

**ECONOMIC GEOLOGY
RESEARCH UNIT**

University of the Witwatersrand
Johannesburg

WORLD GOLD RESOURCES
REVIEW AT THE END OF THE
1980 DECADE

J.R.F. HANDLEY

. INFORMATION CIRCULAR No. 227

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A REVIEW AT THE END OF THE 1980 DECADE

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WORLD GOLD RESOURCES
A REVIEW AT THE END OF THE 1980 DECADE

by

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ECONOMIC GEOLOGY RESEARCH UNIT
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AUTHOR'S NOTE

The data compiled in this report is from many sources ranging from books, company annual reports, scientific papers, journals, press releases and reports and studies by other analysts. In view of the vastness of the subject and because of the constant change due to mining, new discoveries, economic restraints, markets and politics, there is no stage at which the total gold resource for any country is static. The results presented are, therefore, a "best estimate".

Reference to the many sources consulted are not individually made as their inclusion in the text would be a distraction. The references listed give some guidance to individual topics which would prove useful for additional reading. There is no single reference to a country's gold resource as this has been derived, in all cases, by a summation of data from many sources.

Some data is derived from the author's own inference, particularly Table 13, which outlines estimates of tonnages and grades in exploration areas in South Africa. This data is based on some old borehole disclosures, very limited recent disclosures and the intensity of drilling operations. The latter can be freely observed from public highways. Vindication of some past and present estimates is now emerging in the Moab, South Deep and Loraine areas where very recent disclosures have confirmed substantial potential tonnages and good grades of gold ores.

In general, the resources indicate the in situ tonnes and grades and hence the in situ tonnes of gold. Yields will be lower depending on the nature of the ore and the mining method which usually determines the amount of gold recovered. As a rough guide gold recovered will usually lie between the extremes of 50% and 95% of contained gold with an industry mean of possibly 80%.

In many tables yields or grades are given to two decimal points. Such accuracy is not really possible in practice, but has been used so that an arithmetic balance is achieved between the various figures quoted.

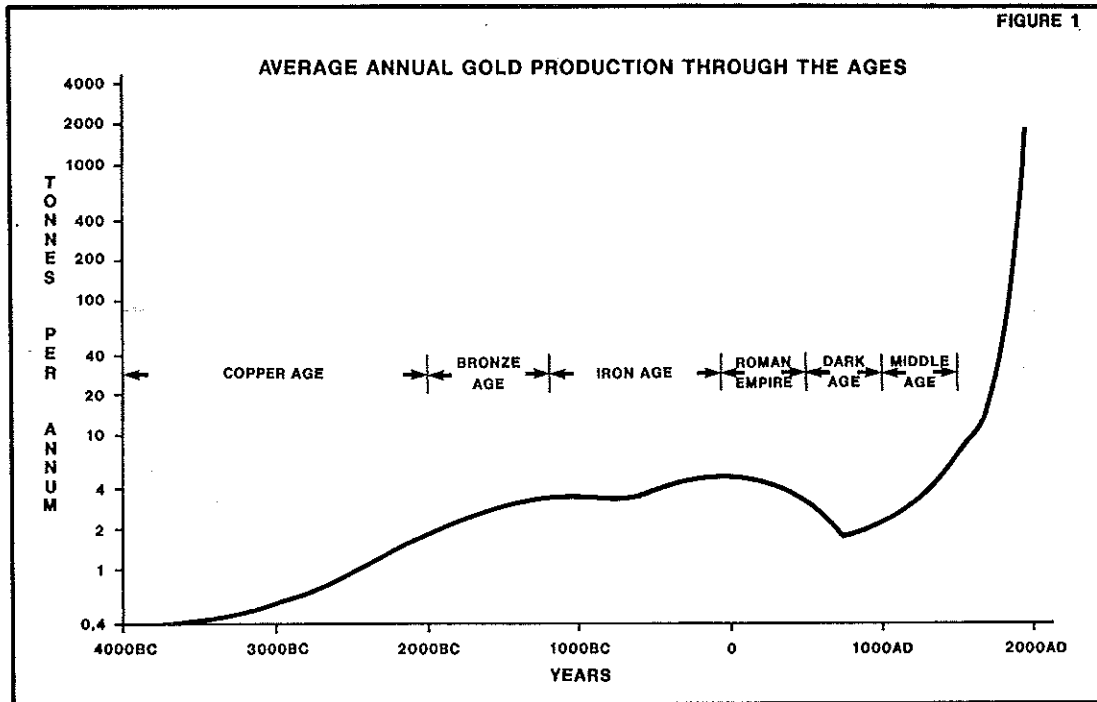
INTRODUCTION

Since time immemorial man has desired gold for its beauty, its properties, its wealth, a currency for all time and an object which cannot be created. Gold has been one of the pillars on which civilisation was founded, has spread and has prospered. The modern computerised financial age tends to spurn gold, but as an item of value, versus inflatable paper currencies, it remains the most reliable indestructible medium of art, currency, exchange and store of wealth available to man.

Nations, banks, churches, companies and individuals have accumulated gold through the ages. It is not possible to account for all the gold mined, but of the estimated 112 570 tonnes recovered to date the following table is based on published data where available.

TABLE I		
	TONNES	
Official stocks	29 204	
International Monetary Fund	3 217	
European Community	2 912	
International Settlements Bank	<u>206</u>	35 539
Private holdings & Banks	28 000	
Jewellery-Religion-Decoration	33 000	
Industrial and lost gold	<u>13 000</u>	74 000
Comecon countries - to balance		<u>3 031</u>
TOTAL		112 570

Estimates place world production in 1989 at 1 652.8 tonnes for the Western World and approximately 400 tonnes for the Comecon countries. This is an all time high as can be seen from Figure 1 which indicates the production of gold through the ages. Since 1979 Western gold production has been increasing at an average rate of 6.2% per annum while the production of gold jewellery from newly mined and scrap gold has been increasing at an average of 15% per annum for the same period. During 1989 the use of gold in jewellery exceeded newly mined gold for the first time in modern records. In the future it is likely that the use of gold in fabrication will exceed new supply and that gold from stocks will be needed to make up the difference. This does not imply a shortage as stocks are very large, as noted above, but there is a reluctance to dishoard gold unless gold prices are high. **The demand-supply relationship in the world market is considered to be becoming finely tuned with demand being greater than supply.** This will become more pronounced in the future as demand is expected to remain high while supply will tend to fall at current gold prices.



A BRIEF HISTORY OF GOLD

Man has been interested in gold since the earliest records of civilisation. The first reference to gold occurs in Egyptian texts when in 3156BC the value of gold relative to silver was set at 2.5:1. This has since changed as silver supplies increased more rapidly than those of gold and today gold is considerably rarer and roughly 80 times more valuable than silver.

The mining of gold spread with the exploration and civilisation of the world by man. From its cradle in Egypt, mining spread first southwards into Africa and eastwards into the Middle East. Later, during the Iron Age and the Roman Empire, it spread to Europe and Asia, though the very early history of Asia may yet unravel some earlier mining. During this period the Phoenicians were reputed to be the leading miners of the day, but they left no written record of their work. The Dark Age saw very little organised mining and a revival awaited the expansion of world trade routes following the Middle Age period.

Portuguese, Spanish, and later, Dutch and British sailors led the colonization of the world and discovered new sources of gold in South America, Australia, North America and New Zealand. This culminated in the discovery of the vast deposits in South Africa in 1886 since which time the availability of gold has increased many fold.

Figure 1 illustrates the progressive rate at which gold has been produced, with output rising to about 4 tonnes of gold per annum during the Roman Empire, falling slightly during the Dark Age, and then rising dramatically to over 2 000 tonnes per annum in the late 1980s. Current resource estimates appear to indicate sufficient gold to maintain production at existing levels for roughly 35 years. This is dependant on a maintained gold-price/working-cost relationship.

Total gold production to the end of 1989 has now exceeded 112 500 tonnes. Major contributors are listed in Table 2 where it can be seen that South Africa, Russia, the United States, Canada and Australia have dominated the scene, collectively producing a total of 84 081 tonnes or 75% of the total.

Estimates of available gold resources for future mining have been made and these are listed in Table 3. It is immediately apparent that outlining of ore and new discoveries during the past 10 years has been largely in the old traditional gold mining areas. Exploration is still catching up in some areas. Provided that the impetus is maintained, re-examination of known deposits and new discoveries will enable the working of ores, which were long ago considered marginal, by modern means.

The dominant players in the future will remain the largest producers of the past with the possible exception of the Pacific rim where future production could exceed past production by several orders of magnitude.

FEATURES OF THE YEAR 1989

1989 was really a non-event year because the gold market became a pawn in matters of greater world financial happenings. The attractions of gold as an investment or a product varied around the world depending on which side of the fence the producer or the buyer sat in terms of gold-price versus international price of the currency in hand. Practically all producers saw their profit margins reduced while purchasers, depending on the international performance of their currencies, either made profits or recorded losses. The inability of physical gold to produce a return in a generally inflationary climate was a bad omen and in general investment demand was slack.

Viewing the gold market as a commodity market one would have been justified in noting that off-take was greater than input. A rising price for the commodity was indicated. Gold loans, a feature of the previous three years, had reduced the necessity for official sales. Gold loans were no longer so popular and many of the loans were becoming due for repayment. This implied that some of the physical gold produced during the year would return to bank vaults and would not be sold on the open market. However, imbalances in international settlements saw official sales return as a significant feature for the first time since 1984. This put some pressure on the gold price which was absorbed during 1989 but which could not be absorbed in the early months of 1990. The result was a very short bull market of approximately six months duration, which has, in 1990, been followed by a bear market.

