Commodity analysis: its application in the context of the South African mining finance house

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SYNOPSIS

In this paper the authors present their views on the actual and potential role of commodity analysis in mining industry. Owing to the dominant influence of the economy on all commodity markets, it is essential that individual commodities are studied not only in depth but within the broader context of economic influences. A commodity unit, which monitors market developments in a wide range of commodities, is well placed to provide the broader perspective in the study of commodity markets.

This paper describes some of the specific functions of such a unit. Some of the methods used for price forecasting are described, and the results of price forecasts by different forecasting methods are compared.

SAMEVATTING

In hierdie referaat gee die skrywers hul siening van die werklike en potensiële rol van kommoditeitsontleding in die Suid-Afrikaanse verband. As gevolg van die oorheersende invloed van die ekonomie op alle kommoditeitsmarkte is dit noodsaaklik dat individuele kommoditeite nie alleen intensief bestudeer word nie, maar ook teen die breër agtergrond van ekonomiese invloede. 'n Kommoditeitseenheid wat markontwikkelings in 'n groot verskeidenheid kommoditeite moniteer, is goed geplaas om 'n breër perspektief in die studie van kommoditeitsmarkte te gee.

Hierdie referaat beskryf sommige van die spesifieke funksies van so 'n eenheid. Sommige van die metodes wat vir prysvoorspelling gebruik word, word beskryf en die resultate van prysvoorspellings volgens verskillende voorspellingsmetodes word vergelyk.

Introduction

At the Eleventh Commonwealth Mining and Metallurgical Congress, held in Hong Kong in May 1978, A. R. Conley of Consolidated Gold Fields Ltd of London presented a paper entitled 'Commodity Analysis in a Mining Finance House'. Conley's paper stimulated us to consider the role of commodity analysis in the South African mining industry. Conley defines commodity analysis as 'part of the general research that is carried out by raw material suppliers to minimize the uncertainties in defining current and probable future market structures'. He adds that 'since no two companies are quite the same so their objectives and approach to analysis differ, although there is some common ground — particularly in the major metal markets and their associated statistics'.

There seems to be little awareness of the actual or the potential role of commodity analysis in mining finance houses in Johannesburg, and we therefore think it appropriate to define and analyse this role. As Conley pointed out, no two companies have exactly the same approach to commodity analysis, but there is sufficient common ground between those who perform this function to make commodity analysis a distinct, well-defined discipline that requires specialized training and experience. This paper sets out our views on the importance and scope of commodity analysis in the South African mining industry in the hope that this will stimulate further debate and contribute to a greater awareness and use of this discipline.

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Necessity for Commodity Analysis

Commodity analysis is indispensable to a mining finance house. Although this function may not even be recognized as a separate and distinct function, nor given a formal structure within an organization, and may be performed only on an *ad hoc* basis, it is nevertheless inconceivable that a mining house can avoid making assumptions concerning the future demand for mineral products and the prices of these commodities.

Feasibility studies for potential new ventures, as well as budget forecasts for current projects, require a wide range of specialists in different disciplines to estimate the expenditures involved. Technical experts include geologists, mining engineers, and metallurgists, who are together responsible for developing the cheapest and most efficient methods for the production of a metal or mineral, and who then assist costing and financial experts in estimating the total capital and working costs required. However, the other side of the equation — the equally important estimation of revenue, based on forecasts of the quantity of the metal or minerals sold and the price obtained — depends essentially on only one discipline: commodity analysis (which takes place before and in conjunction with marketing activities).

Commodity analysis is also an essential tool in decisions involving a choice between the exploitation of different metals or minerals and the production of different processed products. With a wide range of potential mining and metallurgical projects to choose from, it is essential that the mining house spends its limited resources wisely. Fig. 1 compares the trend of the price indices of four different metals — gold, platinum, copper, and tin — over the period 1968 to 1979. The

price indexes plotted on the graph were derived as follows.

(i) The average quarterly free-market prices were calculated for each of the four metals. The copper and tin prices used were the cash prices on the London Metal Exchange (L.M.E.), the platinum price was the first position on the New York Mercantile Exchange, and the gold price was the afternoon fixing on the London bullion market.

(ii) Indexes of the quarterly averages were then calculated with the 1967 average annual prices as the base.

(iii) In the case of copper and tin, where the prices are expressed in sterling, the indexes were adjusted to refer to a constant 1967 value of sterling in terms of its parity with the dollar. This was done in order to allow for fluctuations in the value of sterling.

