

An Overview of Mining R&D Projects and Strategy at Vale Inco

May 2010



Current R&D Strategy for Mines

- › To develop new technical processes that result in improved business results (either by increasing throughput or reducing cost), through the attainment of any of these objectives:
 - › Reduce stope cycle time (increased mining intensity)
 - › At conventional depths
 - › In deep operations
 - › Reduce development cycle times
 - › At conventional depths
 - › In deep operations
 - › Reduce the skill required to design, operate, or service mining operations / assets
 - › Increase the utilization of capital intensive assets

R&D "Pre-Screening" Filter

Project Request	Name of the Initiative
Site Project Sponsor/Owner	Name of the Site Sponsor and Project Owner
Complete one sheet for each proposes initiative	A brief description of the initiative
Meets CCRA criteria for R&D tax credits	
Yes / No	

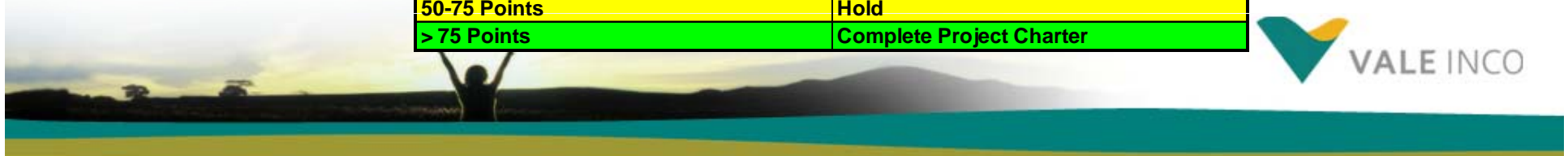
EVALUATION CRITERIA

Estimated Benefits (\$) (increased revenue or decreased cost)	No impact or undefined improvement	<\$100k/year	\$100k - \$500k/year	\$500k - \$1M/year	>\$1M/year
	0	1	10	20	25
Resource Requirements	100% of >5 peoples time + some minor team time	100% of 3 peoples time + some minor team time	100% of one persons time + some minor team time	50 % of one persons time	No requirement w within 2 years
	0	3	5	15	25
Strategic Link	No Link to ANY Strategic Plan	Link to Vale Inco Strategic Plan	Link to Ontario Division Strategic Plan	Link to Mines Engineering Strategic Plan	Link to Mines R&D Strategic Plan
	0	3	10	20	25
Complexity Risk (Do-Able / Complexity / Technology Stretch / Training Requirements)	A lot of variables and uncertainty	Variables not defined but appear manageable	Variables defined - high complexity but manageable	Variables defined - medium complexity - manageable	Variables defined - low complexity - easily managed
	0	1	5	10	15
Measurable (Data Available / Accurate)	No Data Available	Data can be gathered at a cost	Data can be gathered by modifying reports	Data available but questionable	Good data available w with high confidence
	0	1	3	5	10
Time Frame of Expected Results (Within the reserves available)	> 10 Years	5 - 10 Years	2 - 4 Years	1 - 2 Years	< 1 Year
	0	1	5	10	15
Funding Required (\$)	>\$1M	\$500k - \$1M	\$250k - \$500k	\$50k - \$250k	<\$50k
	0	1	5	10	15
Leveragability	No leveragability	To another area	Site Wide	SBU Wide	Corporate Wide
	0	3	5	10	20

