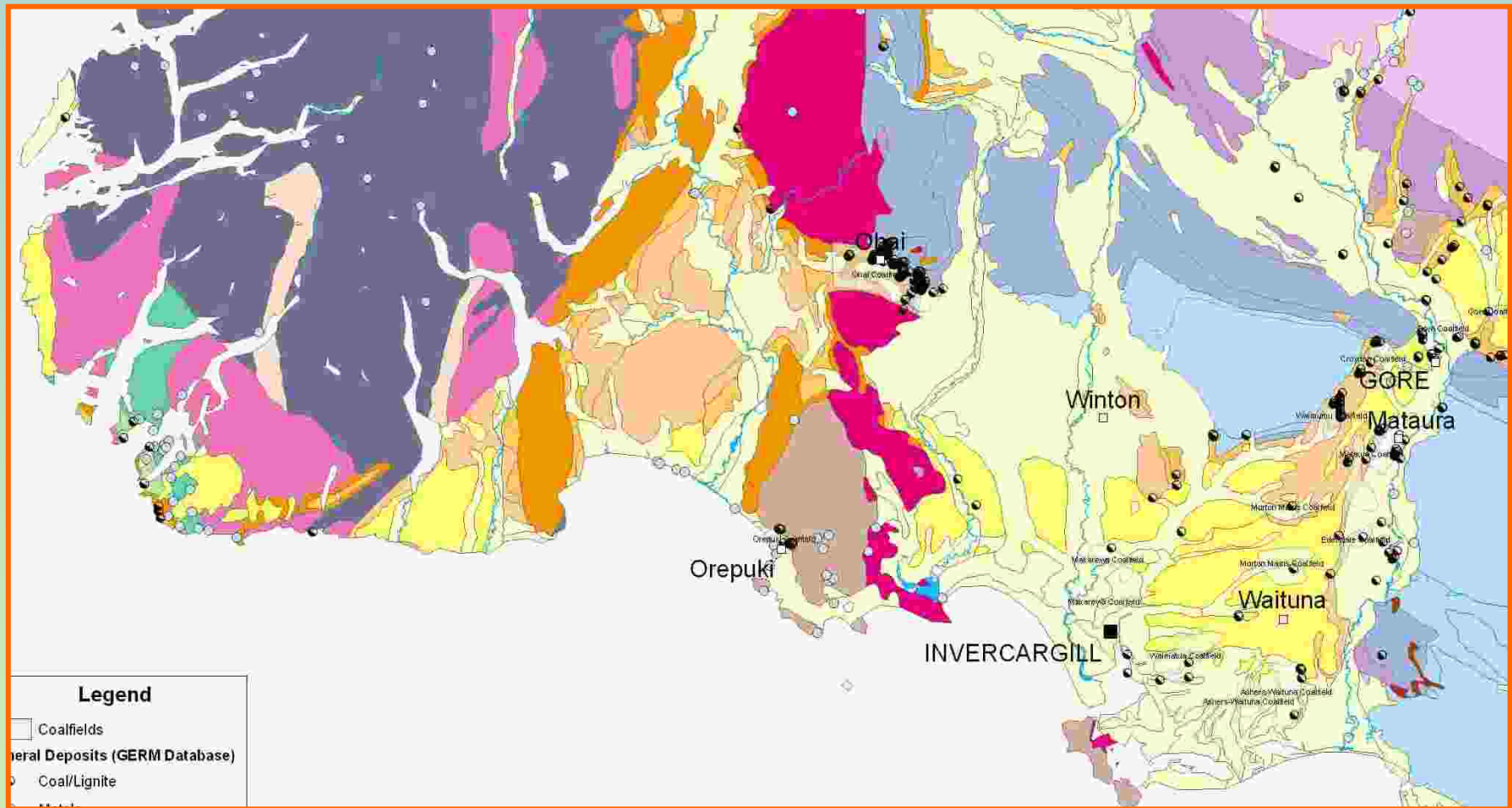
- Water chemistry issues
 - Belle-Brook AMD – extent of sulphides in gravels
 - Slight trace element enrichments As, Zn & B
 - Turbidity
- Additional mine drainage analyses
- ABA from remainder of rocks that could be disturbed by mining in Southland
 - Relate to stratigraphy
- Mining related turbidity

6 A Look Forward



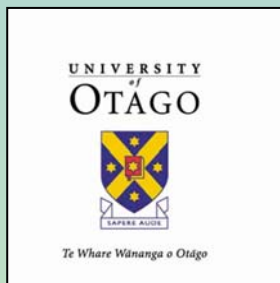
- ABA (acid base accounting) data for rocks disturbed by lignite mining

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