Chapter 4

MINING, BENEFICIATION, AND REFINING

4.1. Mining

Opencast mining of the PGM is seldom resorted to, although such mines exist where the sulphide orebodies are more massive, as at Noril'sk in Russia, and at Sudbury and Lac des Isles in Canada. This method is also being used on the more massive Platreef ores north of Potgietersrus in the northern Transvaal, South Africa. At both the Russian and Canadian deposits referred to, various mining methods were used to extract the nickeliferous ores, including stoping, cut-and-fill, block-caving, and shrinkage stoping. Some mines are highly mechanized, and use large-tonnage track or trackless mining. Placer deposits are usually exploited by bucketline dredging, although labour-intensive hand methods were also employed in some areas in the past.

Although there are a great variety of mining methods that could be used to exploit PGM-bearing ores, the methods described in this section are heavily biased towards those utilized in South Africa. Here, mechanized stoping methods are too costly because of the attenuated thickness of the ore-bearing layers. The South African mining methods are therefore highly labour-intensive stoping and tramming.

Outcrop PGM mines in South Africa at first employed inclined shafts, or winzes, either on or just below the shallow-dipping ore layers. Such inclined shafts were spaced about 1 km apart along the strike of the mineralization, and were originally almost invariably sunk to exploit the Merensky reef, as they provided easy and immediate access to the ore. (However, near the surface, the Merensky is highly oxidized, making it extremely difficult to extract the precious and base metals.) The UG2 ore layer was almost always exploited at deeper levels in earlier times, once the exploitation of the Merensky reef was already well advanced.

As the inclined shafts become deeper and uneconomical to exploit — usually at a depth of about 1200 m down-dip — the payable ore has to be accessed by way of vertical shafts. Some of these take up five years to equip before mining operations can commence. However, vertical shafts have a rather limited life, and provide limited access to the orebody or orebodies; so that either a system of subvertical shafts is sunk from underground, or new and deeper shafts have to be sunk at pre-planned locations from surface to access the deeper orebodies. Because of these factors, particularly in the larger operations (and commonly also depending on the mineral rights, option holdings, and surface ownership on the down-dip side), the planning and sinking of shafts becomes an on-going exercise. Owing to the very high temperature gradient in the Bushveld rocks, refrigeration is almost mandatory below a vertical depth of about 1000 m.

From each vertical shaft, drives at each level, chosen at fixed vertical intervals below surface, are developed towards the orebody. The drives are equipped with an air- and water-reticulation system, in addition to rail tracks for tramming materials and ore to the shaft, which hoists the ore to surface. Footwall haulage drives follow the strike of the regular orebody layers. From these, crosscuts are driven to intersect the orebody in order to draw off the ore blasted in the stopes, by way of a system of near-vertical ore passes that act as temporary storage areas for the broken ore.

Ore from the up-dip or longwall stopes (longwall stoping was introduced quite late to increase efficiency and reduce costs) is fed through the ore-pass into specially designed hopper cars, which are transported to the shaft by either diesel-driven or (more usually now) electric locomotives. At the shaft, the ore is tipped into the main-shaft ore-pass chutes, which convey the ore by gravity to loading boxes at the bottom of the shaft. The ore is hoisted by skips of some 5 t capacity to shaft ore bins, from where it is transported to the concentration plants, either by rail or, more rarely, by road. Double-deck cages are usually employed for transporting men and materials in the shaft.

As regards the stoping procedures, raises are developed between levels, usually at 33 m centres along strike. The raises are connected with stope-preparation drives, some 3 m wide and 1 m high to ensure full exposure of the economic layer for sampling. When the raises are holed, air and water pipes are connected to the levels above for use during stoping, and are reclaimed after use. During up-dip or longwall stoping, pillars are left, spaced at about 32,5 m on dip and at about 21 m on strike — depending on the conditions of the hanging wall rock — although timber or concrete packs are almost invariably added for stope support and safety. After stoping, the panels are swept to within 15 to 20 m from the stope face. The ore is deposited in scraper gullies, which may or may not coincide with the original raises. The broken ore is usually cleared into the ore-pass by means of a scraper winch at the base of the gully. Cleaning is mostly carried out by the night shift, since drilling and blasting is done during the day shift. Worked-out areas are cleaned by shovel and sweeping, and are subsequently either barricaded off or backfilled with waste rock.

These procedures apply equally to the Merensky and the UG2 stopes. The amount of each orebody being exploited varies from mine to mine — according to re-