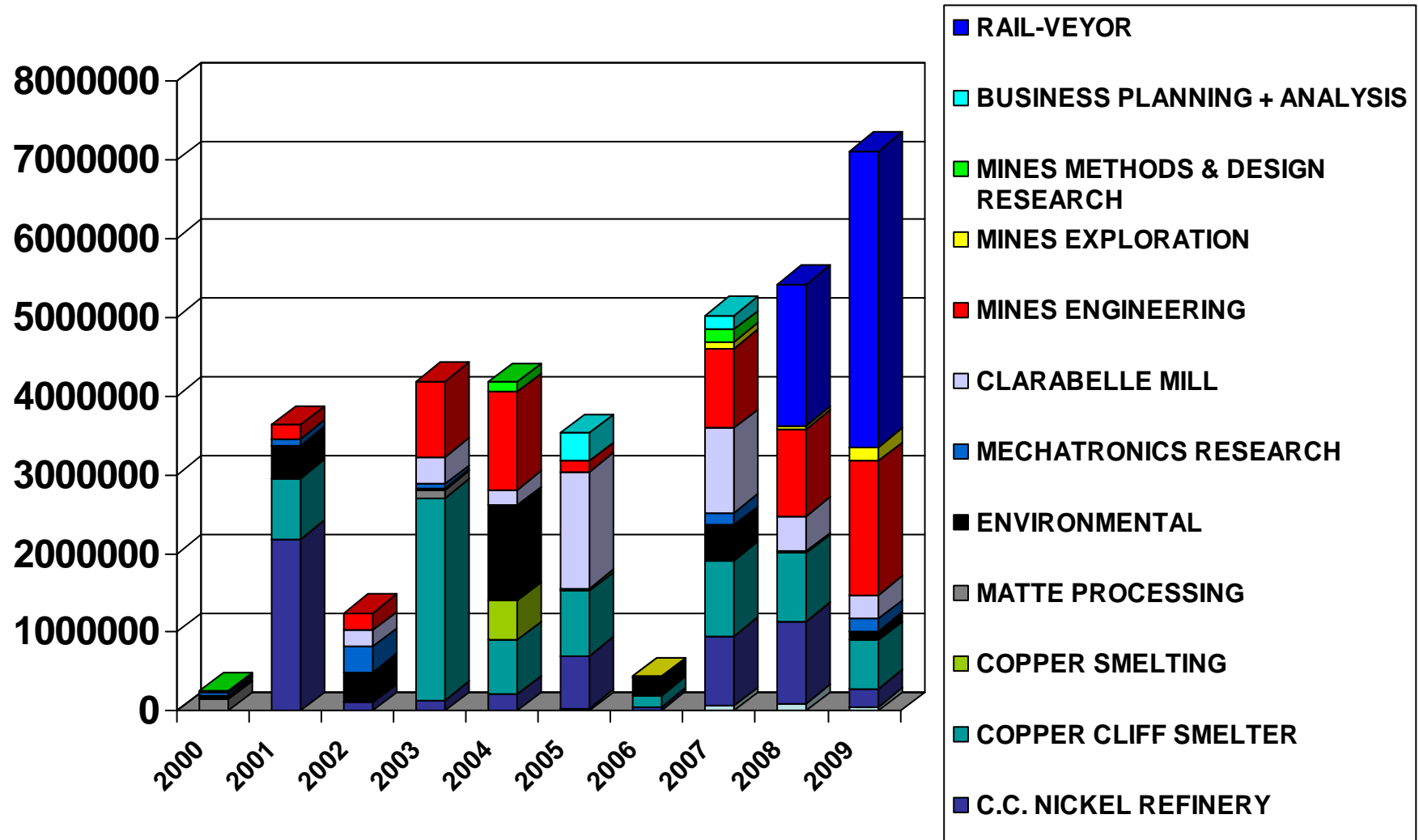
TOTAL POINTS

TOTAL POINTS

Rank Prioritization Number	Recommended Action
15 Points or less	Drop
16 to 50 Points	Could be re-evaluated
50-75 Points	Hold
> 75 Points	Complete Project Charter



