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SOUTH AFRICAN NATIONAL INSTITUTE
OF ROCK ENGINEERING

Rockburst Task Team - Progress

Friedemann Essrich

8 NOVEMBER 2019

SibanyeStillwater Academy (Westonaria)

Overview



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1. Time line
2. ToRs & Confidentiality Agreement
3. Action items
4. Training initiatives
5. Rockburst data collection
6. Quick-win analysis results
7. Research proposals

1. Time Line



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2018

-  Workshop
-  Meeting

January

Su	Mo	Tu	We	Th	Fr	Sa
31	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25		27
28	29	30		1	2	3

February

Su	Mo	Tu	We	Th	Fr	Sa
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	1	2	3

March

Su	Mo	Tu	We	Th	Fr	Sa
25	26	27	28	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

April

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5

May

Su	Mo	Tu	We	Th	Fr	Sa
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17		19
20	21	22	23	24	25	26
27	28	29	30		1	2

June

Su	Mo	Tu	We	Th	Fr	Sa
27						
3						
10						
17	18	19		21	22	23
24	25	26	27	28	29	30

July

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8						
15						
22						
29						

August

Su	Mo	Tu	We	Th	Fr	Sa
29	30	31	1	2	3	4
5						11
12						18
19						25
26						1

September

Su	Mo	Tu	We	Th	Fr	Sa
26	27	28	29	30	31	1
2	3	4		6		
9	10	11	12	13		
16	17	18	19	20		
23	24	25	26	27		
30	1	2	3	4		

October

Su	Mo	Tu	We	Th	Fr	Sa
30	1	2	3	4		6
11	12	13				
18	19	20				
25	26					
1	2					

November

Su	Mo	Tu	We	Th	Fr	Sa
28	29	30	31	1		3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	1

December

Su	Mo	Tu	We	Th	Fr	Sa
25	26	27	28	29	30	1
						6
						13
						20
						27
						3

**ToR &
Confidentiality**

Low participation

**Data
analysis**

**Rf/ Rb
split**

**Training
initiatives**

Mine Data



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1. Time Line



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2019

-  Workshop
-  Meeting



2. Terms of Reference

2. REQUIREMENTS FOR THE TASK TEAM

The MHSC wishes to establish an FOG/ Rockburst mitigation task team in collaboration with relevant industry stakeholders and experts in the SAMI; to develop mitigating strategies for rock related risk and provide recommendation to the Mine Health and Safety Council. The Task Team would require the following to ensure optimisation of resources and facilitate the smooth running of the Task Team:

1. Task Team will be chaired by a representative from the MHSC
2. Leadership structures for facilitation of the development of the required strategies need to be created within the task team.
3. Sub-committees will be created to focus attention on relevant areas of the FOG / Rockburst challenges in the SAMI, viz:
 - Rockfall Subcommittee
 - Rockburst Subcommittee Central overlap of behavioural resources

8. DURATION OF THE TASK TEAM

The FOG/ Rockburst Task Team is expected to be in operation until 31 March 2019 or as soon as the scope of work as listed on the Terms of Reference have been completed to the satisfaction of the Chairperson of the Task Team.

3. SCOPE OF WORK

The scope of work for the FOG/ Rockburst Task Team will cover the following:

- Provide guidelines for data acquisition and data analysis;
- Collect incident /accident data relating to FOGs/ Rockbursts for the last ten (10) years from the DMR, CGS, MINCOSA and the Mines etc. and set up of a database.
- Provide guidelines on independent data analysis service provider should such service be required;
- Conduct a qualitative and quantitative analyse of the data collected.
- Conduct a review of existing industry research (CSIR, COMRO, MHSC, CGS, etc.) on Rockfalls and Rockbursts;
- Conduct a gap analysis of existing industry research to determine short term research projects to achieve objectives;
- Provide guidelines for further research requirements, if any, to consolidate existing research;
- Provide the scope of required research projects for consideration by MHSC;
- Prioritise Research projects through MHSC CoE Research Determination Dept;
- Submit additional proposals to COE for consideration;

2. Confidentiality Agreement



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INDEMNITY AGREEMENT

We acknowledge and accept that, during the undertaking of the different tasks allocated to the Falls of Ground/ Rockburst Task Team, members, their respective employers or organisations may, with good intentions and in good faith, divulge, share or disclose information that may expose them to potential litigation related to incidents or accidents that occurred in the past. We hereby agree that no information divulged, shared or disclosed while carrying out the activities of the task team, shall ever be used against any member, their respective employers or organisations for any incident related to that information during the period of operation of the task team and beyond.