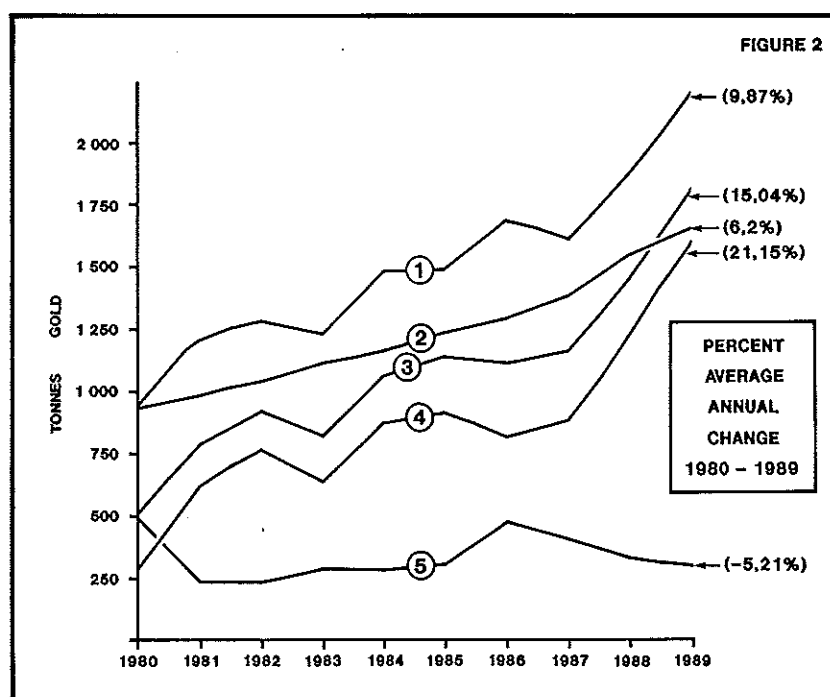
TABLE 2		
ESTIMATES OF TOTAL PRODUCTION BY COUNTRY TO END 1989		
	TONNES GOLD	REGIONAL TOTAL TONNES GOLD
AFRICA		
Egypt	1 753	
Nubia	1 829	
Ethiopia	614	
West Africa	1 685	
East Africa	160	
Zimbabwe	1 766	
South Africa	42 693	
Others	695	51 195
EUROPE		
Iberia	1 900	
France	600	
Great Britain	95	
Italy	230	
Carpathians	939	
Russia	16 219	
Others	1 447	21 430
ASIA		
India	1 520	
Greater China	1 000	
Japan	310	
Arabia	156	
Asia Minor	172	
Others	1 493	4 651
AMERICAS		
Colombia	2 020	
Ecuador	85	
Peru	394	
Bolivia	437	
Chile	515	
Brazil	2 337	
Mexico	1 807	
USA	11 134	
Canada	7 367	
Dominican Rep.	112	
Nicaragua	36	
Others	933	27 177
AUSTRALASIA		
Australia	6 668	
New Zealand	955	
Papua N G Area	334	
Others	160	8 117
GRAND TOTAL		112 570

TABLE 3		
ESTIMATES OF TOTAL AVAILABLE GOLD IN RESERVE		
	TONNES GOLD	REGIONAL TOTAL TONNES GOLD
AFRICA		
Egypt	50	
Nubia	50	
Ethiopia	40	
West Africa	450	
East Africa	60	
Zimbabwe	350	
South Africa	42 000	
Others	150	43 150
EUROPE		
Iberia	100	
France	100	
Great Britain	25	
Italy	25	
Carpathians	50	
Russia	6 200	
Others	100	6 600
ASIA		
India	100	
Greater China	500	
Japan	200	
Arabia	150	
Asia Minor	100	
Others	150	1 200
AMERICAS		
Colombia	250	
Ecuador	150	
Peru	100	
Bolivia	100	
Chile	700	
Brazil	1 500	
Mexico	200	
USA	5 500	
Canada	6 000	
Dominican Rep.	150	
Nicaragua	20	
Others	200	14 870
AUSTRALASIA		
Australia	3 800	
New Zealand	120	
Papua N G Area	3 000	
Others	150	7 070
GRAND TOTAL		72 890

As the end of 1989 approached the gold price started to improve and analysts, almost without exception, predicted a major bull market was in the making. Suggestions that gold was set to test \$500 per ounce were legion and the "silly" season saw most gold investors relaxed and looking towards a bright future. In the event 1990 produced some surprises which have not yet completed a full cycle as commented above.

Total gold fabrication was strongly up at 2 207 tonnes in 1989 from 1 866 tonnes (+ 18.3%) in 1988, with jewellery posting a substantial gain of 334 tonnes while electronics, dentistry, other industrial, medal and coin sales collectively only posted a minor gain of 8 tonnes. All the latter showed slight increases except dentistry which showed a slight decrease. Figure 2 illustrates graphically total fabrication, fabrication of carat jewellery, supply of scrap and mine production.

The jewellery industry appears to be particularly strong with all major manufacturers, Hong Kong and some Middle East countries excepted, showing all-time highs of gold consumed in jewellery. The spread is so world-wide that only a major world calamity can change its direction and if this were to occur it might even drive demand for "hedge" jewellery, bars and coins even higher. It seems fair to conclude that growth in demand will continue to exceed supply.



1. GOLD FABRICATION IN THE WESTERN WORLD - INCLUDING SCRAP
2. MINE PRODUCTION IN THE WESTERN WORLD
3. GOLD FABRICATION IN CARAT JEWELLERY INCLUDING SCRAP
4. GOLD FABRICATION IN CARAT JEWELLERY EXCLUDING SCRAP
5. SUPPLY OF SCRAP INCLUDING INTERNAL RECYCLING

Source:- GOLD 1990 Gold Fields Mineral Services

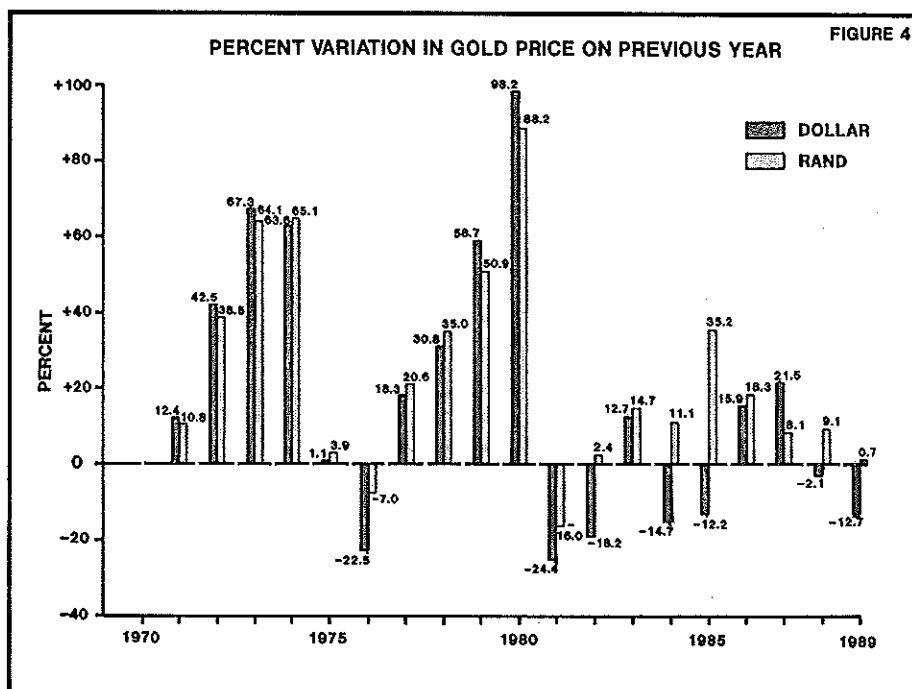
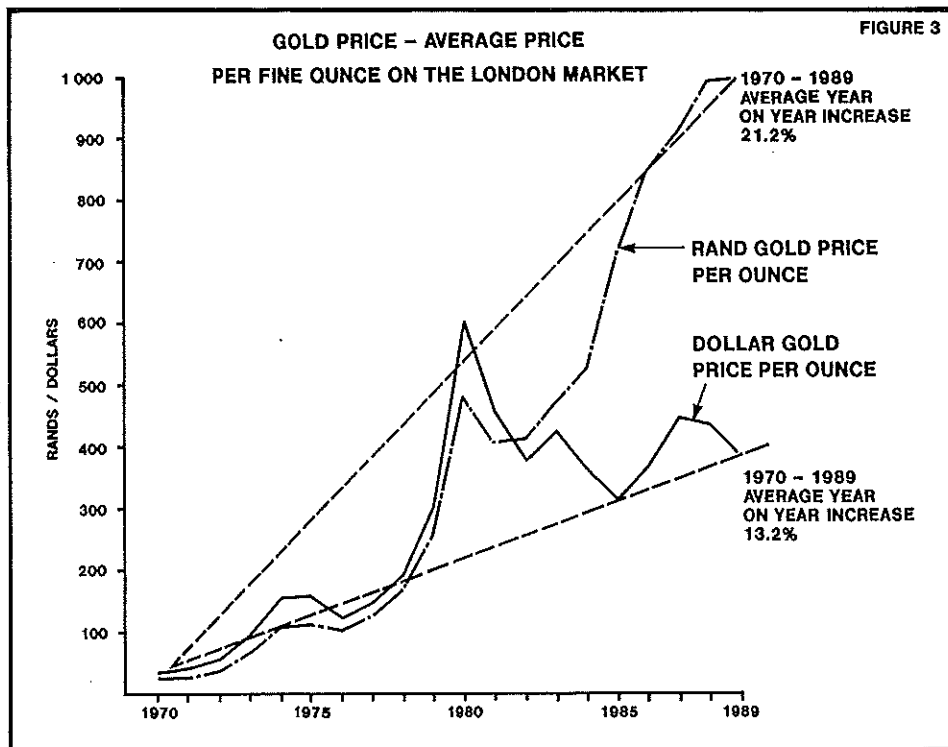
The oscillations in the market are making future planning very difficult. One must remember that the strong rise in the gold price from 1970 to 1980 produced a reaction in additional production only from 1980 onwards. This is, in effect, a measure of the time required for exploration, evaluation and development to be completed prior to the start of production. Some investments in exploration, triggered by the 1970 price rise, are only coming to fruition now. Regrettably, due to the uninspiring gold price performance, some of these investments are now being found to be non-viable. Even worse, capital invested in some new mines, is sunk to the extent that profitable recoupment is now not possible.