(iv) Finally, in order to adjust for inflation, the indexes of the four metals were divided by the quarterly consumer price indexes in the U.S.A.

Fig. 1 shows the wide divergence in the prices of the four metals over this period, and Table I compares the change in the value of the indexes of the four metals in the first quarter of 1979 relative to the first quarter of 1968. The wide variation in the performance of the prices of the four metals over the past decade illustrates the potential role of commodity analysis in the selection of mining projects that offer the optimum long-term investment prospects for a mining house.

TABLE I

CHANGE IN PRICE INDEXES FROM 1968 TO 1979

Metal	1st quarter, 1968	1st quarter 1979	Change, %
Gold	97,37	327,12	+229,75
Tin	91,44	211,70	+120,26
Platinum	124,30	109,49	−14,81
Copper	138,07	80,61	−57,46

Another area in which commodity analysis is essential is in the choice of beneficiated products to be produced from raw materials. It is one of the tasks of commodity analysis to follow changes in the metallurgical processes used by consuming industries that affect their preferences concerning the physical form, grade, and purity of their beneficiated raw materials. An example of such a change of particular relevance to South Africa has been the development of the argon–oxygen decarburizing (AOD) furnace for the production of stainless steel. The manufacturing process using this furnace can tolerate much higher impurities than the previous process used in the production of stainless steel; consequently, the cost per unit of the alloying element has replaced purity as the major consideration in the choice of alloy. In the production of stainless steel, therefore, high-carbon ferrochromium has largely displaced low-carbon ferrochromium, and ferronickel has become more popular than nickel in cathode form.

Ultimately, commodity analysis can be used as an instrument of policy, and can guide the orientation of a mining house in a particular direction. To some extent the range of raw materials and processed materials that a mining house produces is fortuitous, and a consequence of chance in geological prospecting and historical accident. To a large extent, however, the mining house can channel its resources in a particular direction: it may choose a role as a producer of a particular product or group of related products, and concentrate its resources within this limited area. Given the availability of the raw materials, the mining house must also have faith in the future demand for that product or group of products. Metals and minerals can often be grouped together according to the industries or particular function within society that they serve: coal, oil, and uranium are used to produce energy; ferro-alloys (including manganese, chromium, nickel, and vanadium)