2. Confidentiality Agreement



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DMRE Weekly Safety Reports - shared

SAMRASS: Fatalities and injuries per commodity/region: Weekly report 2018
(Provisional statistics)

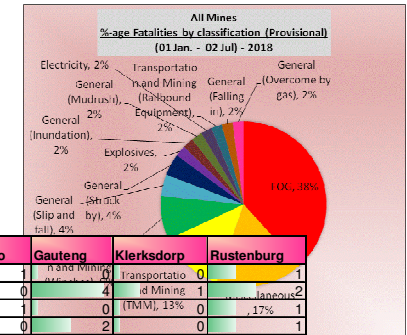
	Fatalities*						Injuries*		
	Actual						Actual		
	01/01/2017-02/07/2017	01/01/2018-02/07/2018	% change	Total fatal accidents** 2017	Total fatal accidents** 2018	% change	01/01/2017-02/07/2017	01/01/2018-02/07/2018	% change
Total	39	47	21	37	30	-19	1369	1083	-21
Gold	16	29	81	16	16	0	564	402	-29
Coal	5	5	0	5	4	-20	103	70	-32
Platinum	13	5	-62	12	4	-67	557	470	-16
Other	5	8	60	4	6	50	145	141	-3

* Provisional figures

Region	Fatalities*						Injuries*		
	Actual						Actual		
	01/01/2017-02/07/2017	01/01/2018-02/07/2018	% change	Total fatal accidents	Total fatal accidents	% change	01/01/2017-02/07/2017	01/01/2018-02/07/2018	% Change
Total	39	47	21	37	30	-19	1369	1083	-21
Western Cape	2	1	-50	1	0	-100	2	10	400
Northern Cape	0	2	200	0	2	200	59	36	-39
Free State	6	8	33	7	6	-14	129	143	11
Eastern Cape	0	0	0	0	0	0	2	0	-200
KwaZulu/Natal	1	1	0	1	0	-100	5	6	20
Mpumalanga	7	3	-57	7	3	-57	109	74	-32
Limpopo	3	2	-33	3	2	-33	72	59	-18
Gauteng	8	21	163	7	9	29	330	187	-43
Klerksdorp	1	3	200	1	3	200	106	83	-22
Rustenburg	11	6	-45	10	5	-50	555	485	-13

* Provisional figures

** Number of accidents in which persons died, catering for multiple fatalities.



Fatalities 2018

	W Cape	N Cape	F State	E Cape	KZN	Mpumalanga	Limpopo	Gauteng	Klerksdorp	Rustenburg
January	0	0	2	0	0	3	1	4	0	1
February	0	0	2	0	0	0	0	4	1	2
March	0	1	3	0	1	0	1	0	0	1
April	0	0	0	0	0	0	0	2	1	1
May	0	1	0	0	0	0	0	7	1	0
June	1	0	1	0	0	0	0	8	1	1
July	0	0	0	0	0	0	0	0	0	0
Total:	1	2	8	0	1	3	2	21	3	6

Total: 47

2018: All Mines Injuries per Classification

Classification	01/01/2017-02/07/2017	01/01/2018-02/07/2018	% Change
FALL OF GROUND/rockfall	238	189	-21
MACHINERY	102	78	-24
TRANSPORTATION AND MINING	242	167	-31
GENERAL	714	581	-19
CONVEYANCE ACCIDENTS (SHAFT/WINZE)	19	7	-63
ELECTRICITY (Not causing fire)	4	9	125
FIRES	4	16	300
EXPLOSIVES	3	7	133
SUBSIDENCE OR CAVING	0	2	200
HEAT SICKNESS	1	2	100
DIVING SICKNESS	0	0	0
OCCUPATIONAL DISEASES	0	1	100
MISCELLANEOUS (specify)	42	24	-43
TOTAL	1369	1083	-21