Annual Research Spending

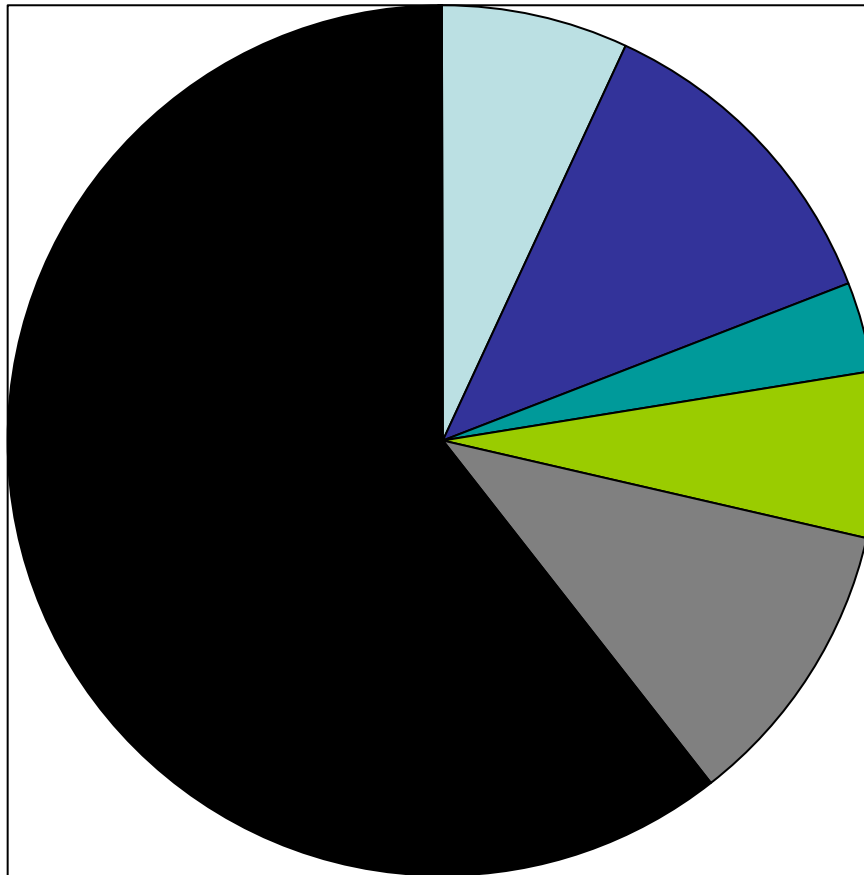


Mines R&D 5 Year Plan

Mines R&D 5 Year Plan		Ranking	2010 Schedule	2011 Schedule	2012 Schedule	2013 Schedule	2014 Schedule
Misc. Consortia	R9009001 - AMIRA P987 ROES	97					
	R9010001 - AMIRA - Mine Automation Design Guideline	100					
	R9006007 - PRIMO (AMIRA project P884)						
	R9010002 - PRIMO 2	86					
	R9007003 - PERM / IMPE						
	R9007004 - Automated Scaler & Shotcrete						
	R9006001 - CAMIRO/DMRC project support						
	R9007005 - Explosives Free Rock Breaking System (EFRB) - Phase 1						
	R9010003 - EFRB Phase 2	96					
	R9008014 - Hydrogen Mining Introduction Initiative (HMII)						
R9009003 - Streaming Mobile Equipment Data Collection							
Vent. Stra.	R9010004 - U/G Emission Control with Ultralow Sulphur Diesel Fuel - Part 2	125					
	R9008009 - International Search to Curtail Diesel Emissions/NIOSH						
	R9010005 - Creighton Natural Heat Exchanger	110					
Rock Mech.	R9008004 - Real Time Geomechanics Risk Management	96					
	R9008008 - Geotechnical Risk Analysis of Haulage Drift (McGill)	77					
	R9008007 - Back Analysis of Ground Instability (U of T)	100					
	R9009002 - Radar Imaging for Underground Mapping	92					
	R9010006 - Compressed Development Cycle Time for Support Installation	87					
Backfill	R9010007 - Self-Heating of High-Sulfide Ore and Tails in Backfill (McGill / UQAT)	96					
	R9010008 - Alternative Binder Research (Canmet)	95					
	R9010009 - Design Guidelines for Underhand Cut and Fill in Paste Fill (UBC)	116					
Vent. Tac	R9008011 - Ventilation On Demand (VOD)	98					
	R9007006 - Thermal Management						
	R9010010 - Ice Slope Project	110					
	R9010011 - Portable Refuge Station	91					
R9010012 - #3 Shaft Overburden Study	86						
Blast	R9006008 - Fracture Process in Rock w.r.t. De-Stress Blasting & Dilution Control	87					
	R9011001 - Predictive Blast Vibration for Mining Sites	63					
	R6807003 - RailVeyor Proof of Concept at Froid-Stobie						



2010 Mines R&D Dollars split by Partner Type



- International Consortium
- North American Consortium
- Government Consortium
- University Based
- Self Directed
- Rail-Veyor

International Consortium Projects

- > AMIRA P884 – PRIMO (Planning & Rapid Integrated Mine Optimization) @ 90%
- > AMIRA P975 – Real Time Geomechanical Risk Mgmt. @ 50%
- > AMIRA P987 – ROES @ 0%
- > AMIRA – (Draft) Mine Automation Design Guidelines @ 0%
- > AMIRA P1037 – (PRIMO 2) @ 0%
- > Automated HPWS & Shotcrete Machine @ 90%
- > Compressed Dev Cycle Time for Support Installation @ 10%
- > MIGS @ 50%

North American Consortium Projects

- > Fracture Process in Rock (UofT) @ 65%
- > PERM / IMPE (Mirarco) @ 80%
- > Thermal Management (CAMIRO) @ 75%
- > Ventilation on Demand (CEMI / Bestech) @ 30%
- > HMII - Hydrogen Initiative (NRCAN et.al.) @ 10%
- > EFRB - Explosives Free Rock Breaking (NRCAN et.al.) @ 85%

Government Consortium Projects

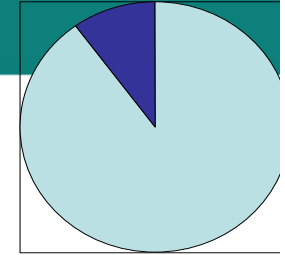
- > CAMIRO (Canadian Mining Research Organization) membership @ ongoing
- > DMRC (Deep Mining Research) membership @ ongoing
- > Alternative Binder Research (CANMET) @ 10%
- > Research into Gelfill (CAMIRO / McGill) @ 90%

University Based Projects

- › Back Analysis of Ground Instability (Laval / UofT) @ 70%
- › International Search to Curtail Diesel Emissions (U of Minnesota) @ 50%
- › Radar Imaging for U/G Mapping (Carlton / UofT) @ 50%
- › U/G Emission Control with Ultralow Sulfur Diesel (U of Minnesota) @ 0%
- › Self-Heating of High Sulfide Ore & Tails in Backfill (McGill / UQAT) @ 20%
- › Design Guide for Underhand Cut&Fill in Paste Fill (UBC) @ 10%
- › Geotech Risk Analysis of Haulage Drifts (McGill) @ 55%