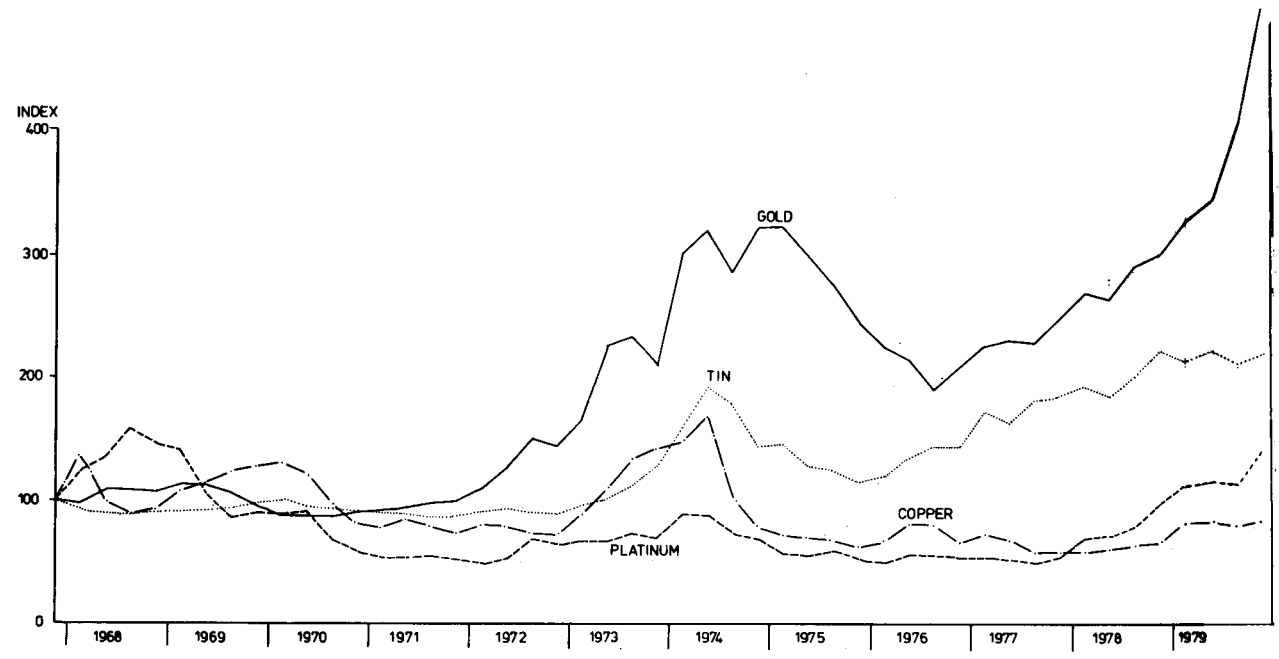

Fig. 1—Quarterly price indexes for gold, tin, copper, and platinum

are required by the steel industry; and precious metals have a high intrinsic value that renders them desirable for investment, jewellery, and monetary applications. Thus, faith in the future demand for a particular metal or mineral, or group of metals or minerals, implies faith in the future growth of an industry (or a specific role in society). In South Africa, we have examples of Gold Fields with its strong orientation towards gold, Johannesburg Consolidated Investment with a strong bias towards platinum, and Samancor, which specializes in the production of ferro-alloys.

Value of a Commodity Unit

Different departments within mining finance houses may specialize in particular metals or minerals, and may be responsible for the production and marketing of those metals or minerals. Obviously this involves the forecasting of sales and prices of the commodity, which in turn necessitates commodity analysis. As specialists, each department has an intimate knowledge of the factors affecting demand and supply *within the markets for its particular commodity*. It might thus be concluded that the function of commodity analysis is carried out in the course of marketing and market research exercises by specialists in each commodity, and that there is therefore no need for the existence of a separate department or unit that would perform this function as a service to all the mines or plants within the Group. In fact, however, the existence of a commodity unit as a separate department provides the mining house with an essential facility that supplements, rather than duplicates, the function of departments specializing in particular commodities.

There are two fundamental and related reasons why a commodity unit can play a role that cannot be adequately performed by specialist departments.

(1) *Generalist rather than specialist*

The commodity analyst is essentially a generalist, rather than a specialist, in the sense that he follows market developments in a wide range of commodities, in contrast to the specialist, who is responsible for marketing a particular commodity or a small, related group of commodities. The specialist has a more detailed but narrower view; the commodity analyst adds the broader perspective. To the specialist a particular metal or mineral is *the* commodity; to the commodity analyst the same metal or mineral is *a* commodity.

The commodity analyst is able to compare the market behaviour of a particular metal with that of other metals; he can see the similarities and the differences, and can distinguish between the general influences affecting markets for a wide range of commodities and the influences that are restricted to the market for a specific metal.

(2) *Dominant influence of the economy*

The state of the economy is the major influence on all commodity markets; the cyclical behaviour of the economy, together with the alternating periods of boom and recession, ultimately affect the demand for all commodities by affecting the level of industrial activity. Fig. 2 compares the quarterly consumption of five metals in the U.S.A. over the period 1969 to 1978. The quarterly values were converted to three-quarter moving averages to reduce the effect of random and seasonal fluctuations, which could obscure the effect of cyclical movements in the economy. The values were plotted on logarithmic graph paper on which equal proportionate changes in size, rather than equal absolute changes, appear on the same scale. The cyclical behaviour of the consumption of the five metals is compared in Table II, which shows the quarters in which the major peaks and troughs occurred.

TABLE II

CYCLICAL BEHAVIOUR IN THE CONSUMPTION OF FIVE METALS

Metal	1970/71 Trough	1973/74 Peak	1975 Trough	1978 Peak?
Copper	4,1970	1,1974	2,1975	1,1979
Lead	3,1970	1,1974	2,1975	—
Zinc	3,1970	2,1973	2,1975	1,1979
Nickel	3,1971	1,1974	3,1975	1,1979
Platinum	4,1971	2,1973	4,1975	1,1979

Both Fig. 2 and Table II show that the consumption of all these metals tends to move in sympathy rather than in a random manner, illustrating the common external influence of the economy. The commodity unit, which monitors market developments in a wide range of commodities, is well placed to identify and assess this influence.

Functions of a Commodity Unit

A commodity unit is, as explained, uniquely equipped to play a major role in a mining house. Its specific functions will vary according to the needs of the mining group, but the following are some of the functions that a commodity unit is qualified to perform.

