Groundwater Flow Mechanisms at Margaret shaft, KOSH Gold Mining Area

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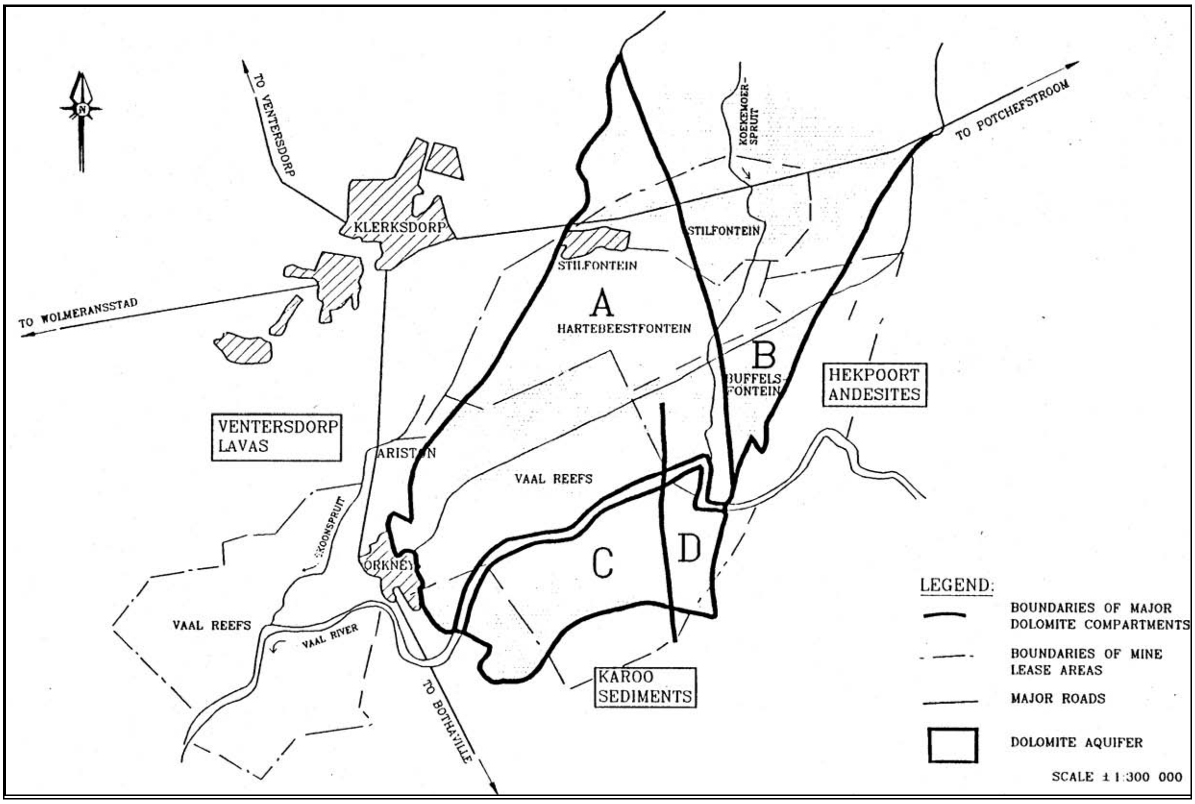
Abstract
Pumping underground water at Margaret shaft is the reason why gold mining can continue in the KOSH gold mining area. More than 80% of water pumped for dewatering underground workings, is pumped from this shaft. However, groundwater flow is difficult to define and structural controls from both geological and underground mined out areas play a pertinent role in the flow of groundwater in the dolomitic aquifer.

Key words: KOSH gold mining area, intermine flow, underground workings, geological structural control, recirculation.

Introduction
The Margaret shaft is situated in the KOSH (Klerksdorp-Orkney-Stilfontein-Hartebeestfontein) gold mining area and was constructed in 1949 as one of the first two shafts in the Klerksdorp Goldfield of South Africa. Other shafts at the same gold mine included Charles, Toni, James and Scott shafts. During the peak production period it was said to be the busiest mine in South Africa and over 272 155 tons was hoisted from a depth of 1829 meters below surface (mbs). All underground mining activities were stopped in 1992 and no ore has been hoisted since. However, Margaret shaft has been used for the sole purpose of manning, serving and maintaining the major pump installation on 10 ½ and 16 ½ levels. The long history of mining within the Klerksdorp Goldfield has led to almost of the underground mine workings being connected and the inter-mine flow of groundwater accumulating within the workings.
The pumping of underground water at Margaret shaft is the reason why gold mining can continue in the KOSH area, since more than 80% of water pumped for dewatering underground workings, is pumped from the Margaret shaft. However, various sources of water enter the shaft from Toni shaft, Charles shaft and the upper levels of Margaret shaft. Defining the flow mechanisms towards the shaft is complex, but critical to mine safety in the KOSH gold mining area.

