CHAMBOVET, G. Keynote Address: Seismic method applied to platinum exploration, a success story!. *International Platinum Conference 'Platinum Adding Value'*, The Southern African Institute of Mining and Metallurgy, 2006.

Keynote Address: Seismic method applied to platinum exploration, a success story!

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Introduction

Applied geophysical methods such as the surface seismic method have been applied for many years and in many places, mainly for oil exploration and to a lesser extent for mineral deposits' exploration in sedimentary basins.

The seismic method fundamental is based on the variations of acoustic impedance in a layered earth model and such variations at each main geological interface create reflected waves that are processed and imaged in order to output a clear picture of the subsurface structure.

The geology of South Africa was historically, and even until recently, considered as unfit for seismic exploration and the mines were always reluctant to spend any portions of their exploration budgets on these techniques.

Hard rocks and high P-waves velocities were creating quite a hopeless model for any mine geologist or geophysicist (if any), unsuitable for the proper use of seismic waves to image their subsurface problems.

Boreholes were considered the only reliable tool to derive a geological image of the mine structural features and were linked sometimes with surface methods such as aero-magnetism.

The obvious flaw of this methodology was the inability to derive a continuous image from a discrete set of measurement points. Surface 3D seismic is the tool that gives a reliable solution from the initial model extracted from the boreholes, as even the aero-magnetism mapping gives a flat image, unable to show any depth correlation from well to well.

The first 3D surface seismic surveys were recorded in the early Nineties only for the gold mines of the Witwatersrand, after a series of serious new shaft sinking failures. The wrong geological locations of these shafts resulted in financial loss of several hundred million rands. The era of 3D seismic just started in South Africa and till 1997, all seismic done in the country was for gold exploration with geological target depths close to the oil exploration average depth of investigation. A very important breakthrough was reached when the depth accuracy of the seismic image was tested in real scale as the stopes were surveyed.

An error of amplitude of 20 m was usual when true depth was compared with the seismic image predicted depth and shape. This accuracy, completely unknown in oil exploration, started to gain supporters of seismic methods in the mining community but the cash problems and the concentration/disappearance of gold mines in the late Nineties, led to the belief that seismic would be just a very short exploration activity for the mining sector.

But starting in 1998 with Impala, a tremendous and continuous 3D surface seismic activity occurred in the platinum mining sector. The seismic world got used to new terms such a Merensky and UG2, which have replaced the VCR and black reef.

If the primary expectation of platinum surface 3D seismic was to determine and ascertain new shaft locations, as for the gold mines, the quality of seismic data led the mine geologists to require smaller and smaller imaging of geological objects. In addition to the main structural image, small faults, potholes, and shear zone were common expectations of platinum seismic. In a constant velocity environment, what saved the day was the sharp density contrast between the PGM reef and the embedding geology. A good contrast of impedance exists in the whole Bushveld and is sufficient to have enough reflected waves from the PGM main layers to build a high quality seismic image of the subsurface.

Recent advances in technology have led in less than 10 years to major improvements in the seismic acquisition by using high frequency vibrating seismic sources, but also in processing and interpretation. With these latest improvements, seismic can detect objects of 7.5 m size, either fault throws, flexures, etc.

The PGM formations of the Eastern limb of the Bushveld Complex are now accessible for seismic imaging, with cost per square kilometre comparable to the borehole cost of the same surface unit. The economically acceptable seismic surveys can be used for UG2 structural imaging up to a depth of 210 m below surface.

Linked with borehole information, 3D seismic today offers a wide range of information for mine development: structural imaging, small fault detection, pothole and shear zone identification.

All users of 3D seismic have also used this technique as a tool in the process to qualify their mineral reserves and especially from the category 'inferred' to the category 'measured'.

Junior mining companies, in the feasibility stage of their projects, are also quite eager to use seismic as a reserve certification tool, when they present financial statements to future potential investors.

The current high demand on platinum, pushes the seismic towards new technologies to be implemented in order to improve the final image. Using surface and borehole seismic together or acquiring seismic surveys with multi-component receivers have been just introduced in South Africa.

In less than 10 years, surface seismic by adapting its methods to the special case of the Bushveld, became a mandatory step in mine development and ore resources evaluation. As part of the 'seismic' world we are proud to be a major player the 'surge' of platinum exploration and production in these last years and we will certainly increase our synergy with the mine sectors in the exciting coming years.