The gold mining industry, world wide, needs to examine the gold market carefully and introduce some constraints to reduce the wild oscillations in the gold price. This implies some control of sales, an element of stockpiling and judicious analysis of the demand-supply situation, to smooth fluctuations. Such a plan has been successfully applied in the diamond market, a commodity valued far higher than gold on a weight for weight basis, suggesting that control of the gold market would be easier and less costly. The five major producing countries, source of nearly 80% of production, should examine the possibility of creating a "controlled gold market".

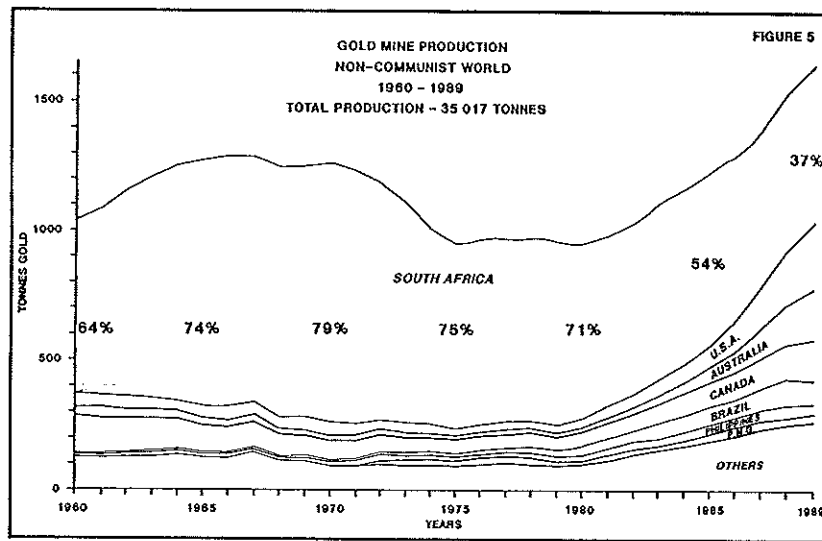
THE GOLD MARKET - 1970 to 1989

A major change in the gold market has emerged during the period 1970 onwards. This was spurred on by the decision of the US Government to allow the price of gold to find its own level from the fixed price of \$35 per ounce which had prevailed for many years. This action moved gold into the position of being a commodity rather than a unit of finance. However, the value of gold as an instrument of exchange remained unchallenged and it continued to play an important role in international finance.

From 1970 the price of gold started to rise in dollar terms. There were a few years during which correction took place, but in general, the trend was steadily upwards. A peak was reached during 1980, coincident with the oil crisis. This can be clearly seen in Figures 3 and 4. This event created much interest in the mining of gold and stimulated production in existing mines and set in motion one of the greatest exploration programmes ever witnessed. The production of gold by the Western World is illustrated graphically in Figure 5 and it can be clearly seen how production was falling during the period 1970 to 1975, was flat during the period 1975 to 1980 and took off in 1980 as the gold mining industry's reaction to the higher price was put into positive action. Considerable spare mining capacity was available, as the oil crisis had set in motion general recessionary conditions which reduced the demand for base metals. Following accidents in the nuclear field public reaction forced a reduction in the demand for uranium. Apart from oil, this left gold supreme as a target for exploration. The slow build up to an increase in production from 1980 indicates the long lead times required for mining projects.



Since 1980 gold production has increased at a steady rate with Western World output rising at an average of 6.2% per annum. The price has fluctuated and has tended to fall in dollar terms. Nevertheless, the long-term gold price is still upwards and interest in gold exploration and mining remains high. However, since 1980 the price has fallen in dollar terms and profit margins are being squeezed. Some mines, which were profitable in the early 1980s, have closed or are about to close.



The tabulation below is a summary of the facts discussed above while Figures 3 and 4 illustrate the average London dollar price for the years 1970 to 1989 and the percentage variation in the gold price year-on-year for the same period.

TABLE 4			
	AVERAGE GOLD PRICE PER OUNCE		AVERAGE ANNUAL PRICE INCREASE %
	1970	1980	
US DOLLARS	36.94	612.86	32.8
RANDS	25.84	476.80	33.8
	1980	1989	
US DOLLARS	612.86	381.54	-6.0
RANDS	476.80	998.89	8.6
	1970	1989	
US DOLLARS	36.94	381.54	13.2
RANDS	25.84	998.89	21.2

The substantial long-term increase in the gold price in rand terms for South African mines has prolonged the life of many mines which would have closed during the period under review. It has also converted many millions of tons of marginal ore into payable ore resulting in a steady fall in the yield of South African mines. This can be seen in Table 11 on page 28. However, the lower yields coupled with average inflation of 14.7% in South Africa over the period of 1980 to 1989 have reduced margins considerably and the industry will be forced to increase yields and curb costs and, if these measures are not possible, or are insufficient, close unprofitable mines. An increase in the gold price would of course introduce a new scenario.

Gold producers in other non-dollar countries, such as Australia and Brazil, receive gold payments in the local currencies which have, in general, followed the South African pattern. Producers receiving payment directly in US dollars have seen margins begin to shrink from the falling dollar price since 1980. Many of these mines are still very profitable but costs will rise appreciably with increasing depth of the mines and local inflation is an added cost-factor which will see margins reduced.

Unless the gold price re-establishes an upward trend many mines will face closure in the next ten years resulting in a downturn in gold production. This in itself might trigger a gold price increase as demand for gold has been increasing more rapidly than supply even during the expansion of the 1980s. The main problem facing gold investors is to judge the impact the various factors in the present gold market will have on the gold price.

In recent years the gold market has been buffeted by several new developments. These range from the mobilisation of gold stocks in the form of gold loans, rapid conversion of gold into currencies to balance foreign accounts, the gold futures and options markets, warrants and bonds and computerised stop-loss selling. Trade has also become a 24 hour phenomenon with Eastern and Western markets all having their turn as a day, and the play, develops world wide. Despite all this, the gold market has survived as a major financial market in a world with many financial inequalities.

Futures contracts during 1989 continued at a level comparable to the previous two years with gold equivalent to 34 000 tonnes being transacted. The options market is still growing and recorded an equivalent of 6 790 tonnes of gold during 1989. These markets are now trading more than the equivalent of one third of all gold ever mined and have certainly resulted in a reduction in the trading of physical gold. The prices at which futures and options are traded can impinge on the physical market tending to smooth prices during quiet markets and add volatility when price breaks develop.

THE IMPACT OF THE GOLD PRICE ON SOUTH AFRICAN ORE RESERVES

During 1989 the gold price received by South African mines barely changed while inflation continued at high levels. Wage adjustments, import surcharges and no improvement in productivity saw profit margins on practically all mines fall. Pay-limit adjustments to avoid losses eroded ore reserves almost across the board with a reduction in the potential gold production in the future. Short-term, South African gold production may increase slightly as higher grades are milled from slightly lower tonnages, but the total long-term production and the life of the mines has been drastically reduced at the current gold price. Many mines are living on past investments and a large number of mines operated at a net loss if expenditure

to replace ore and develop new mining areas within the leases is taken into account. The total ore reserve declared by Witwatersrand gold mines during the twelve months prior to 31 December 1988 and 1989 compare as follows:

TABLE 5					
DEVELOPED ORE - SOUTH AFRICAN WITWATERSRAND GOLD MINES					
TONNES MILLION		GOLD CONTENT - TONNES		GOLD VALUE g/t	
1988	1989	1988	1989	1988	1989
241	239	2 338	2 304	9.71	9.64

This has not yet shown the trends predicted on pay-limit adjustments, but available tonnes and tonnes of gold have fallen. This trend assumed a more rapid fall during 1990 and will become apparent when this year's figures become available. A recent example of major readjustments to accommodate higher pay-limits is Driefontein, for which the 1990 ore reserve was announced as at 30 June 1990. Driefontein's Figures are:

TABLE 6								
DRIEFONTEIN GOLD MINES - COMPARISON OF 1989 AND 1990 ORE RESERVES								
	PAY LIMIT g/t		ORE RESERVE TONNES MILLION		GOLD CONTENT TONNES		GOLD VALUE g/t	
	1989	1990	1989	1990	1989	1990	1989	1990
EAST DRIEFONTEIN SECTION	5.0	6.3	6.007	5.610	81.695	86.394	13.6	15.4
WEST DRIEFONTEIN SECTION	6.2	8.1	6.002	4.275	89.430	74.385	14.9	17.4
TOTAL MINE	5.6*	7.1*	12.009	9.885	170.408	169.939	14.2	16.2

* Weighted on tonnes ore

Here it can be quite clearly seen that the higher pay-limit in 1990 resulted in an increase in the average gold content while the available tonnage and tonnes of gold showed a decrease. (East Driefontein added some tonnes of gold as it is still in a stage of building up reserves). If this tendency to raise pay-limits persists the life of the mine will be reduced.

A reversal of the trend could be caused by a higher gold price. This would immediately convert marginal ore, which had already been developed, into ore. The percentage payability, hence the tonnage reporting to ore in new development, would also be higher. This combination would result in larger tonnages being available for mining and greater amounts of gold being recovered during a longer mine life.

At the same time higher pay-limits must reflect on total available ore as yet undeveloped in the leases and also on the ability of the industry to bring new mines into production. In previous reports mention has been made of the elasticity of ore reserves relative to the ruling gold price. In an effort to quantify this an analysis of ore reserve declarations of several gold mines has been undertaken and, while variations are apparent, some rules can be applied which allow estimates to be made with some degree of confidence.

