Gina Martin

From: William Joughin <WJoughin@srk.co.za>
Sent: 04 May 2018 02:37 PM
To: 'Johan Wagner'; 'Lauren Dell'
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Johan

I phoned Henk and he was extremely vague. He said that he has not responded to the DMR. I asked him if he had any concerns and he said that he would have to check. He didn't seem to think that he needed to respond to the DMR.

I really do not know what to make of it.

Regards

William

From: Johan Wagner [mailto:Johan.Wagner@sibanyestillwater.com]
Sent: Friday, 04 May 2018 12:20
To: William Joughin <WJoughin@srk.co.za>; Lauren Dell <Lauren.Dell@sibanyestillwater.com>
Subject: Re: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Hi William
Could you please phone Henk and find out the same from him?

1. Did they respond back to the DMR (Regional office) with their inputs in respect of our EA application?
2. If not, when are they planning to do so?
3. Did GSC identify any issues? – lack of info or reason for negative advice?

Thank you so much.

Kind Regards

Johan C. Wagner
Head: Strategic Projects • SA Region
T: +1 703 717 8713 • **C:** +27 82 412 4510
www.sibanyestillwater.com

From: William Joughin <WJoughin@srk.co.za>
Date: Friday, 4May, 2018 at 03:17

To: Johan Wagner <Johan.Wagner@sibanyestillwater.com>, Lauren Dell <Lauren.Dell@sibanyestillwater.com>
Subject: FW: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Johan

Please see feedback from CGS. No further concerns were raised with us. I am not sure if they corresponded directly with Sibanye.

Regards

William

From: Martin Brandt [mailto:mbrandt@geoscience.org.za]
Sent: Friday, 04 May 2018 07:03
To: William Joughin <WJoughin@srk.co.za>; Lindsay Linzer <LLinzer@srk.co.za>
Cc: Ian Saunders <ians@geoscience.org.za>; Henk Coetzee <henkc@geoscience.org.za>
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Dear William,

I have completed my part of the review (seismic analysis of local mine-related events) and passed it on for integration into the overall review opinion by the Council for Geoscience.
The overall co-ordinator for the review at the Council for Geoscience (and contact point with the Department of Mineral Resources) is Henk Coetzee.
You may contact him at henkc@geoscience.org.za

Regards,

Dr Martin Brandt

From: William Joughin [mailto:WJoughin@srk.co.za]
Sent: 03 May 2018 04:29 PM
To: Lindsay Linzer; Martin Brandt
Cc: Ian Saunders
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Martin and Ian

Was there a formal response from the CGS in this regard?

Regards

William

From: Lindsay Linzer
Sent: Friday, 09 March 2018 13:59
To: Martin Brandt <mbrandt@geoscience.org.za>

Cc: Ian Saunders <ians@geoscience.org.za>; William Joughin <WJoughin@srk.co.za>
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Hi Martin,

Fantastic. Glad the letter answered your questions and you found it interesting.

Many thanks
Lindsay

From: Martin Brandt [mailto:mbrandt@geoscience.org.za]
Sent: Friday, March 09, 2018 1:31 PM
To: Lindsay Linzer <LLinzer@srk.co.za>
Cc: Ian Saunders <ians@geoscience.org.za>; William Joughin <WJoughin@srk.co.za>
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Dear Lindsay,

Very interesting, that certainly answers my questions…..
Please thank William for the attached letter.

Regards,

Dr Martin Brandt

From: Lindsay Linzer [mailto:LLinzer@srk.co.za]
Sent: 09 March 2018 01:03 PM
To: Martin Brandt
Cc: Ian Saunders; William Joughin
Subject: FW: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Hi Martin,

It was great to chat with you yesterday. Really enjoyed catching up on the work that the Council is doing.

I had a discussion with William this morning and he alerted me to the attached letter, which addresses all of your concerns in particular the local geological structures. I don't think this letter was emailed to you.