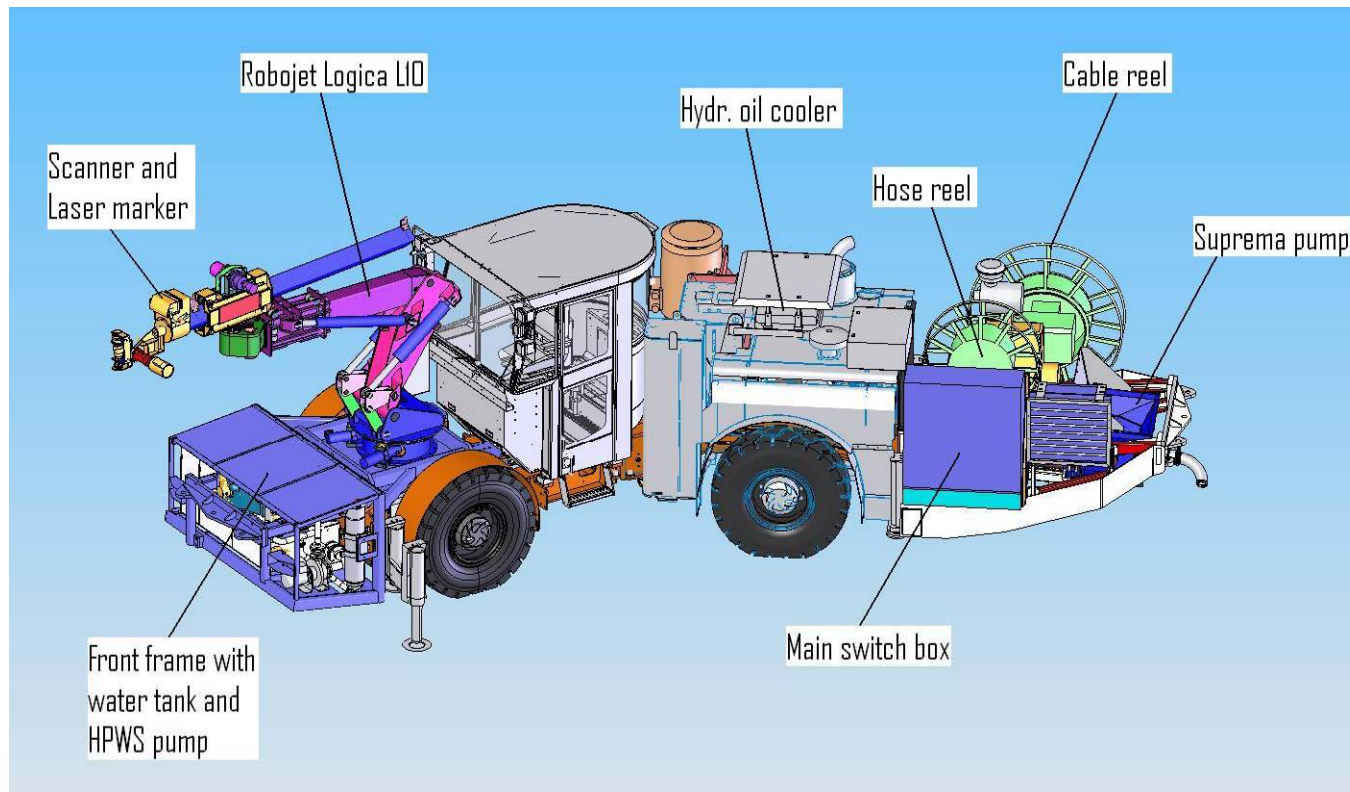
Self Directed Projects

- > Rail-Veyor @ 45%
- > Streaming Mobile Eqpt. Data Collection @ 75%
- > Creighton Natural Heat Exchanger @ 5%
- > Ice Stope Project @ 0%
- > Portable Refuge Station @ 0%
- > #3 Shaft Overburden Study @ 0%
- > Mining Research Admin & Overhead @ ongoing



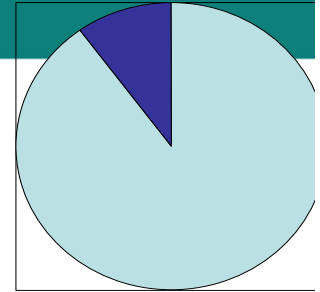
> High Pressure Water Jet / Shotcrete Machine

- > Partners with Rio Tinto and Xstrata nickel. Currently testing at Ni Rim South in Sudbury.