Gold distribution within an orebody is infinitely variable **BUT** every orebody is made up of distinct areas which can be defined and identified. These areas are:

- * *The bonanza area, or the highest grade highest payability portion of the ore. This is frequently 100% payable and if grade is sufficient is immune to normal movements in the gold price.*
- * *The mine area representing the average grade and payability of the bulk of the ore. This will range between 75% and 25% payable and be of ore close to the mean value for the property.*
- * *The marginal area, where payability drops below 25% extractability and the material as a whole does not constitute ore as it cannot be worked profitably*
- * *An anomalous fringe area, where traces of mineralisation are present but ore is in such small units that profitable extraction is impossible under most circumstances.*

There are boundaries between the above four areas which can be identified by sampling and assay. However, only one of these boundaries is fixed. It is the boundary surrounding the bonanza area. This ore will be mined regardless of economic conditions and under almost any gold-price/working-cost scenario. (Political unrest, as at Bougainville, can render such ore temporarily unmineable). All other boundaries are adjustable and can expand or contract depending on higher or lower profit margins. Hence, tonnage available and tonnes of gold content can adjust upwards or downwards as the pay-limit grade is adjusted.

It is general practice in South Africa to test the sensitivity of an ore reserve against variations in the gold price. Thus the reserve is often calculated at the expected gold price and recalculated at prices higher and lower than the expected price. Table 7 illustrates such a series of calculations for several mines. The same data has also been expressed graphically in Figure 6.

TABLE 7							
ORE RESERVE VARIATIONS FOR SOME 1989 DECLARATIONS							
MINE	REEF	GOLD PRICE Rand per kg	GRADE g/t	TONNES GOLD IN ORE RESERVE	PERCENT CHANGE IN GOLD PRICE	PERCENT INCREASE GOLD CONTENT	PERCENT INCREASE IN GOLD CONTENT PER ONE PER CENT CHANGE IN GOLD PRICE
CONSOLIDATED MODDER	Black Reef	28 000	6.92	1.167	28.57	23.40	0.82
		32 000	6.52	1.311			
		36 000	6.16	1.440			
CONSOLIDATED MODDER	Kimberley Reef	28 000	6.09	0.855	28.57	71.81	2.51
		32 000	5.47	1.125			
		36 000	4.95	1.469			
ELANDSRAND	VCR	31 000	10.95	45.42	19.35	7.04	0.36
		34 000	10.45	47.36			
		37 000	10.11	48.62			
FREEGOLD	Many Reefs	31 000	10.84	420.8	19.35	11.78	0.61
		34 000	10.22	446.5			
		37 000	9.71	470.4			
HARMONY	Leader -Basal	28 000	6.08	101.54	42.86	54.05	1.26
		33 000	5.50	130.52			
		40 000	4.95	156.42			
LORAINÉ	Many Reefs	30 000	10.06	41.53	16.67	17.51	1.05
		34 250	9.3	48.45			
		35 000	9.26	48.80			
VAAL REEFS	VCR VR	31 000	11.71	310.01	19.35	6.03	0.31
		34 000	11.25	319.00			
		37 000	10.79	328.70			
WESTERN DEEP LEVELS	VCR	31 000	12.12	46.07	19.35	2.54	0.13
		34 000	11.93	46.86			
		37 000	11.82	47.27			
WESTERN DEEP LEVELS	CL	31 000	21.94	88.88	19.35	2.15	0.11
		34 000	21.35	90.18			
		37 000	21.05	90.79			

It is immediately apparent that an increasing gold price will always result in an increase in the total amount of gold available. It can be seen, for example, that at Consolidated Modder an overall increase of 28.57% in the gold price for the Black Reef calculation results in an increase of 23.4% in the tonnes of gold in reserve. Various increases are obtained for other reefs and mines. The arithmetic mean of the percent increase in gold content for each one per cent change in the gold price is shown for each of the mines. This shows considerable variation between 0.11% for the Carbon Leader Reef of Western Deep Levels to 2.51% for the Kimberley Reef at Consolidated Modder.

This large variation is ascribed to the payability of the reef concerned. It is obvious that a mine with a reef of very high payability will have little or no reef in the marginal category, hence a higher gold price will bring in very little additional ore. The inverse will apply for a reef of low payability.

Not all South African mines publish the sensitivity of their ore reserves to changes in the gold price. However, from Table 7 it can be seen that it would be virtually impossible to obtain an average for the entire South African industry, but it is reasonable to suggest that the average probably lies somewhere between 0.50% and 1% of gold tonnage increase per 1% increase in the gold price. Using 0.5% as a very rough guide, it is apparent that total South African resources, currently placed at 42 000 tonnes of gold, could vary as shown in Table 8 on a dramatic short-term change in the gold price.

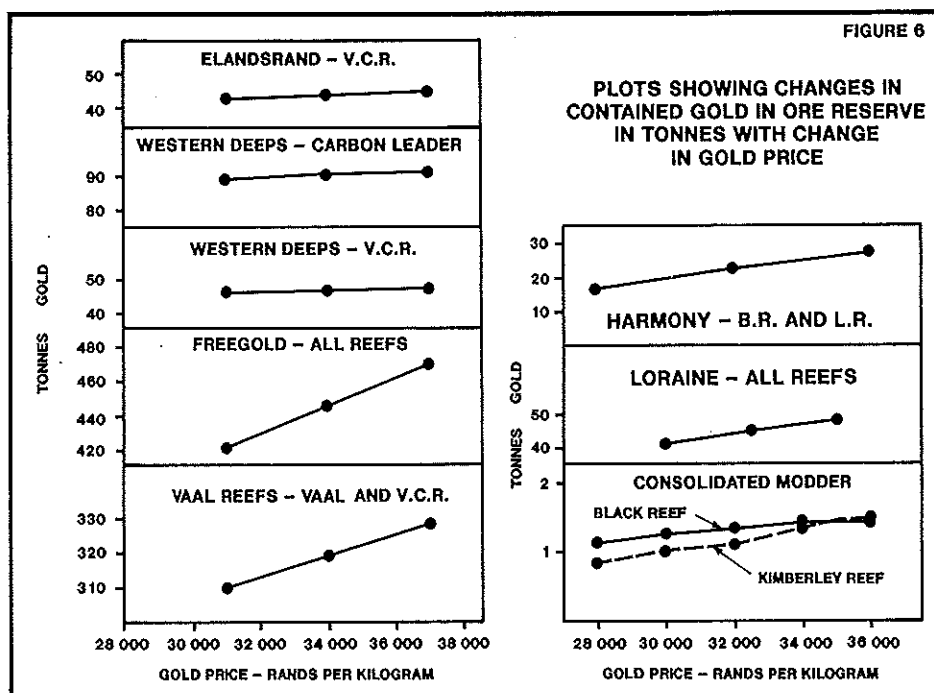


TABLE 8			
GOLD PRICE KILOGRAM	PERCENT CHANGE IN PRICE	PERCENT CHANGE IN GOLD TONNES	TONNES GOLD
R20 000	-37.5	-18.75	34 125
R32 000	Nil	Nil	42 000
R45 000	+40.6	+20.3	50 526

The above table cannot be accepted as fact. It is simply a guide to show the possible impact of gold price changes. A complete unknown is present in many mines, namely, a falling price could reduce an entire mine to such a low level of payability as to make all ore unpayable. Conversely, an increased gold price would convert marginal ore to payable ore and, if the increase in price were large enough, it might bring another reef within the succession into the payability range. Adding a completely new reef over the entire lease area, even at low payability, could have a greater impact on the total gold resource than is suggested.

This exercise indicates the elasticity of the Witwatersrand ore reserves at varying gold prices. It explains the continued existence of mines which would have closed in the 1970s had the gold price remained static, and it also pinpoints the present predicament of marginal mines which have suffered from a gold price which has not risen to keep pace with inflation since 1987.

No comparable figures have been obtained for other mines in the world. However, reasoning based on generally accepted patterns of gold distribution within a rock body suggest:

Large opencast orebodies would probably show low variations but the ratios of waste, heap-leach and milled ores could change with some impact on the total gold content.

Archaean gold deposits and epithermal vein deposits would have marginal ores that could impact similarly to the ranges found in Witwatersrand ores. Other low-grade veins or stockworks on the same property might with an increase in price enter resource lists.

Alluvial deposits frequently have associated marginal ores which could be affected.

CURRENT PRODUCTION AND FORECAST FUTURE PRODUCTION

The countries of the world, almost without exception, are at or close to the highest production in their recorded history. There are exceptions, such as South Africa, which is milling record tonnages but at lower grades, so that tonnes of gold

produced are below the record high. Russia too appears to be below peak production, but the USA, Australia, Philippines, Papua New Guinea, Chile, Brazil, Japan and Canada are at or very close to peak production. Many other countries such as Ghana, Zimbabwe, Colombia, Mexico and Zaire, to mention but a few, are significant gold producers and while they have not reached previous high levels of production, they have increased production several fold over the past ten years. Gold supply is at its highest level in recorded history.

The impetus given to increased production by the high gold prices of the 1980s is still present and a legion of operations are in the expansion or development stage. Gold production is likely to increase during the early 1990s, but it will probably peak, flatten and then fall in subsequent years. This could change if the gold price resumes an upward trend, but even if it does, exploration is currently waning relative to development, and the massive addition to reserves seen during the 1980s is not likely to be repeated. The emphasis in the next few years will probably be on development and production.

Australian production is expected to peak fairly soon and, while the large mines such as Boddington, Kidston, Telfer and others will maintain or increase production, a large number of small mines or marginal operations of large mines will face closure. Exploration expenditure has fallen dramatically in Australia and this will impact on future reserves.

Canada and the USA are both still on an upward trend but the static gold price is already impacting on marginal mines and projects and exploration expenditures are static or falling.