There's an answer to your question about the geological mapping on pages 9 and 10. In essence, the geological structures in the vicinity of the plugs were mapped in detail and classified as minor structures with small displacements. None of the major faults with large displacements intersect the plugs.

There's also a section 5.2 on Failure Mechanisms which covers your other concerns re. water hammer, plug geometry and comments on the seismic wavelengths and plug dimension.

Please would you read the attached letter, which summarises the report, and let us know if your questions are answered?

Many thanks
Lindsay

From: William Joughin
Sent: Friday, March 09, 2018 9:02 AM
To: Lindsay Linzer <LLinzer@srk.co.za>
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Lindsay

Please refer to the attached letter. It describes the possible plug failure mechanisms. I have included a comment on shear dislocation of the plug.

In the phase 1 final report rev2:
Structural geology is discussed in sections:

- 2.2.2 Summary of structural geology
- 4.2.1 "Detailed geological inspections" and "summary"
- 4.2.2 Site preparation – explains pre-grouting.

Please discuss this with Martin and Ian. Let me know if they still have concerns.

Regards

William

From: Lindsay Linzer
Sent: Wednesday, 07 March 2018 13:02
To: Martin Brandt <mbrandt@geoscience.org.za>
Cc: Ian Saunders <ians@geoscience.org.za>; William Joughin <WJoughin@srk.co.za>
Subject: RE: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

Hi Martin,

Thank you for these thought provoking questions.

I've made a plan to visit Ian tomorrow at 10am – will you be around?

Speak soon
Lindsay

From: Martin Brandt [mailto:mbrandt@geoscience.org.za]
Sent: Wednesday, March 07, 2018 10:09 AM
To: Lindsay Linzer <LLinzer@srk.co.za>
Cc: Ian Saunders <ians@geoscience.org.za>
Subject: Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft / Cooke 3 shaft

3.4.1 Gutenberg-Richter analysis

Polygon SDM_all contains all 152 488 events. The Gutenberg-Richter frequency m
M_{max} = 3.5 (Figure 3-16 a). Note that the magnitude scale used here is the loc
scale, and that the magnitude quoted by CGS is likely to be higher.

The log Energy-log Moment (Figure 3-16b) plot shows two populations of events, w
having a higher Energy Moment ratio is related to blasting. The time of the week (
time of day (Figure 3-16 d) histograms show the familiar relationship to production

Only 127 events remain in the SDM_all polygon once a $M_L \geq 2.0$ magnitude filter is
locations of all 127 events are shown in section and plan view in Figure 3-17(a)
largest events of M_L = 3.4 and 3.5 are shown in plan and section view in Figure 3-

The polygon defined for the water barrier pillar, SDM_WBP, contains 3028 event
Richter frequency-magnitude distribution is smooth and the M_L = 3.4 appears to
event population (Figure 3-18a). The log Energy-log Moment scattergram sho
(Figure 3-18b) indicating that no mining has taken place during the defined ti
seismicity described here is fluid induced. Day of the week and time of day eve
shown in Figure 3-18(c) and (d).

When the data in the polygon are filtered using $M_L \geq 2.0$, only six events remain (F
largest of the events M_L = 3.5 is located approximately 500 m below the water b
3-19 b).

Dear Lindsay,

Ian Saunders asked me to read through the seismic hazard parts of reports describing investigations done w.r.t. the water plugs placed between Ezulwini Shaft and South Deep Shaft and future plugs planned between Cooke 3 and Ezulwini shafts.
With regard to: “Chapter 3 – Seismic hazard analysis -- Assessment of the water barrier pillar and the water plugs placed between Ezulwini Shaft and South Deep Shaft.” Report Number 507589/1.