Hydrogeology
The shaft was constructed through the upper weathered aquifer and the lower Karst aquifer of the chert-rich Malmani dolomite. The geohydrology of the overlying strata in the Stilfontein area is still governed by the in-situ, pre-mining geological constraints. Flow in the upper weathered aquifer follows the topography and drainage occurs towards the major river system.
Groundwater movement within the deeper Karst aquifer is associated with NS trending joints and faults, which have experienced preferential solution, and flow takes place towards the Vaal River and points of abstraction such as Margaret Shaft (DARCY 2002). These joints and faults form structural controls that compartmentalise the Karst aquifer, shown in Figure 1. The NS trending Pilanesberg dyke separates compartments A and B.
Recharge in the KOSH area varies between 6% and 12% of mean annual precipitation and is relatively high due to soils which are transmissive and areas of karstification (dissolution) which allow rapid infiltration. Recharge also takes place along the course of streams such as the Koekemoer Spruit. It is likely that the discharge of contaminated water from Margaret shaft into the Koekemoer Spruit has led to the artificial recharge of poor quality water to the underlying aquifer, resulting in recirculation and causing a deterioration of groundwater quality in the vicinity of this stream. (DARCY 2002)

__Figure 1__ Compartmentalisation of the dolomites (taken from L&W Environmental, 1993)



Groundwater flow

Dewatering the underground mine workings at the Margaret shaft impact the water levels in the Karst aquifer along structural controls, to form a cone of depression, Figure 2. Features such as the NS trending Kimberlite dyke and the Pilanesberg dyke dictate the shape and extent of the drawdown cone. L&W Environmental (1993) describes three distinct water tables in the area:

- A perched water level at the interface between the soils and/or weathered rock and the solid bedrock, which will fluctuate seasonally and varies between 1-3 meters below surface (mbs).
- The fractured aquifer of the Malmani dolomite and the natural water level varies between 5 - 100 mbs.
- The third is a deep, artificial water level in the mine itself and represents the level of controlled flooding in the mine workings. The resultant cone of depression has water levels that drop from 1335 mamsl, to the north, to an estimated 1000 mamsl (see Figure 3), or to the level of the flooded mine workings, some 300 - 500 mbs.

Based on the work done by L&W Environmental (1993) the cone of depression is estimated to be 360 m deep, 6 km wide and 9 km long at the time the study was undertaken. Most of the groundwater found within the boundaries of the drawdown cone, or water discharged into it, is likely to flow towards the centre of this depression to be pumped out to surface again.

However, very little information exists to substantiate this cone of depression and this is all still conceptual thinking; L & W Environmental (1993) had no water level measurements available for the deeper aquifer. Pretorius, 2004, measured water levels in the vicinity of the Margaret shaft in the upper weathered aquifer, which showed no significant influence from the cone of depression. This indicates that very little connection to the upper weathered aquifer exists, except for where the different shafts penetrate the weathered dolomitic aquifer and forms a direct connection to the deeper Karst aquifer.

Figure 2 *Scanned image of Margaret shaft spatial extent of cone of depression in relation to geological structural controls (L&W Environmental, 1993)*