The emphasis within these countries will be development and mining of the better quality ores and production is expected to continue to rise.

Brazil is likely to see expansion of the formal mining sector and contraction of the informal sector (unless a rich new surface deposit is found). Brazilian production is likely to fall in the short term.

South African production is facing many problems. The high gold prices of the 1980 decade saw head grades continually cut and tonnage through-put increased. The lowering of grades has reached a point where it cannot continue in the present gold-price/working-cost scenario as approximately 20% of the gold is now produced at a loss and is indirectly being subsidised by production from richer areas. Corrective action is being taken but for some mines it may already be too late. These measures will be directed to reductions of tonnage, mining of higher grade ore, improved efficiencies, cutting of capital programmes and generally a leaner more efficient industry. However, many marginal mines might be forced to close or to implement the above measures to such an extent as to drastically reduce their lives. The impact on the labour force will be a reduction of about

80 000 to 100 000 jobs in a country which already has high unemployment. (See note at end of this section).

The measures discussed above will probably see South African production dip below 600 tonnes for the first time since 1958. The fall is not expected to be very large as new and developing mines such as Oryx and Joel should add some tonnes of gold and several of the larger mines are expected to increase the output of gold. Vaal Reefs, Elandsrand, Western Deeps and Kloof are examples of this category. The great unknowns are mines like Western Areas, Randfontein and Harmony, all of which are large producers and which have increased tonnage through-put and reduced head grades to such low levels that very drastic measures may need to be taken. These measures could severely reduce the remaining lives of these mines. Elsewhere in the industry mines such as Stilfontein, Bracken, Grootvlei, Marievale, Durban Deep and several others are already on borrowed time and could close in the short-term. Other mines like Buffelsfontein, Loraine, ERPM, Leslie and St Helena have potential for lives of around ten years or more but this is dependent on no further erosion of the gold price received relative to the cost.

World wide there is likely to be a narrowing of margins at the current gold price which should tend to slow down exploration and development and see mines concentrate on richer ores. Demand for gold seems very strong, particularly for jewellery on a world-wide basis, so the gold price could be due for an up-turn in the near future.

Taking a five to ten year view the industry will be facing many new hurdles all of which will interplay in the overall market. Factors which will have major negative impact are likely to be:

- *some diminution of reserves and richer ores*
- *further squeezes on margins if inflation exceeds gold-price increases*
- *labour problems either from unions or from AIDS, both of which might demand increased mechanisation*
- *generally increasing depth of ores as near surface discoveries are worked out*

Positive factors are likely to be:

- *increasing demand for gold*
- *increasing personal investment in gold*
- *a return by private and state banks as investors in gold*
- *a more controlled gold market allowing better planning of exploitation*

NOTE: In South Africa closure of mines frequently has a greater socio-economic impact than economic impact. Throughout Africa job creation is desirable to maintain peace and stability in the labour force. The negative impact of the closure

of a mine, with the loss of many thousands of jobs directly, and additional jobs lost in satellite industries, is viewed very seriously. Economic debate on state assistance to keep mining going is extremely complex as the gold produced (at a loss) has a negative impact on the gold price which would probably rise on lower supply. On the other hand, job creation is an expensive business, and subsidy of an existing operation to keep people in employment can be much cheaper than creating new jobs.

AUSTRALIA

At first glance Australia had a very successful year in gold mining during 1989. Production increased from 157 to 197 tonnes of gold, which from the low base of 17 tonnes in 1980 is a remarkable achievement. This represents an annual increase of 31.3% since 1980, the highest for any major producer.

Exploration remains active but the announcement that taxation is to start in 1991 at normal company tax rates has taken the shine off the attractiveness of mining in Australia. With this event looming in the future, many companies endeavoured to maximise profits in the last months of the "tax holiday" and have devoted major efforts to mining and lesser efforts to exploration. This situation has not been helped by the state of the Australian economy where interest rates and inflation are at high levels. Risk money is at a low ebb which has also seen a major reduction in money available for exploration. Accepting that the data extracted for Australian mines and projects in 1988 and 1989 was valid it would seem that the total gold reserve rose only from 3 669 tonnes in 1988 to 3 829 tonnes in 1989. The 160 tonne increase is less than the 197 tonnes mined showing a contracting total reserve.

Of greater concern are the number of projects which were listed in 1988 and which have fallen away in 1989. This suggests some abandonment of more speculative ventures. Added to this is the impact which the economic situation will have on small projects. These will be exploited only if they are favourably situated relative to infrastructure. In a vast continent like Australia, distance from infrastructure can be a major hurdle and can demand high levels of capital injection. Approximately 20% of the gold in the Australian resource is in projects with less than 5 tonnes of gold. Many of these cannot be exploited under present conditions.

The other feature is the impact of working costs increasing at a rate faster than the gold-price. The same squeeze as is evident in South Africa applies here, but the smaller ore bodies have lower degrees of ore selection and many companies do not have finance to support operations. The recent announcement of the closure of the Fimiston underground operations is a result of this squeeze in margins.

In total some 425 mines and projects were identified. The reserves and averages for the various States are given in Table 9.

Predictions by other writers of a major fall in gold production have been made following the imposition of full company taxation on gold mines from 1991. This could force the closure of many small operations, but mines like Kidston and Boddington should continue with only an impact on final profits. It is believed that the elimination of some small mines will be compensated by expansion and development of the larger mines. An immediate fall in production will probably be small and staged over several years.

CANADA

Canadian gold mining had a successful year during 1989 with the production of 158 tonnes, a little short of the all-time high of 166.8 tonnes recorded during 1941. Planned opening of several new mines and increases of production during 1990 should be sufficient to see a new record established despite some low profit margins in the industry arising from a low gold price. In this connection several mines have been put on care and maintenance while some less attractive projects will be suspended. Mining has been stopped at the Beaverdam mine where serious dilution problems were encountered.

These setbacks are minor relative to the whole industry. Canada has an extremely well established exploration and mining industry. The expansion in gold mining during the 1980s has not been as rapid as elsewhere, but from 51.6 tonnes produced in 1980 it has advanced steadily to 158.4 tonnes (average 13.3% per annum) in 1989 and has solid foundations for further steady advances. Exploration expenditure appears to be on the decline but this is healthy with so much mine development planned.

A feature emerging from recent exploration is the discovery of numerous deposits, notably in British Columbia, which have high tonnages with opencast mine potential. Mt. Milligan, a copper-gold ore with an indicated resource of over 150 tonnes of gold and a copper content of 0.35% is the largest. A feasibility study is currently underway. The Snip project in the same province is one of several deposits in the Eskay Creek area where high gold returns have been recorded together with significant silver content. The Eskay Creek deposit on initial drilling has a geological inventory of 5 million tonnes ore at 20g/t - 100 tonnes of gold!

The Tundra project in the Northwest Territories is emerging as a large deposit with a resource slightly in excess of 200 tonnes gold. However, it appears to have only marginal feasibility at present. Adding these recent developments to the exploration for gold across a very broad front throughout the country is establishing Canadian resources firmly for many years to come.

TABLE 9										
ESTIMATE OF GOLD RESERVES FOR AUSTRALIAN MINES AND PROJECTS										
NO. OF PROJECTS	STATE	GOLD MINES/PROJECTS			DUMPS BY-PRODUCT PROJECTS			TOTALS		
		TONNES ORE MILLIONS	TONNES GOLD	AVERAGE GRADE g/t	TONNES ORE MILLIONS	TONNES GOLD	AVERAGE GRADE g/t	TONNES ORE MILLIONS	TONNES GOLD	AVERAGE GRADE g/t
236	WESTERN AUSTRALIA	671	1 614	2.41	79	73	0.92	750	1 686	2.25
51	QUEENSLAND	136	350	1.88	26	12	0.47	212	362	1.71
24	VICTORIA	35	59	1.70	33	32	0.95	68	91	1.33
8	TASMANIA	2	40	17.36	29	54	1.84	32	94	2.98
3	SOUTH AUSTRALIA	0.3	1	3.01	2 000	1 200	0.60	2 000	1 201	0.60
25	NORTHERN TERRITORY	104	272	2.63	12	9	0.75	116	281	2.43
28	NEW SOUTH WALES	20	72	3.66	22	42	1.87	42	114	2.70
TOTALS AVERAGES		1 018.3	2 408	2.36	2 201	1 422	0.65	3 220	3 829	1.19

From the literature searches undertaken 527 mines and projects, for which some form of reserve has been disclosed, have been identified in Canada. A summation of these gives the following resource for gold.

TABLE 10			
	TOTAL RESERVES MILLION TONNES	CONTAINED GOLD- TONNES	AVERAGE GRADE g/t
All ore-bodies	2 225	6 073	2.73
Alluvial & Base metal deposits	1 279	536	0.42
Gold mine reserves	946	5 537	5.86

These results indicate a considerable increase on an estimate made during 1988, when a total resource of 4 195 tonnes of gold was identified. However, many small deposits are present in the list and 250 deposits have a gold resource of less than five tonnes. The total amount of gold in these small deposits is 655 tonnes and much of it might never be mined. However, Canadian goldfields are highly developed and have the infrastructure, expertise and ability to profitably work small near surface deposits. Only a very detailed analysis, where each separate deposit is individually assessed, would enable a reliable figure to be determined of the amount of gold available for mining.

Canada is retaining its position as a major source of world gold. Much ore is in well defined ore-bodies and of a sufficiently high grade to enable mining to take place at depth at a low gold price. The size of the resource relative to current production suggests that Canada will still be a major producer in the year 2025.

LATIN AMERICA

South America as a whole is a major contributor of gold with 229 tonnes being recorded for 1989 (231 tonnes in 1988). Brazil is the largest contributor but estimates for 1989 showed a fall to 97 tonnes from the 100 tonnes recorded in 1988. The formal sector is due to expand in future years from the level of 23 tonnes established in 1989. The informal sector remains loosely controlled and there is no apparent improvement on the 33 tonnes registered and taxed and the estimate of 41 tonnes of contraband gold sold externally and internally. A fall off in production by the informal sector is forecast due to environmental controls, working out of some alluvial deposits and lower margins arising from a static gold price.