Fatalities 2018

	January
Sibanye Stillwater (Au=19; Pt=2)	0
Harmony Gold	2
SASOL Mining	2
Anglo Gold Ashanti	0
Impala platinum	1
Glencore Coal	1
Palabora Mining Corporation	1
Anglo Platinum	0
Mission Point Sand Mine	0
Alexkor RMC JV	0
Zululand Colliery	0
De Beers	0
Petra Diamonds	0
Henric	0
Black mountain	0
Northam Platinum	0
Atlantis Foundries Sand Mine	0
Gold One	0
Village Main Reef	0
Total:	7

Grand total: 47

3. Action Items



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Theme	Duration	Action		Responsibility	Status	
a) Analyses of previous data	Short-term	a. Analyse SAMRASS 3 reports b. Develop and undertake relevant work		Appointed Service Provider/ Other Committees/Other Organisation Appointed Service Provider/ Other Committees/Other Organisation		
				c. Establish an exchange programme with countries such as Japan, Poland and Turkey to tap into their expertise in the areas of rock engineering and seismology d. Introduction of mentoring programmes for Rock Engineers and Seismologists (SANIRE to assist and this be formalised)	Already in Place or in progress or achievable but challenging Already in Place or in progress or achievable but challenging	
			Medium-term	e. Plan for Shift boss training for Rock engineers (REs advise shift bosses and should at least undergo shift boss training – Leadership training) f. Consider Virtual Reality training for employees to understand/appreciate rock engineering related issues	Service Provider/ Other Committees/Other Organisation Service Provider/ Other Committees/Other Organisation	
		d) Sharing of information	Short-term	a. Information sharing to be improved amongst stakeholders (DMR-MHSC-Organised Labour and Employers) b. Merge the national seismicity network and company/mine specific networks with an objective to expand it to the Bushveld platinum mines. (Different in coordinates between CGS and the mines makes it a challenge to address this action)	Service Provider/ Other Committees/Other Organisation Already in Place or in progress or achievable but challenging	
		Medium-term	c. Improve the accuracy and relevance of DMR statistics and information to be useful to the industry	Service Provider/ Other Committees/Other Organisation		
	Medium-term					
	Long-term					
b) Dissemination of previous research outcomes	Long-term					
		e) Production				
		f) Review of Roles and Responsibilities	Short-term	a. Re-asses the role and duties of Rock Engineers on mines (not auditors) (In process being undertaken through MRAC)	Service Provider/ Other Committees/Other Organisation	
		g) Dissemination	Long-term	b. Improve on the quality of Seismic data	Service Provider/ Other Committees/Other Organisation	
		h) Uncategorized		a. Report on the competency of assessor who conduct on-the-job competency assessment of trained employees after they left the training centres. (PTO Assessor) b. Quality of training of Seismologist c. Investigate the viability of including names of mines and injuries on the weekly statistics d. Relook at the entry examination compliance and close-out of inspection reports. (Deviations by looking at what is there as in best practices). Look at how do you effectively do entry examination specifically of FOG. e. How realistic are targets (production) set for screws? (Walking distances and travelling times/shift)	Provider/ Other Committees/Other Organisation Task Team Service Provider/ Other Committees/Other Organisation Service Provider/ Other Committees/Other Organisation Service Provider/ Other Committees/Other Organisation	
c) Training	Short-term					

32 Action items:
Allocated to
responsible parties
and prioritised –
Awaiting execution.

4. Training initiatives

**11 students study towards Geophysics (Hon.) at Wits
to become Mine Seismologists**



Other training programmes were recommended:

- DMR safety inspectors
- Rock Engineers
- Mine production personnel



5. Rockburst data collection

Information released by AG-A, Goldfields, Sibanye, Harmony and Village Main:

- 16 gold mines: West Rand, KOSH and Welkom region
- Period: 2008 – 2018

	Number of events								Rockbursts		No of Injuries		Workers		Production						
	-.0.5<=M<0	M0-0.9	M1-1.9	M2-2.9	M>3	Mmax	Moment	Incidents	Min. Mag	Non Fatal	Fatal	U/Ground Workforce	Mil hrs worked	Area mined	Tons	Depth range		M>2	M>1		
2008	2555	2375	667	70	7	3.4	929.6	89	0.9	0	7	17544	41157084	513738	2904935	800 to 3200		283	22		
2009	1972	1799	640	83	9	3.6	2002.07	122	0.9	50	6	17639	41381787	525045	3089221			536	64		
2010	1921	1819	521	75	6	3.7	1927.33	89	0.9	16	0	17204	40361520	508968	3064377			588	62		
2011	1561	1344	367	55	1	3.4	941.28	47	0.9	91	3	16461	38618658	429537	2592614			563	58		
2012	1527	1103	233	20	3	3.4	620.93	33	0.9	43	0	13775	32316857	320950	1886274			450	71		
2013	2384	1615	361	43	3	3.6	1083.62	77	0.8	51	0	13452	31558808	397579	2527917			167	24		
2014	2730	1831	406	44	1	3.3	782.83	72	0.9	35	0	10405	24411250	374914	2496915			152	28		
2015	2277	1558	401	45	3	3.7	1574.39	71	0.9	51	0	10790	25312816	384109	2413239			192	16		
2016	1268	981	255	31	1	3	623.8	46	0.9	42	0	11451	26864474	311155	2054719			222	588		
2017	1356	1072	254	33	3	3.1	655.62	50	0.9	39	1	12067	28309528	321050	2137069						
2018	1103	785	228	42	3	4	757	16	0.9	17	7	11121	13350649	119454	819603						

Note: Mine X's Mag relation differs from all others

Note: Mine X's Mag relation differs from all others
(approx. 0.4 lower for a M=2.0 event).

2016	733	585	18	1	0	2.3	831.5	0	0	0	0	0	0	0	0	0	0	0	0
2017	334	536	23	0	0	1.8	1198.3	0	0	0	0	0	0	0	0	0	0	0	0

5. Rockburst data collection



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Causal chain:



6. Quick-win Analysis



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6. Quick-win Analysis



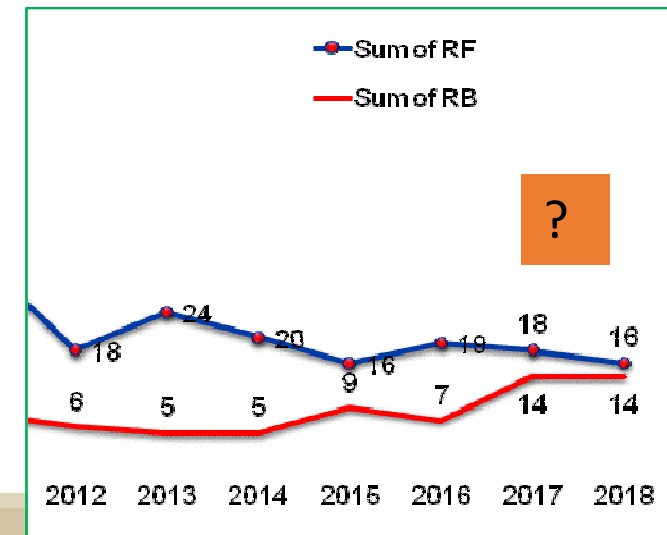
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Rockburst Risk			Risk Mitigation		
Causes of seismicity	Seismicity	Rockbursts	Protection	Workers	Legal
Mining strategy	Frequency	Frequency	Support design	Competence	Laws
Blasting practice	Size	Size	Support installation	Training (effective?)	Regulations
Production rate	Location	Location	Materials	Production pressure	Enforcement
Rock properties	Source Mechanism	Damage Mechanism	Tools	Fatigue	Reasonable-ness
Geological Structures		Ground conditions	Equipment	Attitude / behaviour	Practicality
.....			PPE	Bonus system	
				Size of u/g work force	
				Oversight	
					

📌 Covered by DeepMine & SIMRAC research after 1990.

