mium 0,80 per cent. The density of the Platreef is assumed to be the same as that of the Merensky reef (3,2). There is, however, a dilemma as regards the depth to which the assessment should be taken. To conform with previous resource estimates that have been universally quoted (Von Gruenewaldt, 1977, and Buchanan, 1979), I have supplied the tonnage to 1200 m depth (Table 2.6) although this has been done very much with reservations in respect of the Potgietersrus figures. Realistically, the Platreef can currently be exploited only by opencast mining methods, say to 250 m depth (dip 45°; for which the amounts of PGE are also supplied in Table 2.6). Only considerably more experience with the mining of the orebody will demonstrate whether underground mining will be practically and economically feasible.

With regard to Table 2.7, one of the earlier published attempts to ascertain the resources in the Bushveld Complex to 1200 m vertical depth was undertaken by von Gruenewaldt (1977), based on recoverable PGE. Regrettably, this work was based on an average 12° dip for all the economic layers of the Bushveld Complex (the actual average dip is 20°), so that the estimate was grossly overvalued. The use of 20° reduces his PGE tonnage from 50 600 to 31 720 t. The oft-quoted data published by Buchanan (1979) of 61 771 t of PGE in the main mineralized layers of the Bushveld Complex unfortunately contain no details of the vital parameters (strike, dip, thickness, etc.) utilized for the calculation. The average in-situ grades used are, however, very much overvalued (Merensky 8,1 g/t PGE; UG2 8,7 g/t PGE; Platreef 7 to 27 g/t PGE), thus seriously overestimating the resources. However, the resource calculations presented here have been based mainly on original trenching and underground workings, augmented by such later published borehole and other information as is available. The staff of the local Minerals Bureau (Van Graan and Fourie, 1992) have had the advantage of being able to use all the confidential drilling information of the mining and prospecting companies (the results of some 650 boreholes and their multiple intersections are housed in the offices of the Geological Survey and the Government Mining Engineer) to establish a reserve base for the Bushveld Complex. Although their results are not vastly different from my own (58 900 t of metals compared with 62 816 t), the parameters used in the derivation are very different in many instances. Van Graan and Fourie's calculations are for PGE+Au, and mine are for only the PGE, and they used lower densities (3,1 for the Merensky and Platreef and 3,9 for the UG2, compared with my 3,2 and 4,3 respectively) for those layers. Their vertical depth was that of the deepest borehole intersection in an area (300 to 3300 m), as against a standard 1200 m vertical depth which I have used. The mean of their depth variation, weighted by strike length, yields an average vertical depth of 1304 m for the Merensky, 1423 m for the UG2, and 850 m for the Platreef, which are similar to my own figures. The total strike lengths for the Merensky are also similar, 304,2 km (Van Graan and Fourie) compared with 302,12 km (present work), but their grades turn out to be lower. Their determination of the various classes of identified resources, and hence their resource base, sensitivity analyses etc. are much advanced compared with those given here, owing to their rather comprehensive data. As regards resources, according to the ISMI classification (Sutphin and Page, 1986), the bulk of the resources referred to in this work are either R1E, R2E, or R1M, and thus exploitable, although some would be inherently subeconomic (but not evaluated), while others would be subeconomic, mostly due to unavoidable mining and extraction losses.

The distribution of the PGM resources of the Bushveld Complex is shown in Figure 2.7.

2.1.5. *Other deposits in South Africa*

Chromitites below the UG2

Since the UG2 has been such a consistently high PGE carrier, the chromitite layers below it have been somewhat neglected, although Cousins and Feringa (personal communication, 1968) were well aware that they contained PGE. Recent work by von Gruenewaldt and his co-workers resulted in published PGE information on these layers (Table 2.8).

Although the rhodium content is similar to that of the UG2 (7,62 per cent), the ruthenium content is remarkably high. Merkle (1989) undertook mineralogical work on these chromitites, and found that between 8 and 96 per cent of the discrete PGE minerals are locked in chromite, and are therefore not recoverable. However, for the balance of the PGE minerals in the silicate matrix, the potential recovery by flotation is estimated to be up to 97 per cent (Pt+Pd+Rh), but less than 50 per cent for Ru+Os. These ores would be interesting only if the chromite was mined (i.e. they are classed as provisional resources), but even then, the cost of a plant to extract the PGE may not be justifiable.