International Consortiums

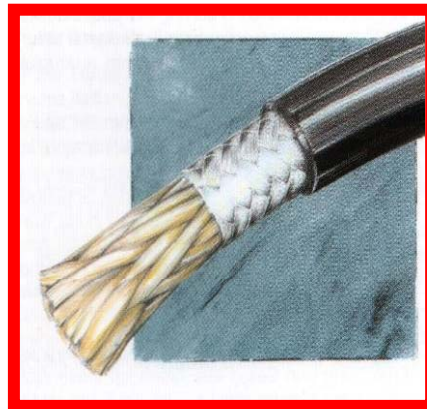
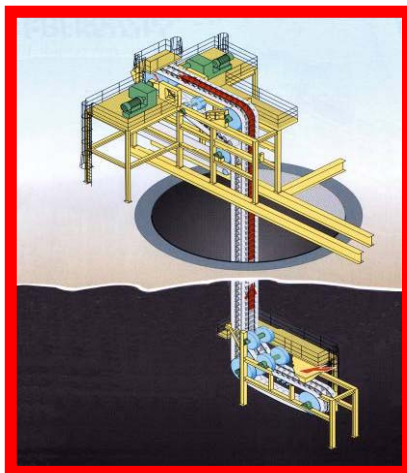
- › **AMIRA – P884 “PRIMO” (Planning & Rapid Integrated Mine Optimization)**
 - › Adding new mine planning tools
 - › Beta software available and being tested on case studies
 - › Greens Creek (ex Rio Tinto)
 - › Prominent Hill (Oz Minerals)
 - › Olympic Dam ODO Area H (BHP)
 - › New tools include:
 - › MIRARCO -SOT (Stope and development schedule optimizer)
 - › UofM – DOT (Decline and access network optimization)
 - › AMS – PUNO (Stope Design Optimization)
 - › AMC – LOBOS (Overall Strategy Optimization)



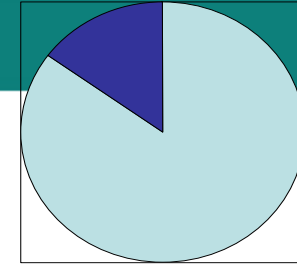
Government Consortia

> DMRC Projects

- > Semi-Synthetic Hoist Rope (D.McIvor)
- > Geothermal Energy (M. Ghomshei)
- > Heat Stress (Univ. of Ottawa)
- > Pocket Rope Conveyor prototype (Metso)
- > TSL Thin Spray-on Liner (3M)



North American Consortiums



EFRB (Explosives Free Rock Breaking) Consortium

- > Focus on Microwaves, Plasma Torch, and Ultrasound as assists or “pre-treatment” for mechanical rock breakage methods

Table 1 Explosive-free rock breaking methods.

EFRB Field	Technology					
Mechanical Equipment	Activated cutting	Activated roller cutting	Disc cutting	Mini-disc cutting	Oscillating disc cutting	Single disc cutting
	Button cutting	Impact ripping	Pick cutting	Radial-axial splitter	Microwave-assisted impactor	
Fluid Application	Hydro-fracturing	Jet-boring	Water pulse rock breaking	Foam injection	Controlled foam injection	
Electrical Discharge	Plasma blasting	Electrical blasting	Electrical pulse blasting	Electrical rock breaking		
Heat Discharge	Thermal fragmentation	Laser cutting				

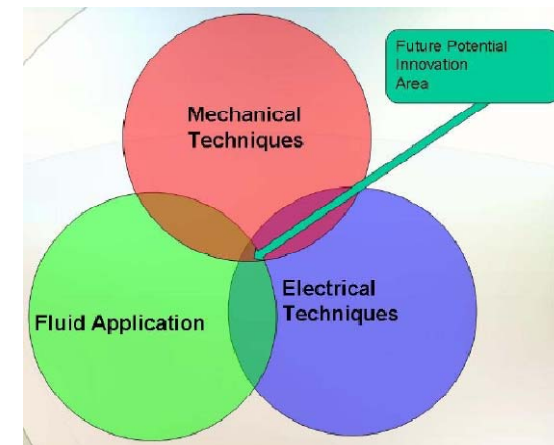
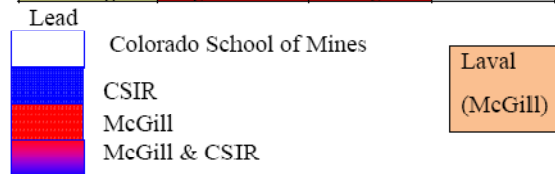


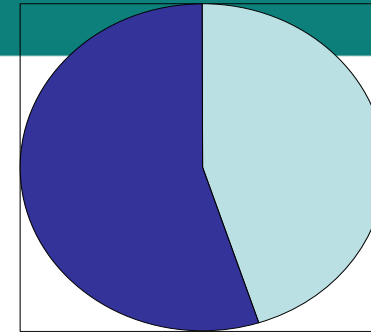
Figure 20. Plasma torch applied in a vertical sweeping motion.