- I have 3 questions:

3.1 Previous seismic hazard analyses

In the absence of data, Ortlepp ((Ortlepp & Stacey, 2002), (Ortlepp, 2003) and 2006)) based his analysis on regional data recorded by the Council for Geoscie deterministic scenarios in which the likelihood of occurrence of different source m to be the cause of the larger seismic events, which might threaten the integrity The possible modes of failure of the plugs was also hypothesised, and based on a source mechanisms that have been categorised by (Ortlepp & Stacey, 1994), only to be capable of producing large magnitude seismic events. The probability of a through intact rock was considered to be extremely low due to the absence of su to drive such a rupture. Pillar-crush failure of the boundary pillar was also conside unlikely since three requirements are not met: a critically low width:height ratio; l and average pillar stress exceeding the UCS of the rock. Consequently, the poss failure occurring anywhere along the length of the boundary pillar was conside small. Pillar foundation failure was also ruled out since the high driving stress thought to be present.

The work by Ortlepp is thorough, well-reasoned and technically sound. There are

Firstly, the calculation of the probability of having a particular magnitude earthq area could be improved. In the report, it is assumed that the recorded seismic eve within the seismogenic volume and the risk of having M_L = 4.5 (for example) is area (calculated from Brune's source radius) divided by the seismogenic area. Th is defined in the report as being within a 50 km radius of the plug area, an area of

The concern is that large seismic events do not occur randomly in space but are fault zones. A more representative approach to determining the probability of magnitude event occur within a spatial extent is to divide the seismic source estimated fault plane area (i.e. fault trace length multiplied by depth of faultin assumes that there is a causal link between the seismic event and a fault, rather

Have the authors considered a mine-related (not water ingress related) seismic event of magnitude ~4.5 at distances of ~7.5 km away from the plugs? Is this a realistic scenario when considering future mine operations? Would the effect of the long period waves on the water filled tunnels, caused by such an earthquake, be able to generate hydrodynamic pressure on the plug?

3.4 Analysis of South Deep water barrier pillar

The South Deep and SV1 data set comprises 458 946 events spanning eight c (-5.22 to 3.88) recorded during the period 31/01/2004 to 17/06/2017 (Figure 3-3). the South Deep water barrier pillar seismicity for different magnitude cut-offs are to Figure 3-11. Magnitude versus time scatter plots for the entire catalogue, surrounding the water barrier pillar, are given in Figure 3-12 and Figure 3-13. The in the data between 2012 and 2014 for the water barrier pillar polygon, and c sensitivity are also evident. Caution must therefore be applied when interpreting by event rate.

The first part in this analysis applies standard seismological methods such as frequency-magnitude graphs, log Energy-log Moment plots, and histograms show to describe the nature of the mining- and fluid-induced seismicity. Two polygons over South Deep (SDM_all) and the water barrier pillar (Figure 3-14), and constrained over the water barrier pillar only named SDM_WBP (Figure 3-15).

In the second part, a site-specific strong ground motion equation (GMPE) is deri data, from which PPVs at selected positions in space (e.g. on the sidewalls of c plugs, etc.) can be estimated from large events that have occurred at South Deep part investigates the PPV and PGA data that has been recorded by geophone an the SV1 network and compares these to the site-specific GMPE.

It should be noted that the major faults with large displacements described in (Mc 2003) do not intersect the plugs. This observation was confirmed by Marius van discussion on 26/07/2017.

Is it possible that a minor fault, which is connected in an obscure way to one (or more) of the major faults, could intersect the plug? Is this a realistic scenario? Or is this extremely unlikely?

The authors selected Mmax=3.5, which is equal to the magnitude of the largest observed event recorded by a specific mine network. A conservative approach could be to set Mmax=Mobs + Oe, where Oe is the magnitude uncertainty of the largest observed event, maybe 0<Oe<0.1? Would this lead to a too conservative maximum magnitude? Would the effect on the PPVs be significant?

- I also read through: Chapter 3 – Seismic hazard analysis of "Assessment of the water barrier pillar and the positioning of future plugs between Cooke 3 and Ezulwini shafts." Report Number 507589/2. I also have the same 3 questions.

Regards,

Dr Martin Brandt
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