(a) *Forecasts of Demand, Supply, and Prices of a Specific Commodity*

A thorough analysis of probable trends in demand, supply, and prices is required by a mining group when considering the production of a new metal, mineral, or chemical or metallurgical product. The revenue from the project will depend on the quantity of the commodity sold and the price (net ex production plant in rands) at which it is sold. Forecasts of demand and supply will indicate whether there is likely to be a future world or domestic oversupply, or a shortage, of the commodity. Future prices will depend to a large extent on the balance between demand and supply. The time factor is an essential element in forecasting; commodities pass through phases of shortage or surplus, and a future shortage or surplus of a commodity is a meaningless concept unless related to a specific period. In a later section of this paper, we examine some methods that can be used in the forecasting of prices.

(b) *Regular Market Reports*

Another function of a commodity unit is the provision of regular and digestible comment and an assessment of developments in metal markets. Such regular reports serve two principal purposes.

(i) They monitor market developments to keep interested staff informed and to save them the

time involved in reading the many articles from a large number of different sources that they would otherwise find necessary in order to remain up-to-date.

(ii) They place market developments in a particular commodity in overall perspective to concomitant economic developments and developments in other commodity markets. For example, as a precious metal, platinum is likely to benefit from periods of currency instability when investors are attracted by its high intrinsic value; as a major base metal, copper has a very wide range of industrial applications in both consumer and capital goods, and the demand will thus respond quickly to an economic upturn; the demand for stainless steel is orientated more towards capital than consumer goods, and the demand for nickel and chromium, which are the major alloying metals used in the production of stainless steel, will therefore tend to rise comparatively late in an economic upturn (economic recovery usually affects consumer goods first and capital goods only later).