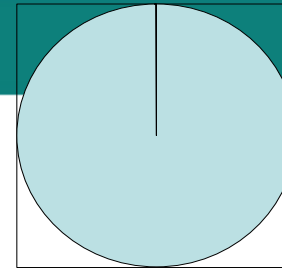
Self Directed Projects

> Rail-Veyor – Proof of Concept Work

- > Purpose: To solve the critical issues that stand in the way of R-V based mine design being considered for future Vale Inco projects
- > Identified 8 key focus areas (sub-projects):
 - > Stobie Surface Testing
 - > Development using R-V
 - > Fragmentation
 - > Loading R-V
 - > Maintenance
 - > Moving other materials (including people)
 - > Regulations
 - > Stakeholder Engagement
- > Contributes to FEL 2 Study for Upper Kelly Lake

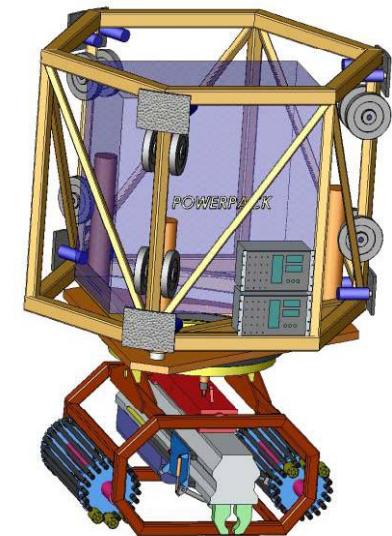
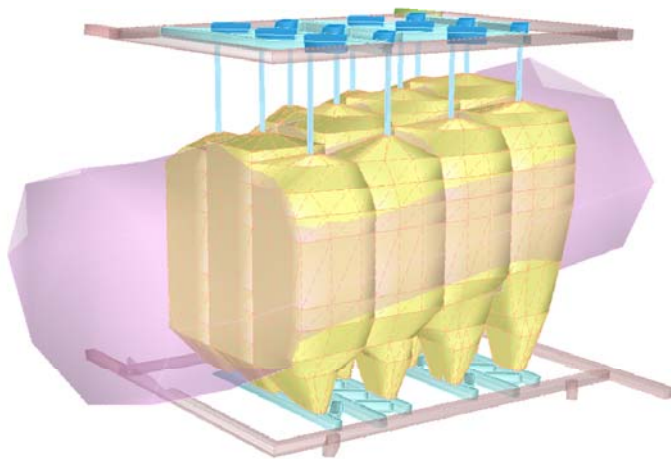


International Consortiums

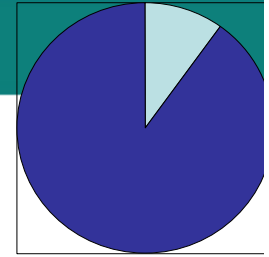


> AMIRA – P987 “ROES” Mining Method

- > CSIRO Australia based initiative to create a new bulk Mining Method. Expected to kick off Q2 2009.



North American Consortia



> HMII (Hydrogen Mining Introduction Initiative)

- > Consortium to investigate issues involved in bringing H₂ underground to recharge fuel cell powered equipment



> Context

- > Ensure that project will provide a strategic advantage to Vale Inco with respect to safety and productivity
- > More mineral resources can be transformed into wealth by minimising disruption to the operation.
- > Unexpected ground instability can destroy wealth and result in production issue.
- > Underground tour at all mines with Manager
- > From tour, establish needs for mine



> Current Projects

1. Back Analysis of Ground Instability (CCM and Creighton through U of T)
2. Geotechnical Risk of Haulage Drift (Garson Mine through McGill)
3. Real Time Geomechanics Risk Management (Coleman Mine MOB1 through Rocksciences, U of T and CEMI)
4. Stand Up time of stopes (Thompson, Birchtree Mine through U of Saskatchewan).
5. Mine Induced Seismic Periodicity (Creighton through MIRARCO)
6. Rock mass characterization with Radar Imaging (Queens University and Carleton University)

Back Analysis of Ground Instability

> Purpose

- > Design support system that will maintain opening stability through operation life while minimising or eliminating reconditioning

