Maandagshoek, which was thought to have an initial mine and mill capacity of 50 000 t/month. The original scheme envisaged for Atok was to expand mine and mill capacity to 70 000 t/month by 1990 and 100 000 t/month by 1993. However, these goals were thwarted by unforseen labour disputes that involved dismissals and retraining, so that the lesser capacity was only achieved in July 1992. Further expansion has been deferred, but the sinking of a vertical shaft will, when completed, expand the mine output to 3215 kg or 100 000 oz per year. Lebowa Platinum and RPM have a long-standing toll-refining and marketing agreement, so the entire output of the mines will be processed by the RPM facilities.

Potgietersrus Platinum Ltd. The mining of the Platreef at Potgietersrus has always been on the cards, but it was seriously mooted only in 1988 as a possible underground mine. RPH and Lebowa, who owned Potgietersrust Platinums Ltd at that time, formally announced their intention of exploiting the Platreef by opencast methods in September 1990, although the funding, the scope of the operation, and the eventual output have been modified many times. The original average grade for underground mining was 8,7 g/t PGM + Au over a width of 3,7 m, but the opencast grade is said to be 5,0 g/t PGM + Au with 0,27 per cent nickel and 0,14 per cent copper (that is, a nickel grade double that of the Merensky reef and 25 times that of the UG2, according to Johnson Matthey). The open-pit reserves are said to be 88 Mt to a depth of 250 m (giving a life of 30 years), and an additional 167 Mt to a depth of 750 m. From this, the calculated production will be about 240 000 t/month (officially 200 000 t/month), or about 2,93 Mt/y, but this is expected to increase by 50 per cent after about 9 years as the operation moves into areas where the PGM grade is lower. According to Shuttleworth (1985), the operation will commence on the farm Sandsloot 236 KR but, as reserves dwindle, mining will move to the deposits on Overysel 815 LR and Zwartfontein 818 LR, thus apparently giving rise to three major opencast pits. The production of 200 000 t/month is expected to yield 5288 kg (170 000 oz) platinum, 5132 kg (165 000 oz) palladium, and 404 kg (13 000 oz) rhodium per year. This mine is expected to have one of the lowest cost structures in South Africa, particularly because it can be mined by both opencast and underground mining methods. The ore is to be processed in a concentrator with two process routes, each with a capacity of 100 000 t/month. The flotation concentrates will be transported to Rustenburg for smelting and final refining.

The contribution of the Rustenburg Group to the South African production of PGM will be discussed below. At Rustenburg, smelting is done by Matte Smelters and refining is undertaken by Matthey Rustenburg Refiners (MRR), in which RPH holds the majority investment. A further refinery, managed by MRR, is situated at Wadeville near Germiston, just east of Johannesburg. The base metals are refined at Rustenburg by a wholly owned subsidiary, Rustenburg Base Metal Refiners. Apart from the PGM, gold, silver, nickel, and copper, as well as cobalt sulphate, sulphuric acid, and sodium sulphate, are produced at the mines. At Wadeville, metals of high purity are produced (platinum and palladium 99,95 per cent; ruthenium, rhodium, iridium, and osmium 99,9 per cent), together with metal sponges of the individual PGM. Also at Wadeville, a separate company, Johnson Matthey (Pty) Ltd (a subsidiary of the well-known British parent, see below), produces rhodium–platinum catalyst gauze, platinum–rhodium thermocouples, rhodium–platinum bushings, platinum and palladium electrical contacts, platinum crucibles and laboratory-ware, dental alloys and medallions, PGM salts and chemicals, as well as many other PGM products for the South African market. Some 3110 kg or 100 000 oz of RPM's future PGM output will be sold domestically to a plant built jointly by Johnson Matthey and Samcor, a producer of motor vehicles, for the local manufacture of vehicle-exhaust catalysts. All surplus PGM output by RPM is exported, mainly to Johnson Matthey in the UK for further distribution. Rustenburg's refinery capacity on last reporting in 1979 (Roskill) was about 31 100 kg or 1 million oz of platinum, 12 440 kg or 400 000 oz of palladium, 2052 kg or 66 000 oz of ruthenium, 1680 kg or 54 000 oz of rhodium, and 373 kg or 12 000 oz of iridium per annum.

The Rustenburg companies have had a long association with the London-based Johnson Matthey Plc which, apart from being a major shareholder in MRR, is also responsible for the global marketing of Rustenburg's PGM output through its international network of branches and manufacturing plants such as Matthey Bishop in the USA. Johnson Matthey also refine the PGM (particularly from Rustenburg's gravity concentrates) at its plants at Royston and Brimsdown in the UK. Under a long-term agreement, part of RPM's PGM output is purchased by the Engelhard company, which runs a major refinery at Cinderford in the UK, and also produces specialist electrical and electronic components.

3.1.2. The Impala Group

Impala Platinum Holdings Ltd (IPH) is the ultimate holding company of Impala Platinum Ltd. Both companies are currently domiciled in the Republic of Bophuthatswana. After Rustenburg, Impala is the second-largest producer of platinum in the western world. IPH is controlled by the South African Gencor group (51 per cent). Impala has a 27 per cent interest in both Western and Eastern Platinum Ltd which are controlled by the London-based company Lonrho Plc (see below). Impala also acquired from Sanlam a 55 per cent interest in Messina Ltd, and holds a 38 per cent interest in Barplats Investments (formerly held by Rand Mines), the holding company of Barplats Mines Ltd. The details and operations of these companies will be reviewed later.

