Productivity in Platinum Mining

A CONTINUING PROGRAMME OF SUCCESSFUL DEVELOPMENT IN UNDERGROUND MECHANISATION

Notable progress has been made by Rustenburg Platinum Mines in their efforts to increase mechanisation and to improve efficiency during mining operations; a brief account of some aspects of this work is presented here. It is anticipated confidently that such means will help them to maintain supplies of the platinum group metals at prices which both encourage demand and ensure supply.

The Bushveld Igneous Complex includes three extensive geological formations which contain platinum group minerals; these are the Merensky Reef, the Upper Gabbro Seam 2 and the Platreef. While it is not possible to determine with accuracy the platinum group metals content of the Complex, or the amount recoverable by existing mining techniques, it has been estimated that the reserves in the Merensky Reef and the Upper Gabbro Seam 2 amount to 1,330 million ounces, of which 800 million ounces are platinum (1). When this is compared with the world output of the six platinum group metals in 1977, about 6.4 million ounces (2), it is clear that there are sufficient reserves to meet all foreseeable needs for many decades.

The Merensky Reef

At present commercial mining of the Complex for platinum group metals is confined to the Merensky Reef and the mines situated on it are the only major ones in the world producing platinum as the primary metal. As primary producers they have the potential to respond most rapidly to the changing needs of the platinum users, and Rustenburg Platinum Mines Limited—the world's largest producer of the platinum metals—is actively engaged in a programme of research and development designed to increase the productivity and efficiency of all their operations, in line with world market needs. Previous articles in this journal have described the discovery and the geology of the Merensky Reef (3, 4, 5) and the mining, extraction and refining of the platinum metals (6, 7, 8, 9, 10), while over the years the expansion of output by Rustenburg Platinum has been reported frequently as capacity has been increased to about one and a quarter million ounces of platinum a year. Their mines form the world's biggest underground mining operation and this article features some of the areas where increased effort has been committed to achieving significant improvements in the utilisation of resources, and specifically labour productivity during mining operations. Similar programmes are examining the surface facilities, such as those shown in Figure 1, which complement the underground operations.

Where the Reef meets the surface it outlines a vast oval, approximately 200 miles across the longer axis, and the platinum-bearing seam is frequently described as saucer-shaped because it dips inwards towards the centre of the complex. Rustenburg Platinum Mines are currently working three sections of the seam: the Rustenburg Section adjacent to Rustenburg town, the Union Section about 60 miles to the north and the Amandelbult Section some 15 miles to the north-east of Union. In each locality the degree and direction of the dip of the platinum bearing reef varies. For many years the bulk of the material extracted from the relatively shallow mines was brought to the surface by inclined haulage systems which follow the plane of the Reef. Now, however, deeper workings have increased the need for vertical shafts for both haulage and ventilation purposes, and the