> Cost

- > \$305,000

> Project Life

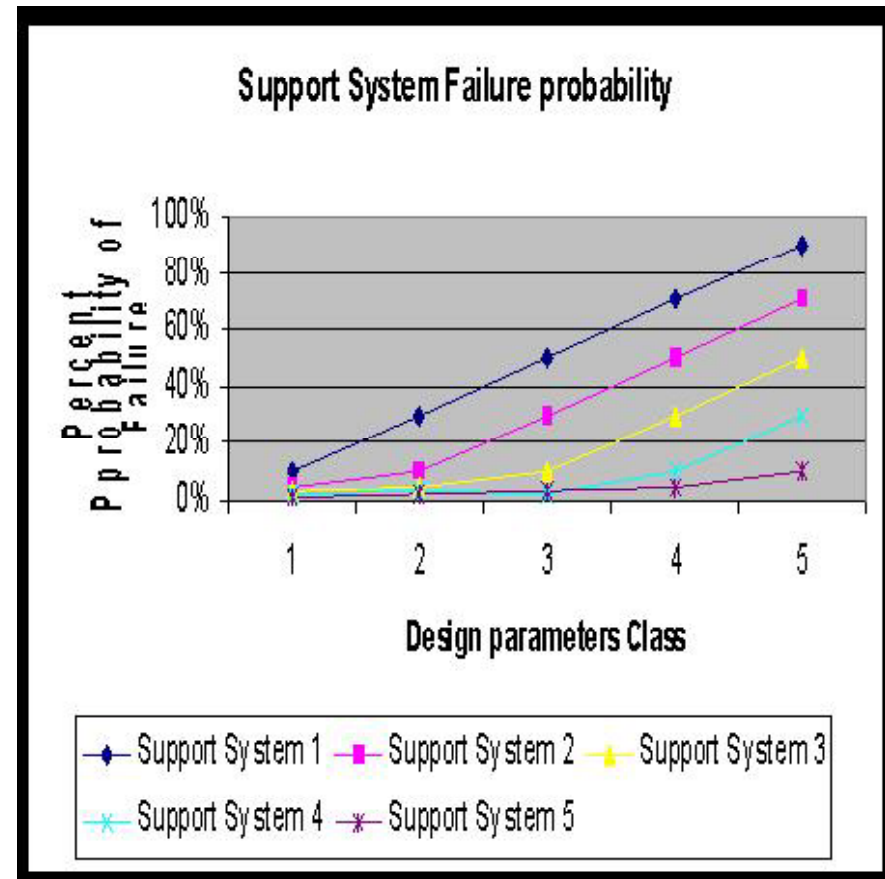
- > 2 years.

> Deliverables

- > Design chart as function of support system, expected stress, rock mass conditions and life span of openings.

> Status

- > 10% completed



Geotechnical Risk Analysis of Haulage Drift

> Purpose

- > Provide a planning tool that will quantify the risk probability associated to haulage drift with respect to extraction ratio, sequence, support systems and rock mass properties.

> Cost

- > \$420,000

> Project Life

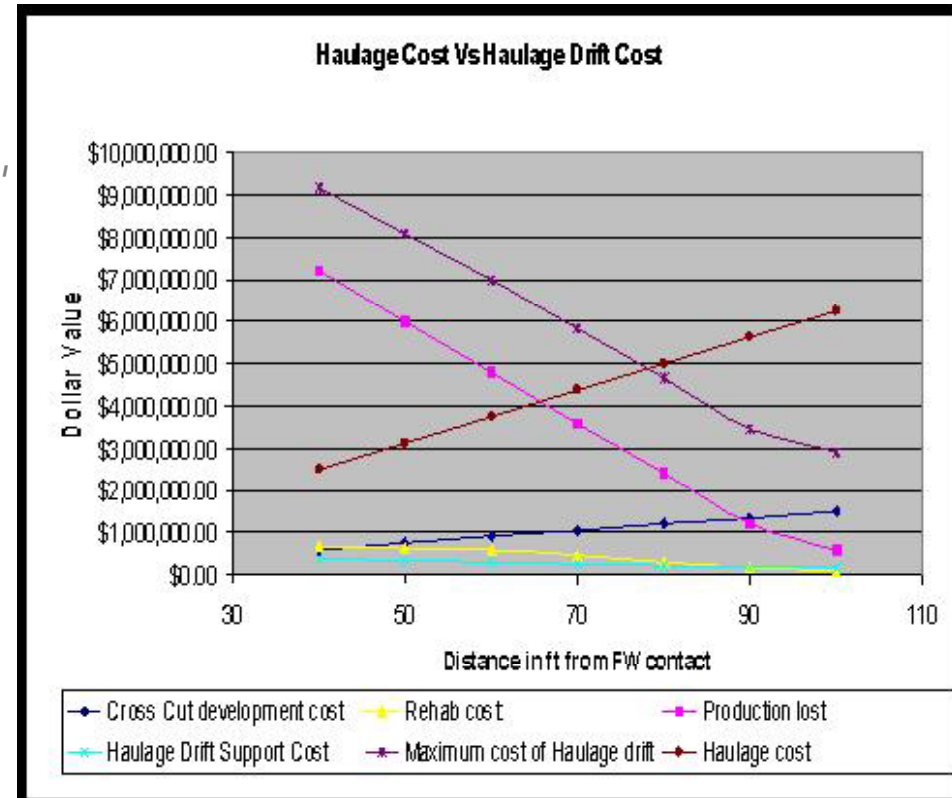
- > 3 years.

> Deliverables

- > Key risk factor for haulage drift
- > Probability of instability associated with key factors

> Status

- > 50% completed



Real Time Geomechanics Risk Management

> Purpose

- > To develop a system that will help mining companies manage risks arising from the geomechanics challenges

> Cost

- > \$300,000

> Project life

- > 3 years.