The formal sector will see continued advance with three or four new mines being planned and expansion in hand at several mines. Total resources in all the formal mines is placed at just over 1 000 tonnes of gold. Most of this is at grades which can be worked at the present day gold price but in some instances, particularly in

Amazonia, costs of establishing infrastructure could be prohibitive in the short-term and mining development may have to await general development in the area.

Colombia is the second largest producer on the continent but internal instability has resulted in a fall in production from the informal, largely alluvial, sector. Declared ore reserves are not large and it is difficult to forecast future production. Nevertheless, Colombia has established itself as a consistent producer at around 30 tonnes of gold per annum and will certainly remain so for many more years.

Chile is emerging as a significant producer with output rising steadily from 9.3 tonnes in 1980 to 26.1 tonnes in 1989 (average increase 12.1%). A high proportion of the gold is as a by-product from large porphyry-copper mines but recent years have seen the emergence of gold or gold-silver mines. Total Chilean reserves are placed at 700 tonnes gold which is a solid base for current production of 26 tonnes of gold per annum. The newly opened Marte mine is reported to be making losses which is indicative that the static gold price ignores political boundaries.

Venezuela, Peru, Mexico, Bolivia, Ecuador and the Dominican Republic all make significant contributions of between 15 and 7.5 tonnes of gold per annum.

MINOR PRODUCERS

This section covers a number of areas where current exploration is liable to impact favourably on future production.

Argentina has not had a great history of gold production. Recent announcements of plans to develop the large Bajo de La Alumbrera gold-copper porphyry could see this change. In addition Argentina shares a boundary along the high Andes with Chile and the rich El Indio deposit is not far from the Argentinean border.

Ghana has been the focus of re-examination of fallow deposits during the past few years and estimates place current gold resources at 382 tonnes of gold. Extensions to old ore bodies and new ore bodies have been identified and Ghana is liable to enter the lists as a medium-sized producer in the future.

Ireland & Spain have become the focus for quite extensive exploration. The former has only a limited precious metal mining history but the latter was an important source during the Roman Empire. Recent developments suggest that both these countries will be gold producers in the future.

New Zealand has been a major gold producer in the past with 955 tonnes of recorded production and 120 tonnes in currently identified reserves. However, New Zealand is a world leader in conservation and new mining licences are being

granted only under the most stringent terms. In addition a revision of the mining law could result in long delays in the granting of leases (up to 10 years), while increased licence and inspection fees and a 5% *ad valorem* tax are detractions. Some mining companies have already indicated their withdrawal from the country.

The potential in New Zealand is considered to be high as it lies on the Pacific Rim and could contain epithermal and porphyry type deposits. Past history has seen large alluvial deposits mined in rivers emerging from the mountains, but the source of the alluvial gold has not always been identified. It is incumbent on the companies operating in New Zealand to show that mining can be done with consideration for the environment and that rehabilitation is possible. In this way the correct climate may be generated to allow mining to proceed for the benefit of all.

Pacific Islands: Indonesia, the Philippines and Papua New Guinea are the major producers at present. However, Fiji, New Caledonia, the Solomon Islands and others are receiving attention and are well placed geologically for gold deposits.

The Philippines has been a steady gold producer for many years having both a formal and informal mining sector and deposits based on copper-gold and gold ores. Present estimates place the gold resources at 689 tonnes which will ensure production and allow for expansion in the future.

There are many countries which have had fairly extensive production in the past but which have still not reacted fully to the exploration boom of the 1980's. The slow start may be due to one or more of several reasons such as high political risk, poor infrastructure, lack of capital, remoteness and general difficulties for exploration. Amongst such areas are parts of Central and South America, China, Eastern Europe, Ethiopia-Nubia and Central Africa. There is little doubt that these areas will be receiving attention in the future.

PAPUA NEW GUINEA

During 1989 several projects were being brought to account and will be producing within the short-term. However, the entire future of mining in this area is faced with political and geographical difficulties. As an example, a local tribe, claiming massive compensation for traditional ground, brought the large Bougainville property to a halt. Despite government participation in the project and the very important cash flows accruing to the government from taxes and profits, Bougainville has remained closed. Ok Tedi also faced problems. The extremely heavy rainfall coupled with the steep topography made tailings disposal well nigh impossible without expensive capital works (over \$380 million). In the event permission has been granted to the mine to dispose of tailings into the Fly River. The ecological impact of some 70 million tpa being placed in a river used by locals

for water and fishing could have serious consequences. Time will tell whether this solution is locally acceptable particularly as Ok Tedi faced riots in 1986 which required government intervention with troops, and temporary closure was forced on the mine in January 1990 by local tribes.

Papua New Guinea's gold production suffered for the above reasons and fell from 36.6 tonnes in 1988 to 33.7 during 1989. This fall was despite the start up of the new Misima mine which produced a maiden 5 tonnes in 1989. With Misima planning to produce about 10 tonnes in 1990 and the Porgera and Lihir deposits expected to produce about 25 tonnes each per annum later in the decade, there is little doubt that PNG production is set to increase dramatically during the next few years. The Misima and Lihir deposits are on islands (after which the mines are named) and being much smaller entities could be far easier to police than the much larger Bougainville island.

It must be admitted that the PNG area has challenging political, climatic and topographical restraints. However, this has not deterred Placer Dome and Partners from investing an estimated \$C1 100 million, excluding financing charges, at Porgera. Risks will continue to be taken in this area since the prizes are most attractive as indicated by the tabulation.

Some of the deposits are very large by world standards and rank with large South African mines. Exploration has been intensive for only about 10 years, following the discovery of Bougainville in 1974, and will continue well into the future. Many other prospects, amongst which are, Wafi, Maice, Simberi, Woodlark, Sehulea and others, are being actively examined. In 1986 there were 159 Prospecting Authorities issued and this has probably increased rather than decreased. Companies involved are largely Australian but also include Canadian, USA, British and South African companies, as joint venture partners, and many local companies.

TABLE 11			
PROPERTY	TONNES MILLIONS (cubic metres)	GOLD VALUE g/t	TONNES GOLD
BOUGAINVILLE	710	0.47	334
HIDDEN VALLEY (WAU)	40	1.98	79
LAKEKAMU	(300)	(0.16)	(48)
LALOKI	0.35	3.7	1
LIHIR ISLAND	443	63.0	1 329
MISIMA ISLAND	56	1.38	77
MOUNT KARE	3	3.33	10
MOUNT VICTOR	0.314	4.6	1
OK TEDI	376	0.6	226
PORGERA	84.4	5.8	490
TOLUKUMA	1.07	22.0	24
WAPOLU	5.9	1.4	8
WILD DOG	1.0	6.0	6
TOTAL	1 721		2 585
AVERAGE		1.50	

Geologically the islands are in an active tectonic zone which hosts porphyry-type copper deposits, with associated gold, and large epithermal deposits related to the active volcanism of the area. The Lihir deposit, for example, is within a caldera (collapsed volcano) and one of the challenges facing mining of this deposit will be active hot springs (geysers) and "hot" rock.

The discovery rate since 1980 has been impressive, far outstripping that of most other countries, with the possible exception of South Africa, the United States and Canada. If the known deposits can be brought to account and reserves increased PNG is likely to be pitched into fifth position in the world after South Africa, Russia, the United States and Canada before the end of the decade. This projection is based on the premise that discovery and production in Australia and Brazil will not be maintained and will fall during the next five years.

RUSSIA AND THE COMECON COUNTRIES

Some releases of information during the past year have given a slightly clearer picture of Russian production and sales but a full picture has still to emerge. It would appear that Western estimates of production have been fairly accurate and it is thus not necessary to modify estimates of past production of 16 219 tonnes.

Russian reserves were estimated by Richard M Levine (Metal Bulletin Monthly - March 1990) to be a minimum of 6 200 tonnes of gold which has been included in this report. A high figure of 7 800 tonnes was also quoted, but this is discounted for reasons which appear below.

Russia is going through a period of political change (glasnost) and greater disclosures of mining production are expected. Relaxation of some strict controls has resulted in political and labour problems which have caused disruption of several industries. The impact on gold could result in higher working costs and up grading of equipment and methods. Both of these might result in marginal ores being left unmined. However, the system, in its strong drive to create foreign exchange, might produce gold at a loss.

Sales and gold swops have been a feature of Russian dealings with British and Swiss banks during the early part of 1990 and the freeing of this gold has impacted negatively on the gold price. It is also reported that Russian and Chinese sales of uranium, also to raise foreign exchange, have had a negative effect on the uranium spot market. This need for foreign exchange will not be solved quickly so that sales of commodities, including gold, will remain at the highest possible level from Comecon countries.

Russian production appears to have been stable at around 300 tonnes per annum during the last five years with very little growth. Russia, at this level, has remained the world's second largest producer, but it may be overtaken by the United States which produced 259 tonnes in 1989 - a 28.9% increase on the

previous year. If the USA posts a similar increase during 1990 it will easily overtake Russian production.

In summary, total Russian production to the end of 1989 is placed at 16 219 tonnes of which 2 500 tonnes are retained in bank reserves. Gold reserves in ore to be mined are placed at 6 200 tonnes, though the latter figure is not well documented or substantiated.

Other Comecon countries remain small producers, namely, North Korea, Yugoslavia and Romania. China appears to have increased production in recent years to levels between 80 and 100 tonnes per annum. However, political changes and relaxation of economic controls appear to have created an internal market for gold in China. It is government policy to sell all available gold to help service foreign debt, but internal demand for gold may see China a net importer rather than exporter.

