GROUND PENETRATING RADAR FOR DIAGNOSIS OF FAULTING ALONG PARTING PLANES IN SOUTH AFRICAN BUSHVELD MINES

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1. INTRODUCTION

The Bushveld Complex in South Africa is a layered igneous intrusion that contains the world's largest known deposit of platinum group metals, as well as significant deposits of vanadium and chrome [1]. It spans about 350 km from east to west and is mined from surface down to about 2300 m. The platinum group metals are concentrated in two planar orebodies, the Merensky and the UG2 reefs, which are between 0.7 m and 2.5 m thick, and which dip towards the centre of the complex at between 8° and 20°. Mining is largely by hand-held drill and blast, with some mechanized sections.

One of the primary risks to miners on the UG2, is the presence of parting planes in the immediate hangingwall of the excavation. The parting planes are typically chromitite seams, ranging from a single band to many thin bands, typically 0.5 m to 12 m or more above the excavation. The chromitite seams form parting planes as they are substantially weaker than the surrounding strata. Ground Penetrating Radar (GPR) is now routinely applied on many mines to determine the distance to the parting plane, in order to ensure that adequate support is put into place to prevent falls of ground. GPR is an excellent tool for detecting the chromitites, because the surrounding rocks, anorthosite, norite, or pyroxenite, are typically very resistive with typical relative permittivities of 8 or 9, while the chromitites have a much higher relative permittivity, typically about 16-20 [1].

This paper discusses the potential of using GPR to identify a different geological risk: flexural slip faults.

2. PROBLEM

Another major risk, somewhat less well understood, is the presence of what are colloquially known as "curved joints" or "cooling domes". These are structures defined by a plane of weakness that runs along and cuts across the strata, including the UG2 and Merensky, and their foot- and hangingwalls. Perritt and Roberts [3] found these structures to be caused by layer parallel faults and linking ramps, interpreted to be flexural-slip structures formed during the bending of the originally horizontal Bushveld Complex into a basin sometime after intrusion. These features are difficult to map where they are not immediately visible in the excavation.

3. METHODOLOGY AND RESULT

GPR observations show how a parting plane can be identified as having a layer parallel fault running along it, as part of a flexural slip structure. If a the parting plane is also part of a fault structure, it will be weaker than expected, and there are likely to be nearby ramp faults that can lead to extensive falls of ground. Observations were carried out using a Sensors and Software RockNoggin GPR, with a 500 MHz antenna [5]. Processing was undertaken in Reflex [4]. Two lines were surveyed, one on strike and one on dip, ie perpendicular to one another, in the same area. The images presented here have had only simple processing applied: average removal, low pass filtering and automatic gain control.

From the figures overleaf, the radar image quality is excellent, confirming that the Bushveld Complex can be an excellent environment for radar. The first line, Figure 1, shows the expected radargram for a typical hangingwall where parting planes are present. The second line though, in Figure 2, showed unusual corrugations at about 28 ns into the hangingwall, corresponding to a height of about 1.6 m above the excavation, at an assumed radar velocity of 0.11 m/ns. The cause of the corrugations was not immediately obvious until the work reported in Perritt and Roberts [3], which showed a picture of the effect of a flexural slip fault that caused a large block to fall out of the hangingwall, Figure 3. The fault planes are characterized by obvious corrugations. The hypothesis presented here is that when the radar profile runs parallel to the corrugations, the reflection appears flat, as in Figure 1. If the radar profile crosses the corrugations, characteristic hyperbolas are produced by the corrugations. Modelling will be undertaken to confirm this hypothesis.

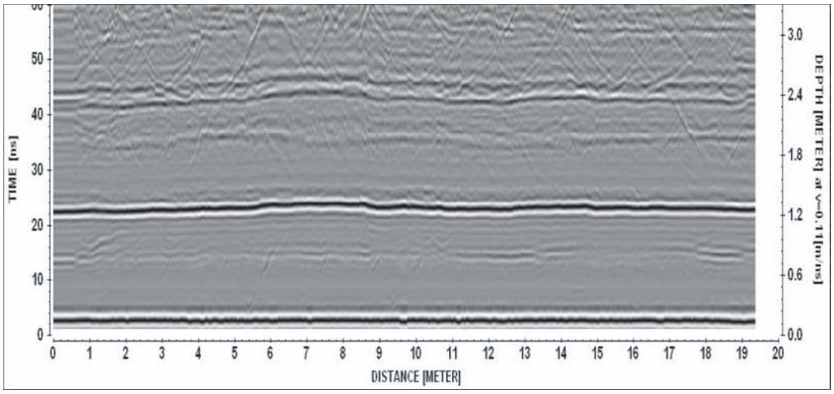

Figure 1. GPR line looking up into the hangingwall of the UG2, in a bushveld mine.

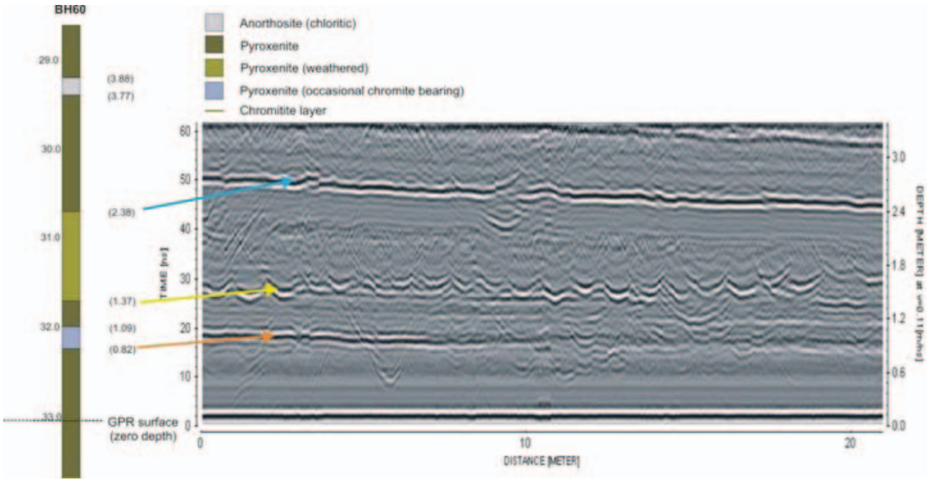

Figure 2. GPR line looking up into the hangingwall of the UG2, perpendicular to that in Figure 1, together with a log of the expected geology in the hangingwall. Note the marked corrugations at about 28 ns.

Figure 3. A block that fell out of the hangingwall along a flexural slip fault (Perrit and Roberts [3]).

4. CONCLUSIONS

GPR has been shown, under certain conditions, to be able to map an interface, the flexural slip fault, that is known to exist in platinum mines, but that is difficult to map using any other technique. The difference in radar response depending on the survey direction shows that the nature of the interface may not be determined if lines are only run in a single direction. Ideally, survey design should take into account the expect direction of such flexural slip features.

Further work is required to characterize the surfaces of typical flexural slip structures, to map more of these structures using GPR, and to confirm that the GPR is picking up the corrugations characteristic of faulting. If it can pick up faulting, GPR will become even more useful as a safety tool in Bushveld platinum mines.

11. REFERENCES

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