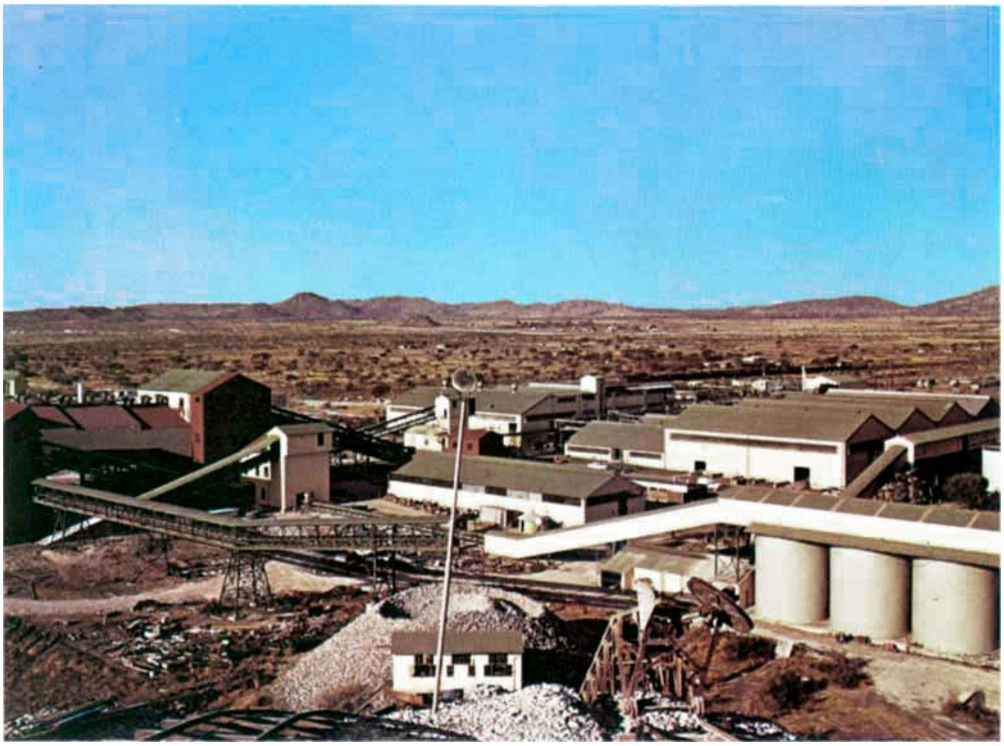

Fig. 1 The Bushveld Igneous Complex of central Transvaal contains three extensive geological formations that contain platinum group metals, although at present they are only mined commercially on the Merensky Reef. The mines of Rustenburg Platinum form the world's largest underground mining operation and the processing of material brought to the surface, by inclined haulage systems and vertical shafts, requires extensive facilities, possibly in remote country areas

sinking of these is one of several operations to benefit from continuing research and development work.

Shaft Raiseboring and Sliping

Traditional shaft sinking methods involve making a hole in the ground which is progressively deepened until the required depth in the earth is reached. If underground access is already available to the position of the bottom of the proposed shaft the method known as raise boring may be employed, and Rustenburg Platinum Mines has successfully used this technique during the development of their underground programme. It involves boring a pilot hole vertically downwards to the existing access at the bottom of the proposed shaft and then reaming upwards, that is enlarging, from the lower access point such that the diameter of this hole is the required shaft width. The broken rock falls to the bottom of the hole and the technique allows for greater flexibility in handling the spoil. In addition to lowering costs and saving time the safety hazards associated with the older methods have been reduced significantly.

Incline and Haulage Development

The degree of success achieved with raise boring has also been obtained with the mechanisation of incline and haulage development. Rigs incorporating one or more pneumatic drills, such as that shown in Figure 2, are now in general use to drill the holes required for shot firing during haulage development, and their successful application has contributed to higher productivity and improved working conditions. Mechanical loaders, such

Fig. 2 Single or multi-boom rigs are now in general use for drilling the holes which carry the blasting explosives during haulage development. The introduction of such rigs has improved working conditions and reduced operator fatigue, and has contributed to increased productivity

as those shown in Figure 3 carrying out cleaning operations during incline development at the Amandelbult Section of the mines, have significantly improved the rate of advance with a reduction in the amount of labour required.

Mechanisation of the Stoping Operations

Stoping, that is excavating ore from which the platinum group metals will be extracted, is the mining process which uses the largest number of operators and is consequently an area where mechanisation could provide considerable benefit. As the platinum bearing minerals mostly occur in a narrow seam within the Reef the stoping width is kept to a minimum, so that the platiniferous ore hoisted to the surface for milling and extraction is diluted as little as practicable by waste material broken from above and below the seam. One result of this is that the development of mechanical equipment is hindered by the need to work in a stope which is frequently only 80 cm high.