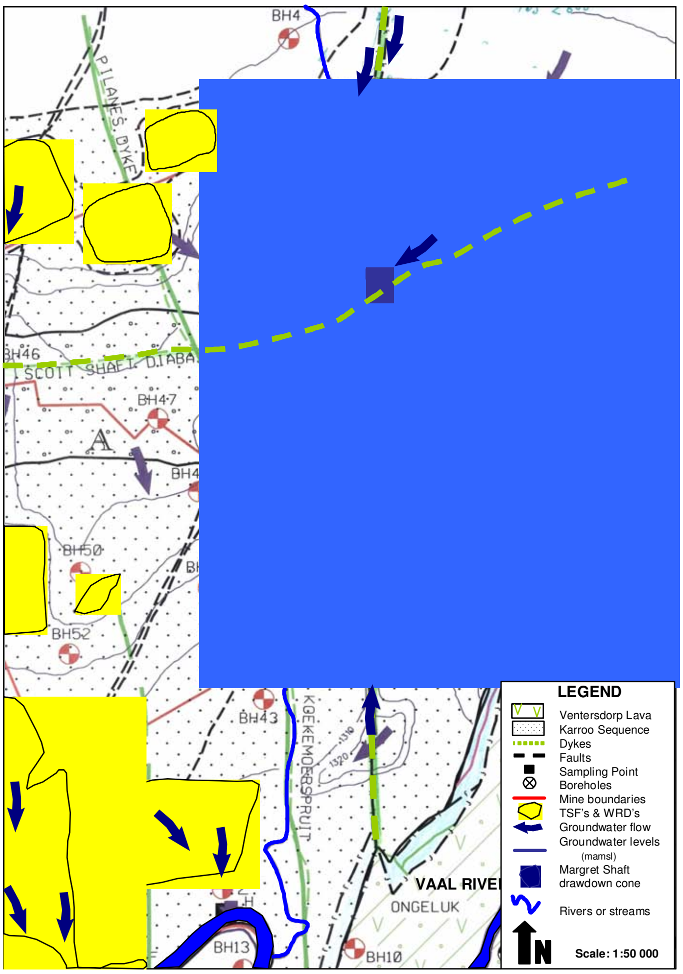
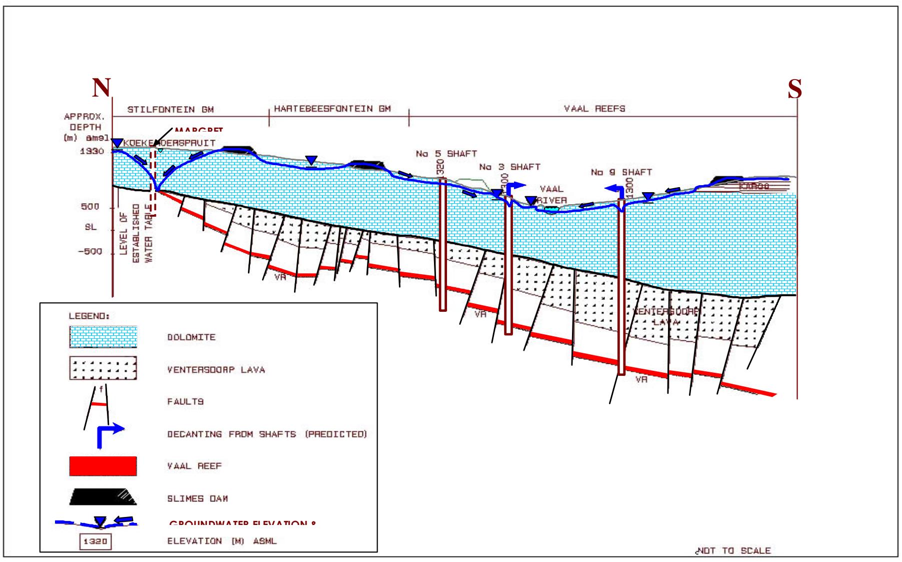


Figure 3 *Scanned section of Margaret Shaft cone of depression in relation to the general geology (L&W Environmental, 1993)*



Other considerations

Water flowing towards the shaft consists of groundwater from the upper weathered aquifer, the Karst aquifer, geological structures, other shaft areas and old flooded underground workings. Contamination from surface, e.g. pollution from the reworking of old tailings dams in the vicinity of the Margaret shaft or acid mine drainage from the old flooded mine workings, will also move preferentially in these structurally controlled and karstified zones and can enter the shaft at various levels.

From on-site investigations, Pretorius, 2004, identified the sources of water entering the Margaret shaft and these include water from Toni shaft, Charles shaft and the upper levels of Margaret shaft. Water quality at the upper levels of Margaret shaft indicates high levels of contamination from sulphate and sodium-chloride. Because of the upper levels' proximity to surface this contamination is most likely pollution from gold mine tailings and rock dumps.

Much speculation exists regarding the recirculation of contaminated groundwater pumped and discharged at surface. The water pumped from the Margaret shaft was previously discharged into the Koekemoer Spruit, an adjacent non-perennial river. Aquatic ecosystems in the Koekemoer Spruit were dependant on this discharged water, since water would otherwise only be available in this stream at high rainfall events a few times a year. At present the water is discharged, via a dedicated pipeline, directly into the Vaal River, a perennial river at a fair distance from the previous discharge point. With the change in discharge arrangements it will be interesting to see the change in the aquatic ecosystems and the change in volume and quality of recharged groundwater reporting to the Margaret Shaft.

Acknowledgements

The Authors would like to thank Stilfontein Gold Mine and the Margaret Water Company for giving them the opportunity to present this information at the IMWA 2008.

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