Table 2.6

Calculated *in-situ* and millhead reserves of the individual PGE in the area north of Potgietersrus to an opencast mining depth of 250 m, kg

Category	Pt	Pd	Ru	Rh	Ir	Os	Total
In-situ	414 798	471 330	38 624	26 717	8 809	7 744	968 022
Millhead	201 358	228 801	18 750	12 970	4 276	3 759	469 914

Table 2.7

Calculated *in-situ* and millhead reserves of the individual PGE in the Bushveld Complex to a depth of 1200 m, t

Area	PGE	Pt	Pd	Ru	Rh	Ir	Os
Merensky and Platreef: *In-situ*							
W. Bushveld	15 292,0	8 932,7	4 351,5	1 081,7	570,3	214,5	141,3
E. Bushveld	10 868,2	6 079,3	3 438,2	809,0	338,8	130,3	72,6
Potgietersrus	6 581,3	2 820,1	3 204,5	262,6	181,6	59,9	52,6
Totals	**32 741,5**	**17 832,1**	**10 994,2**	**2 153,3**	**1 090,7**	**404,7**	**266,5**
UG2 *in-situ*							
W. Bushveld	17 064,8	8 892,8	4 087,2	2 322,9	1 330,4	302,2	129,3
E. Bushveld	15 665,6	6 386,4	5 721,8	1 753,6	1 126,6	450,1	227,1
Totals	**32 730,4**	**15 279,2**	**9 809,0**	**4 076,5**	**2 457,0**	**752,3**	**356,4**
Total Bushveld	**65 471,9**	**33 111,3**	**20 803,2**	**6 229,8**	**3 547,7**	**1 157,0**	**622,9**
Less mining*	**2 655,9**	**1 480,4**	**852,8**	**185,4**	**81,8**	**35,6**	**19,9**
Total reserves	**62 816,0**	**31 630,9**	**19 950,4**	**6044,4**	**3 465,9**	**1 121,4**	**603,0**
Million troy oz	**2 019,6**	**1 016,9**	**641,4**	**194,3**	**111,4**	**36,1**	**19,4**
Merensky and Platreef: millhead							
W. Bushveld	10 635,8	6 203,6	3 050,7	748,3	390,5	147,7	94,9
E. Bushveld	8 152,6	4 555,2	2 585,7	606,0	253,3	97,9	54,4
Potgietersrus	4 281,1	1 834,5	2 084,5	170,8	118,2	39,0	34,2
Totals	**23 068,5**	**12 593,3**	**7 720,9**	**1 525,1**	**762,0**	**284,5**	**183,5**
UG2: millhead							
W. Bushveld	13 002,4	6 769,3	3 118,8	1 773,0	1 014,6	228,5	98,1
E. Bushveld	11 742,5	4 787,0	4 288,8	1 314,5	844,5	337,5	170,2
Totals	**24 744,9**	**11 556,3**	**7 407,6**	**3 087,5**	**1 859,1**	**566,0**	**268,3**
Total Bushveld	**47 814,4**	**24 149,6**	**15 128,6**	**4 612,6**	**2 621,1**	**850,5**	**451,8**
Less mining	**2 656,9**	**1 480,4**	**852,8**	**185,4**	**81,8**	**35,6**	**19,9**
Total reserves	**45 158,5**	**22 669,2**	**14 275,8**	**4 427,3**	**2 539,3**	**814,9**	**431,9**
Million troy oz	**1 451,8**	**128,8**	**459,0**	**142,3**	**81,6**	**26,2**	**13,9**

Due to individual rounding, totals may not always tally. The amounts of PGE extracted by mining are based on the best estimates available (1926 to 1992). Where more than one figure was available for a given year, the higher value was accepted

The Insizwa nickel–copper deposits

Four large differentiated complexes of Karoo age (Insizwa, Ingeli, Tonti, and Thabankulu) collectively make up the Insizwa group near the town of Kokstad in the northern Transkei. Their stratigraphy consists of basal olivine gabbros, dunites and troctolites; a central zone of gabbros and gabbronorites; and an upper or roof zone of quartz diorites and monzonites (Scholtz, 1936; Maske, 1966; Cawthorn, 1980; and Lightfoot *et al.*, 1984). The massive and disseminated ores are apparently confined to the base of the Insizwa complex (Waterfall Gorge). They occur as massive, podlike lenses of stratiform nickel-rich (pyrrhotite–pentlandite) ores of up to 1 m thickness, occurring along the basal contact (dipping 30 °N), followed by upper copper-rich (chalcopyrite) ores, either as a zonation in the same ore pod or as near-vertical veins up to 1 m thick that emanate from the massive orebody. The globular disseminated ores consist of small (0,5 to 3 cm) vertically orientated, elliptical pellets that mirror the nickel–copper segregation of the massive ores. Dykes, breccia dykes, or sub-rounded bodies of granophyre intrude the footwall ores.

Limited old underground workings, now abandoned and partly flooded, were developed over a strike of 175 m and for 35 m downdip. The workings were sampled by Scholtz (1936) and Lightfoot *et al.* (1984). The averaged results are shown in Table 2.9. At this stage, the deposit would appear to be very small, but the extensions to the mineralization have not, as far as it is known, been well prospected, particularly in the other complexes of the Insizwa group.

The Uitkomst nickel–copper deposit

This deposit is hosted by a layered mafic to ultramafic body that intrudes the lower Transvaal Sequence (Pretoria shales, Bevet's conglomerate, Malmani dolomites and the Black Reef Formation) on the farm Uitkomst 541 JT in the Carolina district of the eastern Transvaal (Kenyon *et al.*, 1986). This generally conformable sill-like intrusion is of Bushveld age (2025 My), measuring some 5,2 by 1,1 km, with an average