Ore is broken from the Reef stopes by explosive charges which are set in carefully positioned holes drilled in the working face of the stope. At one time all drilling was done by hand held drills but now several varieties of partially mechanised drilling rigs have been tested, and some adopted for general use. The primary objective of these rigs, which are only regarded as an intermediate step towards full mechanisation, is to increase productivity by reducing operator fatigue and improving drilling accuracy. In addition, more complex stope drilling rigs designed and manufactured to Rustenburg Platinum Mines own specifications have been developed over a period of years to a stage where their practicality and reliability

Fig. 3 Loaders powered by compressed air have increased productivity appreciably during incline and haulage development. The rail-mounted machines shown here scoop up rock broken from the work face in front of them; the buckets are then swung over the loaders to tip the rock into a wagon ready for removal from the working face. Because of the head room required, such machines cannot be used in the stopes

have been proved. The equipment illustrated in Figure 4 enables a skilled operator to increase his productivity by over 300 per cent. The broken rock blasted from the Reef plane must be removed from the stope and passed to the haulage roadways along which it is transported to one of the inclined haulages, or vertical shafts, for hoisting to the surface. Traditionally removing rock from the stope face has necessitated a considerable amount of manpower, due in part to the physical restriction imposed by the very narrow stope width. Now a programme designed to mechanise this operation is nearing completion, despite difficulties created by the lack of geological uniformity in the working areas.

Hangingwall Support

The stope hangingwall, that is the rock formation which rests on the platiniferous seam, is controlled by a system of stope supports. Packs of timber were conventionally used for this purpose, but a system of timber stick support and concrete has now been designed to achieve this hangwall control with the minimum use of both timber and labour. Manhandling of timber into the stopes has been replaced wherever possible by the use of mono rope winches, again achieving significant savings in labour requirements. When mining at increased depths, and where the technique of longwall mining is practised, a system of concrete pack supports has been introduced successfully to give improved control of the hangingwall. For this form of support the concrete is pumped from the surface into expanded metal frames containing cloth bags positioned in the stope. During filling the sides of the bags are restrained by the metal frames, but these are removed for use elsewhere once the concrete has set. By pumping the cement mix from the surface directly to the working stope a saving of manpower is achieved and shaft hoisting capacity is increased.

Longwall Mining

Conventional scattered-mining involves the removal of the mineral seam from a series of systematically arranged panels over a comparatively large distance on strike with uneconomic sections of the orebody left in-situ to provide selective mining as well as regional support. The fundamental principle of longwall

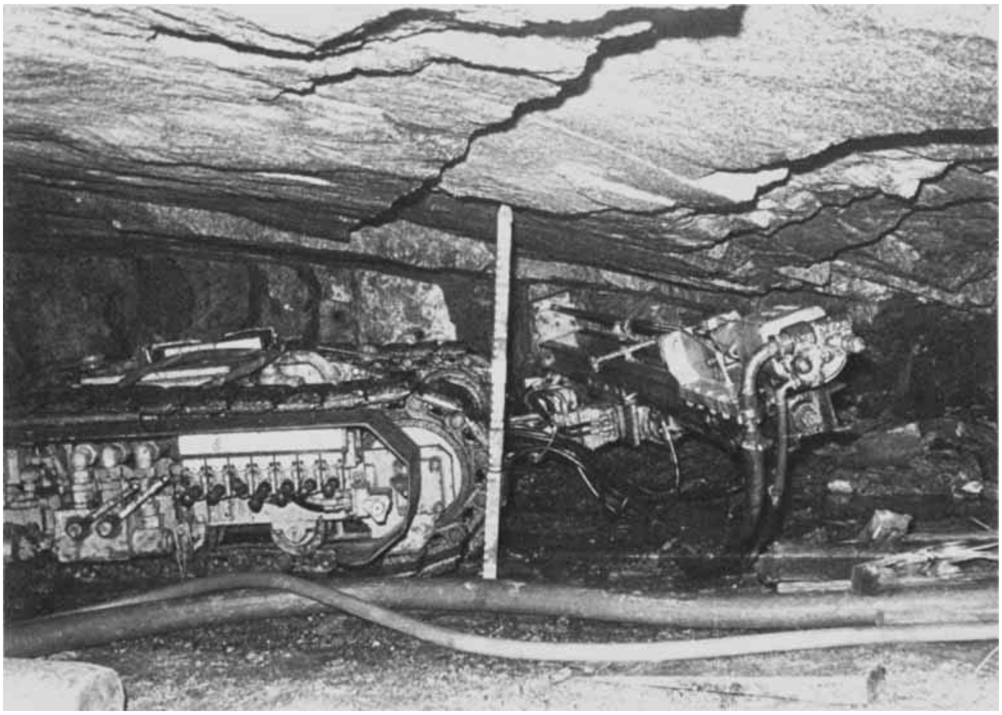

Fig. 4 Rigs mounted on crawler tracks and powered by compressed air have been designed and built to Rustenburg Platinum Mines' own specification to facilitate mechanical drilling in very narrow stopes. The sophisticated drilling rig shown here enables a highly trained, skilful operator to increase his productivity by over 300 per cent and has demonstrated its mechanical reliability and economic viability for drilling the hard rock of the Merensky Reef