SOUTH AFRICA

South Africa remains the world's largest producer of gold and, provided present political adjustments are achieved without serious disruption, is likely to remain so well into the 21st century. Nevertheless, South Africa's share of Western World gold production continues to fall, recording 36.8% in 1989 against 79% in 1970, see Figure 5. This is reflected in the production of 608.3 tonnes of gold against 1 001 tonnes in 1970 whilst world production continued to increase. Once again tonnage through-put increased and grade declined in 1989 as can be seen in Table 11.

Production from sources other than the Witwatersrand mines showed a slight increase, largely due to the start-up of some small Archaean gold mines and increased production from platinum mines.

PRODUCTION TO DATE

Total recorded production of gold up to 31 December 1989 is estimated to be 42 680 tonnes, as indicated in Table 12. The individual goldfields summate production from mines which have been or are members of the Chamber of Mines. Other production includes non-members, Archaean gold and by-product gold from base metal and platinum mines.

RECENT PRODUCTION

Table 11 shows production trends, costs, profits, taxation and the impact of varying gold prices and inflation during the period 1979 to 30 June 1990. This summarises many features of the industry and indicates quite clearly the effect that falling grades, inflation and a fairly constant gold price have had over the past

three years. The rise in the cost per kilogram has resulted in a serious fall in profits which are impacting adversely on the industry as a whole. However, upward adjustments of grade and introduction of economies will undoubtedly take place on many mines as a result of these developments. The impact of gold price fluctuations on ore reserves and hence the total available gold reserve has been fully discussed in a preceding section.

TABLE 11

PRODUCTION					
YEAR	SA PRODUCTION GOLD tons*	TONS MILLED †	YIELD g/t ‡	GOLD PRICE RAND kg +	COST PER kg RANDS 0
1979	705.4	83 529 000	8.19	8 274	3 464
1980	675.1	89 915 000	7.28	15 566	4 587
1981	657.6	91 860 000	6.92	13 055	5 719
1982	664.3	94 998 000	6.76	13 246	6 751
1983	679.7	99 910 000	6.55	15 285	7 680
1984	683.3	101 128 000	6.44	16 799	8 861
1985	671.7	104 562 000	6.09	22 106	10 938
1986	640.0	107 674 000	5.63	27 160	13 799
1987	607.0	107 634 000	5.28	29 226	17 294
1988	621.0	112 673 000	5.13	31 947	20 040
1989	608.3	113 690 000	4.99	32 036	23 340
1990*	6297.4	655 897 000	64.95	632 310	25 658

FINANCIAL							
YEAR	WORKING REVENUE R/tons ‡	WORKING COST R/tons ‡	WORKING PROFIT R/tons ‡	PERCENT PROFIT	TAXATION R millions ‡	TAXATION AS A % OF WORKING PROFIT	CAPEX R millions ‡
1979	72.08	30.18	41.90	58.1	1 650	52.8	656
1980	120.56	35.53	85.03	70.5	3 667	53.8	895
1981	95.60	41.89	53.71	56.2	2 022	45.9	1 186
1982	92.70	47.28	45.45	49.0	1 772	44.7	1 208
1983	103.25	51.88	51.37	49.8	2 229	47.1	1 352
1984	112.03	58.94	53.09	47.4	2 246	46.6	1 597
1985	139.22	68.78	70.46	50.6	3 301	44.8	1 790
1986	167.88	80.22	77.66	49.8	3 351	43.5	2 416
1987	160.37	94.90	65.47	47.4	2 673	41.4	2 404
1988	171.13	106.77	64.36	37.6	2 409	36.1	2 671
1989	161.21	116.97	44.54	27.6	1 534	30.5	2 630
1990*	162.62	127.50	35.15	21.6	504	25.6	1 242

ESCALATION					
YEAR	GOLD PRICE RAND kg +	YEAR ON YEAR % INCREASE	SA CPI %	GOLD PRICE 1979 = 100	SA CPI 1979 = 100
1979	8 274	-	13.4	100	100
1980	15 566	88.0	14.0	188.0	114.0
1981	13 055	-16.1	15.4	157.7	131.6
1982	13 246	1.5	14.9	160.1	151.2
1983	15 285	15.4	12.4	184.8	169.9
1984	16 799	9.9	11.5	203.0	189.4
1985	22 106	31.6	16.3	267.2	220.3
1986	27 160	22.9	18.6	328.4	261.3
1987	29 226	7.6	16.1	353.4	303.4
1988	31 947	9.3	12.9	386.2	342.5
1989	32 036	0.3	14.7	387.4	392.8
1990*	32 310	0.9	613.0	390.9	443.9

+ Average of the price received for precious metals by mines. Members of the Chamber of Mines in Rands per kilogram.
 * Six months to 30 June 1990. * Gold Fields Mineral Services. + GOLD 1990. e Estimate. ‡ Chamber of Mines statistics.
 0 Calculated from Chamber of Mines Statistics for which the basis of classification has changed slightly over the years.

TABLE 12			
TOTAL RECORDED SOUTH AFRICAN PRODUCTION			
GOLDFIELD	TONNES MILLED MILLION	GOLD RECOVERED KILOGRAMS	AVERAGE YIELD g/t
CENTRAL RAND	924.833	7 672 299	8.30
EAST RAND	1 181.177	9 866 662	8.35
WEST RAND	375.206	1 983 009	5.29
KLERKSDORP	458.898	4 740 774	10.33
WEST WITS LINE	645.777	7 489 646	11.60
WELKOM OFS	815.347	7 876 138	9.66
EVANDER	155.906	1 192 571	7.65
SUB-TOTAL	4 557.144	40 821 099	8.96
OTHER	234.098	1 858 744	7.94
TOTAL	4 791.242	42 679 843	8.91

EXPLORATION FOR GOLD IN SOUTH AFRICA

Since the discovery of the Evander goldfield in 1952, the South African industry was pre-occupied with its development as well as the expansion of the newly established Orange Free State, Klerksdorp and West Wits Line goldfields. This was a massive task in terms of demands on expertise, senior personnel and capital. Since their discovery these four goldfields have produced a total of roughly 21 300 tonnes of gold, but some of their mines are, after 30 to 40 years of production, approaching old age and some may face closure within a few years.

This was anticipated during the past 20 years and exploration in the fringe areas of the goldfields has seen the formation of eight new mining companies and extensions added to the leases of several existing companies. According to calculations by the author existing leases and extensions of Witwatersrand mines contain 21 796 tonnes of gold of which 2 304 tonnes is in proved reserves and the balance in drill-indicated reserves. Thus at, roughly, 600 tonnes gold production per annum the South African industry can continue to survive for at least 36 years based on existing mine leases.

Exploration has now extended far outside the immediate areas of the existing goldfields. A detailed study of exploration activity from the limited disclosure of results to date was completed in July 1990 by the author. This study indicated a high probability that eighteen new mines could emerge within the next ten years while a total of forty projects (including the eighteen mentioned) might form new leases or parts of new leases in the longer term. This may seem a little optimistic except that three major new developments are imminent, namely, Moab, South Deep and the Sun area while four more (Poplar, Doornrivier, Kalkoenkrans and

TABLE 13			
ESTIMATES OF RESOURCES IN EXPLORATION AREAS			
AREA	ESTIMATED TONNES-MILLIONS	GRADE g/t	GOLD CONTENT TONNES
O.F.S. South	350	8	2 800
O.F.S. North	250	8.5	2 125
Potchefstroom	800	10	8 000
South Deep - Fochville	500	7.5	3 750
Western Ultra Deeps	100	11	1 100
Central Rand South	50	12	600
Evander Goldfield	95	6.0	570
South Rand Goldfield	30	10.0	300
TOTALS/AVERAGE	2 175	8.85	19 245

TABLE 14						
GEOLOGICAL RESERVES AND CONTENT						
	TONNES ORE MILLIONS		GOLD CONTENT TONNES		GOLD VALUE g/t	
	1988	1989	1988	1989	1988	1989
MINE LEASES	3 029	2 865	22 399	21 841	7.39	7.62
DUMPS & SLIMES	(1 124)	(1 238)	252	323	(0.22)	(0.26)
ARCHAEOAN	59	58	426	417	7.26	7.19
BY-PRODUCT	N/A	N/A	(500)	(500)	N/A	N/A
NEW GOLDFIELDS	1 870	2 175	16 785	19 245	8.98	8.85
TOTALS/AVERAGE	4 958	5 098	39 862	41 826	8.04	8.20