> Deliverables

- > State-of-the-art instrumentation
- > Data transfer to surface
- > Calibrated 3D models

> Status

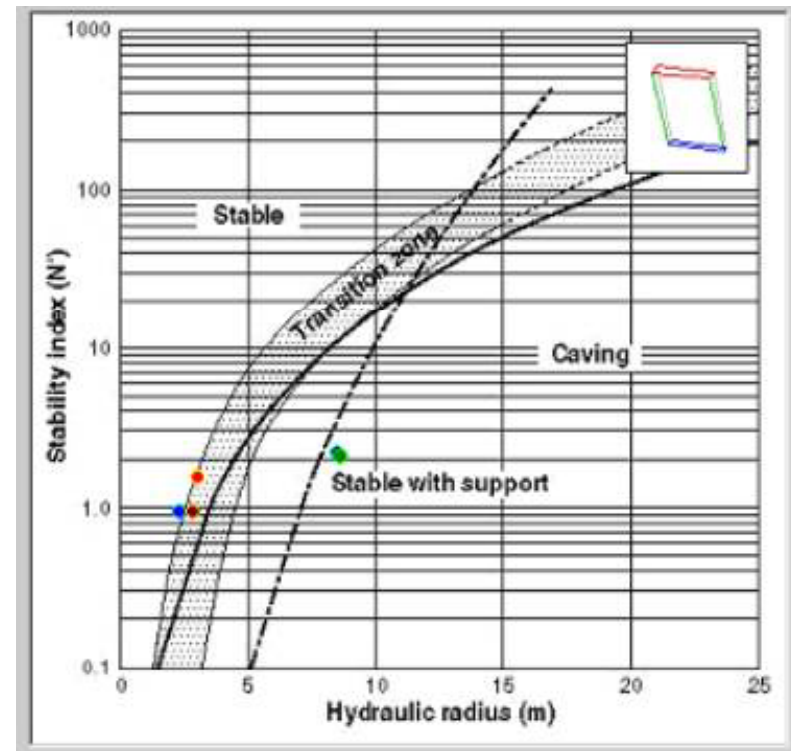
- > 25% completed

wireless



Stand Up Time of Stopes

- > **Purpose**
 - > Establish the optimum stope size for given in situ stress conditions, rock mass quality and mining method that will maximize production while minimizing dilution.
- > **Cost**
 - > \$100,000
- > **Project life:**
 - > 1 to 2 years.
- > **Deliverables**
 - > Site specific design guidelines for stope size with respect to cycle time and geotechnical characteristics .
- > **Status**
 - > Initiation phase for Birchtree



Mine Induced Seismic Periodicity

- › **Context**
 - › Long period of inactivity may allow increased store energy leading to a large MN event.
- › **Purpose**
 - › Prove or disprove that extended mine shutdowns may lead to large RB seismic events upon resuming operations.
- › **Cost**
 - › \$35 000 (from perm)
- › **Project life:**
 - › 3 months.
- › **Deliverables**
 - › Proof of Concept
- › **Status**
 - › 20% completed

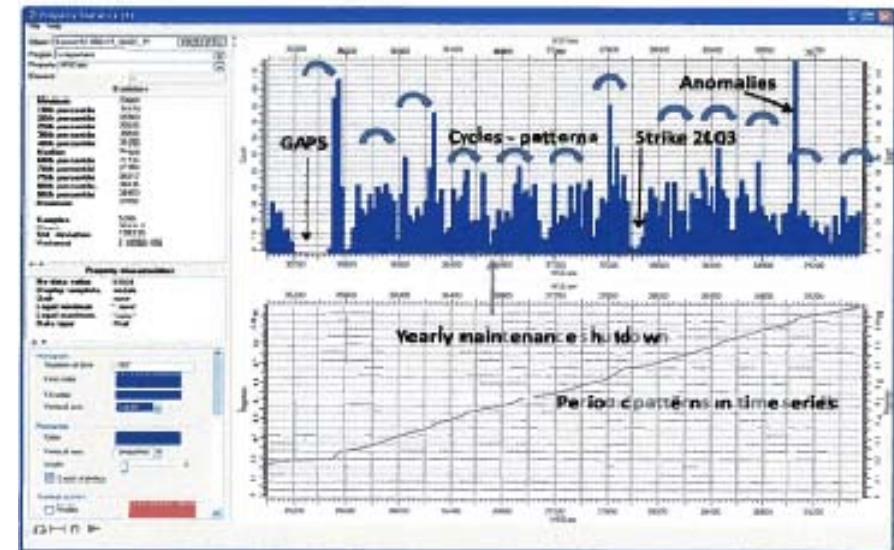


Figure 1. Seismic data time series showing yearly seismicity for the period from 1995 to 2008.

Rock Mass Characterization with Radar Imaging

- > **Context**
 - > Improve methods of defining the rock mass may allow better support selection and desing thus allowing reduction in cycle time. Automatic method of data acquisition and processing may minimise the impact of skill labour shortage
- > **Purpose**
 - > Demonstrate the potential of 3D laser imaging for evaluating RMR in an underground mining environment.
- > **Cost**
 - > \$35 000
- > **Project life:**
 - > 2 years.
- > **Deliverables**
 - > Proof of Concept
- > **Status**
 - > 50% complete