The net assets of Impala were R2409 million at 30 June 1992, and the net profit of the company was R266,6 million by midyear 1990, R181,6 million by midyear 1991, and R260,3 million by midyear 1992. The latest 1993 figures (Walker, 1993) suggest that the mine is capitalized at about R3 billion and has a debt of R100 million. These figures partly reflect the consequence of serious and violent labour unrest (37 deaths, 2000 workers dismissed, R11 million damage from looting and arson, 400 000 man-days of labour time lost) that resulted in strikes and other protracted disruptions of production. Estimates of production losses are 2,4 Mt of ore and 3858 kg (120 000 oz) of PGM, although some of these losses can also be attributed to technical mining and refining problems.

Impala commenced mining in 1969 at four mines (Bafokeng North and South, Wildebeesfontein North and South) in the Bafokeng district of Bophuthatswana, in a lease area covering 10 673 ha, adjoining the Rustenburg mines and north of Rustenburg town towards the Pilanesberg. The rated capacity of these mines is 29 550 kg (950 000 oz) of PGM per year. Impala mines both the Merensky reef (95 cm thick) and the UG2 (65 cm thick) with a head grade of 5 g/t. The yield from the Merensky reef is 90 per cent, and that of the UG2 74 per cent of metal content. Impala currently (1993) mines 42 per cent of its ore from the UG2, an increase from 25 per cent in 1989.

Impala announced a projected expansion to produce almost 42 000 kg (1 350 000 oz) by June 1995 but this has been reduced to 40 123 kg (1 290 000 oz) and there are even suggestions that this target may be achieved only in 1997. During 1990, Impala negotiated with the Bafokeng people of Bophuthatswana to mine the area called the 'Deeps', contiguous to, and down-dip from, their present operations (Merensky reef 8,3 g/t over 95 cm, the UG2 is wider but has a lower grade) in order to replace the reserves that have become exhausted in the present lease area. This area is being mined at present (1993). Part of the arrangement with the Bafokeng includes their right to subscribe for 7 per cent of the equity of the operations within their area (this move indicates an improvement of relations with the Bafokeng, damaged in recent times by a royal dispute). However, mining of the 'Deeps' will be capital-intensive, which Impala can ill afford owing to its reduced income resulting from production shortfalls, which has severely constrained its projected expansion programme. The shafts being sunk to exploit the 'Deeps' are No. 15 (sunk to 1690 m from surface, hoisting capacity of 250 000 t/month) and No. 16. The latter, at a cost of R1,1 billion to 1,7 billion, will produce 265 000 t/month when commissioned in 2004, equivalent to 8191 kg of platinum. However, expenditure has been pared to a minimum, and there are indications that much of the new area will be exploited by underground declines operating from the present vertical shaft system. Nevertheless, decisions were taken during the 1992 financial year to increase stoping mechanization from 30 to 85 per cent of the present stoping areas in a bid to increase production. Staff was been cut from 50 000 in 1991 to 37 500 in 1993.

PGM outputs for the mid-years 1991 and 1992 were 33 187 kg (1 067 000 oz) and 26 905 kg (865 000 oz) of platinum; 15 458 kg (497 000 oz) and 12 597 kg (405 000 oz) of palladium; and 2053 kg (66 000 oz) and 2924 kg (94 000 oz) of rhodium. Apart from the labour disruptions, part of the drop in output can be attributed to extensive potholing of the UG2 layer at the Wildebeestfontein North No. 2A shaft, and lower extraction from the No. 11 shaft on Bafokeng South mine. On a calendar year basis, the production of platinum was 33 187 kg (1 067 000 oz) in 1990 falling to 28 464 kg (921 000 oz) in 1991. This compelled the company to buy in some 2177 kg (70 000 oz) of platinum between July and December 1991 in order to maintain deliveries to its customers. Impala may be heading for production shortfalls from its existing four mines, in which case it will either have to exploit the 'Deeps' or to draw PGM from its other holdings, which are reviewed below.

Impala does not apparently expect any PGM from its Karee mine, which has been ceded to the Lonrho operations, as will be discussed later. A possibility will be the holdings of *Messina Limited*, over which Impala gained control in April 1988. These holdings include the following farms or portions thereof in the extreme north-western extremity of the eastern Bushveld: (from east to west) Doornvlei, Naboom, Turfpan, Kalkbult, Kaffirskraal, and the eastern part of Zebedelia's location. The so-called Voorspoed holding near Potgietersrus (location uncertain) is also included in Messina's portfolio. Prospecting results on the former farms have yielded an average grade of 6,49 g/t PGM for the Merensky reef and 6,2 g/t for the UG2. The respective tonnages for the two layers are as follows: demonstrated reserves to 600 m vertical depth, 17,8 Mt and 32,8 Mt; indicated reserves from 600 to 1200 m, 25,2 Mt and 41,7 Mt; and inferred resources from 1200 to 1500 m, 14,5 Mt and 23,0 Mt. The total tonnages are 47,5 Mt and 97,5 Mt. Original planning suggested a call of 60 000 t/month from the Merensky reef and 100 000 t/month from the UG2 to contribute towards the projected Impala output to 1995. However, finalizing of the lease area over the farms listed has been difficult and protracted because of legal uncertainties and the large number of landowners involved. The Voorspoed property at Potgietersrus was projected to be capable of yielding 2333 kg (75 000 oz) of PGM per annum in its own right. Falling PGM prices and an apparent shortage of capital have, however, caused Impala to mothball all the Messina projects for the time being.

In May 1991, an agreement was reached between Rand Mines, Genmin, and Impala, whereby Impala became the controlling shareholder and operator of all the assets of *Barplats Investment Ltd*. These include the former Lefkochrysos mine near Brits, now renamed the Crocodile River Mine and the former Rhodium Reefs, now called the Kennedy's Vale mine in the Steelpoort valley of the eastern Bushveld. Crocodile River was specifically geared to exploit the UG2 reef in the Brits graben, a down-faulted part of the Bushveld Complex near the Hartebeespoort dam. The grade of the UG2