Which are the most relevant factors?



6. Pertinent questions

1. Did the drivers of seismicity change significantly after 2013, i.e. production rate, mining depth or mining method?
2. Is there evidence of an increase in seismic hazard over the past 5 years?
3. Has the min. Magnitude of damaging events changed over time?
4. Has the likelihood of damage increased?
5. Has the exposure of the workforce to seismicity and rockbursts changed significantly, i.e. size of the workforce or MHrsW?
6. Do human factors such as behaviour and fatigue play a greater role?

LEARNINGS 1st workshop



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1. Most incidents are related to sub-standard conditions and non-compliance.
2. New concepts required for ultra-deep mining, e.g. pre-con/hydro-fracturing or mechanisation.
3. New research required to address excavation support under seismic conditions.
4. Information is lacking for CoM to complete comprehensive analyses.
5. Difficult to identify the root causes.

OUTCOMES 1st workshop



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1. Blasting and barring practice need to improve.
2. Behaviour related issues, e.g. fatigue and worker attitude need to be addressed.
3. Increase in effective training required.
4. Compliance levels should be monitored and improved.
5. Data – industry needs to raise more data and improve quality.
6. Internal investigations are very detailed, but not all details can be shared.

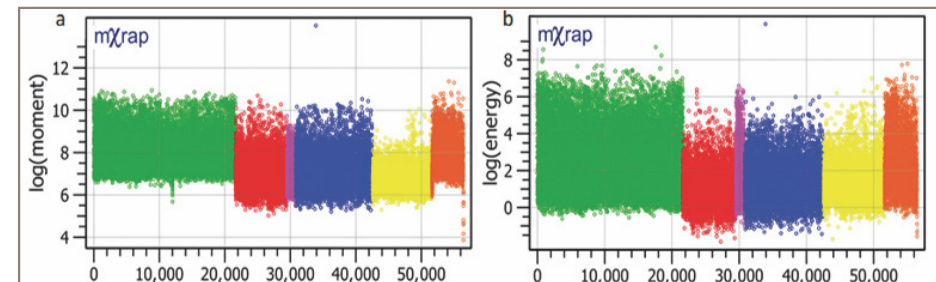
OUTCOMES 1st workshop



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ROCK ENGINEERING

1. SCO and RE workloads are too high to ensure compliance.
2. Need to conduct more rock mass modelling; lack of testing facilities.
3. Certain software and instrumentation should be upgraded or commercialised .
4. Information exchange between DMR, MHSC, CoM and industry needs to improve.



L. Linzer

6. Quick-win Analysis

Correlations: 11 years, 4 high-risk mines

	Incidents	Injuries	Fatalities
W'force	0.85	0.13	0.43
MHrs worked	0.81		
Prod. (t)	0.92		
M>0	0.88		
M>1	0.87		

Rate of production and size of workforce seem to influence seismic response and incident numbers, but not injury frequency and severity.

Question:

Is seismicity **directly linked** to injuries and fatalities?



?

7. Research proposals

Recommendations:

1. Formulate research objectives based on the preliminary analysis.
2. Focus on the four high-risk mines.
3. Establish why RB injury rates were stable or decreasing, while fatality rates continued to rise.
4. Use case-specific information when analysing possible causes.
5. Define deliverables aimed at mitigating the circumstances, causes and contributing factors responsible for the increase in RB fatalities after 2014.

7. Research proposals

Research proposals prepared for presentation to MHSC:

1. Detailed Analysis of SA Mining Industry (SAMI) rockbursts .
2. Gap Analysis SA Mine Seismic Systems vs. international best practice.
3. Is it possible to predict rockbursts, strainbursts or seismic events?
4. Are earthquakes and large seismic events inherently unpredictable?





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Thank you!

Questions?