mining is the removal of all the seam in one continuous dip face. Since the first longwall face was brought into production by Rustenburg Platinum in 1976 increasing areas at all three sections of the mine are being worked by longwalling, which now accounts for approximately 35 per cent of the total area mined. As well as better extraction of the seam, the advantages of this system include greater opportunities for mechanisation, higher productivity, improved ventilation and ground control, and better supervision.

Conclusions

The continuing development of mining equipment and techniques, such as those briefly described here, demonstrate a desire on the part of the world's largest platinum producer to utilise economically viable technology for the efficient mining of platiniferous ores. Similar programmes of research and development are being carried out on surface operations, on the mechanical handling of ore and waste materials, and on many stages of the extraction and refining processes.

In addition Rustenburg Platinum Mines is exploring various areas of the Bushveld Igneous Complex, as part of a continuing evaluation of possible future mining areas. Although the whole range of platinum-bearing ores is being evaluated, particular emphasis is being placed at present on the Platreef in the Potgietersrust district. Prospecting results so far indicate that this area, which was originally mined in the 1920s, has the potential to support a major new mine for platinum, nickel and copper. Furthermore, it appears that this orebody might be exploitable by open-cast methods that may be significantly cheaper than the cost of conventional underground mining. However, the metallurgical characteristics of the ore are different from those currently being worked, and much work has still to be done to evaluate the deposit.

By such exploration, research and development Rustenburg Platinum Mines will contribute to the availability of platinum metals from the rich deposits in the Bushveld Igneous Complex in the quantities, and at the time, that they are required by the platinum metals users of the world.

Acknowledgement

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The Platinum Metals are Essential to Industry

Supply and Use Patterns for the Platinum-Group Metals, National Materials Advisory Board Publication NMAB–359, National Academy of Science, Washington, 1980, 197 pages

The platinum group metals continue to be used for a wide and increasing variety of applications because their remarkable properties, particularly their freedom from chemical attack—even at high temperatures, their ability to catalyse a large number of chemical reactions, their high melting points and strength, make them more effective than other materials that are initially cheaper and more readily available.

A most valuable study of the present and future uses of these metals and their compounds has just become available. Conducted by a panel drawn from processors, suppliers, users and minerals economists, it is based upon data compiled up until the end of November 1978 and is concerned mainly with the situation in the United States of America. However, the information it contains makes it essential reading for platinum producers and users, world wide. The geology, reserves and resources of the platinum group metals are surveyed, and as further background information a summary of their chemical and physical properties is given. This is followed by an account of their extraction, refining, and recycling after use. The production and fabrication of the metals and some of their compounds are also briefly considered.

Production and consumption statistics are given, and present and potential applications are discussed. Over the 25 year period since 1954 the total world production of the platinum metals has increased by 850 per cent, thus generally keeping pace with the enormous expansion in their utilisation as industry has responded to such crucial problems as the need to increase the world's food supply, to utilise fuel and energy more sensibly, and to limit further damage to the environment. In addition to the many industrial uses, the platinum metals are also used for a variety of other purposes including medical and dental applications, in laboratory investigations and for jewellery. It is suggested that the requirement for the platinum group metals will more than double in the next 12 to 15 years, although this increase will not be the same for all the six metals. One significant increase in demand for platinum is predicted to be for the production of first generation commercial fuel cells, an application which seems close to realising its potential as a viable, environmentally acceptable source of electrical power.

While some of the conclusions of the study relate especially to the U.S.A. most are relevant to all industrial countries, as it is stressed that the platinum metals, particularly platinum, palladium, rhodium and iridium, are essential to many of the most vital industries.

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