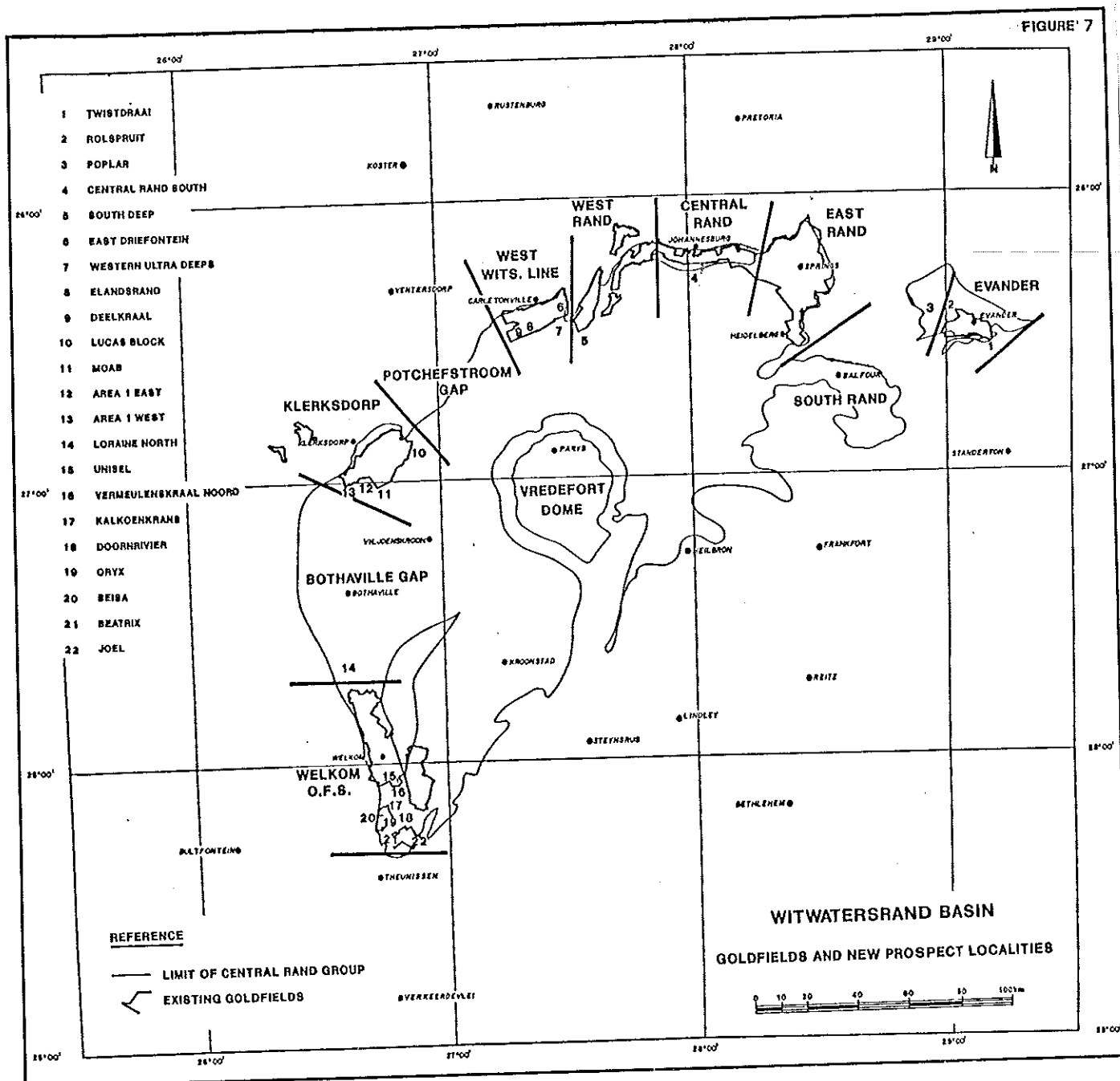
Vermeulenskraal Noord) are very close to feasibility studies. Anglo American recently did a feasibility study on the Weltevreden area, south of the Sand River, and has several other projects approaching feasibility. Weltevreden was considered not to be feasible at the current gold price. However, there are many developments taking place close by so that it might become part of a large lease. (See Figure 7 for localities).

From the above study Table 13 was compiled. This suggests that within current exploration targets over 19 000 tonnes of gold may be present as a total resource. Some of the areas still require to be drilled-out and some are very deep. It is probable that parts of this resource will only become available in stages during the next twenty-five years. Nevertheless, as it is developed, it will cushion the other reserves which are currently being depleted.

Table 14 sets out the current expectation for future reserves and gold content. The grand total of 41 800 tonnes of gold would see South Africa able to produce

gold at the 600tpa level for a total of nearly seventy years, namely, to the year 2060.

This life is far in excess of the life for other major producers, nearly all of which have large reserves of shallow opencast ore which already have a foreseen life of twenty years or less. The grades in other areas are also low, severely restricting the ability to follow the surface deposits underground.



UNITED STATES OF AMERICA

Gold mining and exploration have surged ahead in the USA during 1989. Production reached an all-time record of 259 tonnes and new mines in the pipe-line or building up production will see this figure increase yet again in 1990. However, closure of some marginal operations indicates that the low gold price is impacting in the USA as well.

Exploration has resulted in the identification of new ores, particularly in the Carlin belt, where the Deep Star (Post) deposit, north of the large Genesis mine, is emerging as one of the world's greats. Figures released by Newmont at the end of 1989 place a total resource of 376 tonnes of gold in this deposit, but exploration still is incomplete, and with the depths now being encountered, will take many more years. A conservative geological tonnage estimate based on borehole depths, disclosed strike and sample grades suggest that Deep Star alone could contain over 1 000 tonnes of gold. The Deep Star deposit is only one of seven discovered in this area by Newmont since 1987 so that the ultimate tonnage which is likely to be found along the Carlin trend is certainly approaching that of a South African goldfield. Newmont's total gold resource at the end of 1989 was placed at 1 235 tonnes, most of which must lie in the Carlin trend.

American Barrick is another large player in the Carlin field and the Betze/Goldstrike mine has a total resource of 557 tonnes. It is quite apparent that the total amount of gold in the Carlin trend is large and quite comparable with the total estimated remaining gold resource of the Driefontein mine of just over 3 000 tonnes.

A summation of declared reserves for 243 mines and prospects has been made. In the case of the USA many of the deposits are large and only about 4% of the ore bodies contain less than 5 tonnes of gold. It is thus probable that most of this gold will be exploited except that marginal ores might fall away if the gold price continues at low levels. A feature which emerged strongly during 1989 was a tendency for many mines to record gold resources in ounces only, without indicating the tonnage or grade. As a result the overall grade of the resource cannot be calculated as is evident in the table below.

TABLE 15			
	TONNES ORE MILLIONS	CONTAINED GOLD TONNES	AVERAGE GOLD VALUE g/t
MINES & PROSPECTS	2 090	4 182	2.00
MINES & PROSPECTS	N/A	967	N/A
TOTAL		5 149	

There is a likelihood that USA production will increase at the same rate in 1990 as during 1989. Should this happen the USA is likely to become the world's second largest producer as Russian production may fall following strikes and political unrest.

SUMMARY AND CONCLUSIONS

It is quite apparent that the increase in the gold price since 1970 has spurred exploration and production of gold. This is a new wave which is still in its ascendancy, and the peak, in terms of discoveries and production, has not been reached. World gold production, over several centuries, is progressing on an exponential curve, and new heights are indicated. However, resources are limited at current gold prices, and maintained production at present levels will see a reduction in available gold in the long term. In most countries a life of less than 20 years can be seen, but the main producers appear to have resources well in excess of this time-span. Nevertheless, the ability of the majors to continue to produce at the high levels of today might come under pressure beyond the year 2010, and shortages of gold might begin to be felt. The current low gold price will result in many mine closures if it persists in the future.

South Africa will be the dominant source of gold for many years, with 21 841 tonnes of gold estimated to be inside present mining leases at an average grade of 7.62g/t. New goldfields and mines are estimated to contain 19 245 tonnes of gold in ores, with an average grade of 8.85g/t. Together with base metal ores and by-product ores, South Africa is set to produce another 42 000 tonnes of gold. This could be produced at a slightly accelerated rate relative to present production which would still leave South Africa dominant in world gold until the year 2040.

Three other countries, the USA, Canada and Australia, have substantial reserves of 5 149 tonnes gold in ore averaging 2.00g/t, 6 000 tonnes gold in ore averaging 2.73g/t and 3 829 tonnes in ore averaging 1.19g/t respectively. In all three countries production is rising rapidly as easily accessible ore close to surface, is brought to account. The USA in 1989 produced 259 tonnes, Australia produced 197 tonnes and Canada 158 tonnes, which would suggest that production at these rates would see current identified reserves depleted in 22, 19 and 38 years respectively. Australia, in particular, will see production fall off rapidly in the next decade.

The estimate of total ore reserves suggests that some 72 890 tonnes of gold are available, against the approximately 112 570 tonnes already mined. Carat jewellery has been using increasing amounts of gold since 1980 when 513 tonnes of gold was used against 1 811 tonnes in 1989, representing an annual compounded increase of 15.04%. During the same period mine production in the

Western World has increased from 959 tonnes to 1 653 tonnes, or a compounded rate of 6.2%. It is apparent that a shortage of gold will emerge despite increased production.

With increasing world populations, each man, woman and child will have available to him or her less than half an ounce of gold, which represents only a few rings, so that in the long term it is believed man's demand for gold will increase, rather than decrease, and the price will adjust accordingly.

EXECUTIVE SUMMARY

Gold is a medium of currency, a store of wealth and a hedge against economic or political disaster. Since time immemorial an estimated 112 570 tonnes of gold have been produced.

Africa has been the largest producer with a record of 51 195 tonnes followed by the Americas with 27 177 tonnes, Europe with 21 430 tonnes, Australasia with 8 117 tonnes and Asia with 4 651 tonnes.

The six countries with the highest recorded production are South Africa (42 693 tonnes), Greater Russia (16 219 tonnes), U.S.A. (11 134 tonnes), Canada (7 367 tonnes), Australia (6 668 tonnes) and Brazil (2 337 tonnes). No other countries have exceeded 2 000 tonnes.

Revival of gold exploration and mining since 1980 has seen a 6.2% annual increase in production in the Western World for the period 1980 to 1989.

New discoveries and expansion of known deposits have resulted in an estimate of reserves for South Africa (42 000 tonnes), Canada (6 000 tonnes), U.S.A. (5 500 tonnes), Australia (3 800 tonnes), Papua New Guinea (3 000 tonnes) and Brazil (1 500 tonnes). No details of Russian reserves are available. These have been set at 6 200 tonnes.

At present production rates most countries will deplete existing reserves within 20 years, except South Africa (70 years), Canada (38 years) and U.S.A. (22 years).

The total gold content of known reserves is set at 72 890 tonnes. This is roughly 12 grammes of gold for every man, woman and child on earth today.

A shortage of gold supplies is likely as demand for jewellery alone has increased at 15.04% per annum for the period 1980 to 1989, while total gold fabrication has increased at a rate of 9.9% per annum for the same period.

The first contraction in gold supplies is likely to come before the turn of the century when Australian production is expected to fall rapidly and some other countries will mine out immediately available ore. Unless the gold price increases the contraction will take place sooner on a world-wide basis.

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