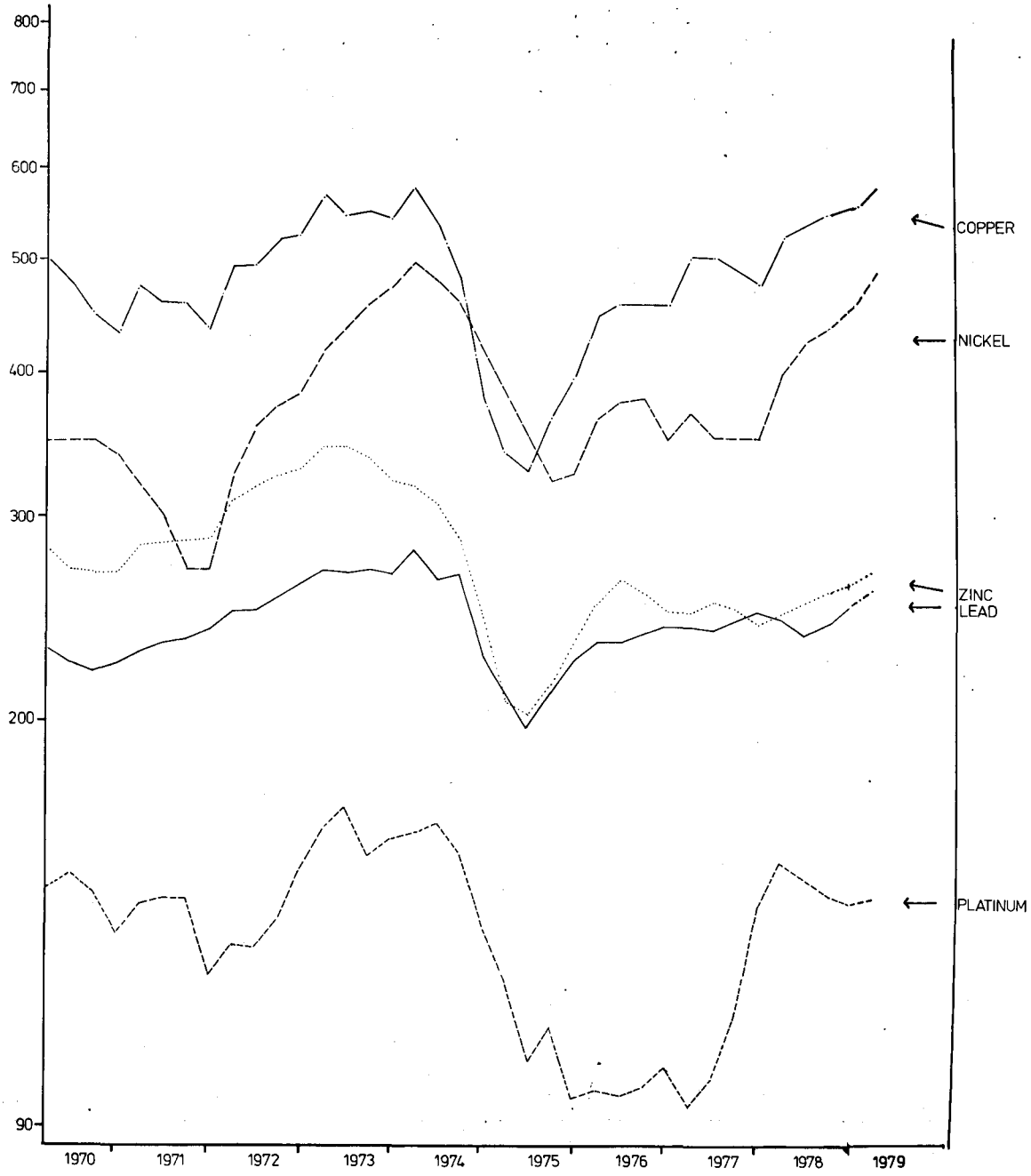

Fig. 2—Quarterly consumption of copper, nickel, zinc, lead, and platinum in the U.S.A. (three-quarter moving averages)

Scale: Copper, lead, and zinc $t \times 10^3$
Nickel $t \times 10^2$
Platinum tr. oz $\times 10^3$

(c) *Forecasts of Metal Prices for Group Budget*
The value of a broad view of commodity prices is illustrated when a mining house makes forecasts of metal prices for annual budgets. Each specialist department takes a different view of the price prospects of the commodities with which they are concerned according to their particular assessment of the outlook for demand and supply. Demand is determined by two groups of interrelated factors: specific factors affecting the demand for a particular commodity, and general factors related to the economic environment. Inasmuch as the general factors to some extent affect the demand for most or all of the commodities produced by a particular mining house, consistency requires that all the price forecasts are based on the same view of world economic prospects. For example, a forecast of copper prices for 1980 based on the assumption of a world recession is inconsistent with a forecast of nickel prices based on the assumption of a continuation of world recovery.

(d) *Liaison with Overseas Commodity Research Organizations*
Many overseas research organizations have the facilities to carry out very sophisticated and comprehensive market studies of commodities. They usually have a large staff employed exclusively for this purpose, and market studies are often their sole *raison d'etre*. Thus, they possess all the necessary resources, expertise, and international contacts to offer in-depth studies and regular reports of a high standard for sale on a confidential individual or multi-client basis. Obviously, a mining house in Johannesburg, remote from world markets and with a limited staff involved in commodity analysis, does not have the resources to produce in-depth reports of the same quality as those of some overseas research consultants. Special studies and regular market reports by these consultants can therefore be very useful and, sometimes, essential.
However, the utilization of research consultants cannot replace the in-house commodity unit, but rather supplements it by providing an additional facility to be used when required. The in-house commodity unit is qualified to advise (in liaison with the specialist department concerned), when this service is required, on the type of report required and which research consultant should be used. Furthermore, the completion of the report by the research consultant marks the beginning, rather than the end, of the market research project. In such a report, the consultant has to make certain assumptions regarding future demand and supply; however well current markets and production capabilities have been researched, certain assumptions may prove to be incorrect with the passage of time, thereby largely invalidating the forecasts of demand and supply. Nevertheless, this need not invalidate the report as a whole. It is obviously unrealistic to expect all assumptions relating to the future to be correct, and an expensive report by an overseas research consultant should be subject to regular and critical in-house monitoring.

(e) *Advice on Exploration and Investment Policy*
In addition to its role in decisions on potential new projects through forecasts of demand, supply, and prices, and in operating projects through budget forecasts of commodity prices, a commodity unit has an important role to play in advising a mining group on exploration and investment policy.
Present decisions concerning prospecting affect the future in ten to fifteen years, and the Group must therefore decide on priorities in exploration. It must decide which minerals it is specifically searching for, and what proportion of its exploration budget should be allocated to each mineral or group of minerals. The Group may perhaps be spending too much money in looking for a particular mineral of which there is likely to be a world oversupply, and too little in the search for another mineral of which there is expected to be an acute world shortage. There may also be strategic reasons for seeking a certain material, such as oil and bauxite (aluminium ore) in South Africa.
It is also important that the Group's investments in mines and projects in which it does not have managerial or financial control should be directed towards commodities that are considered to have good growth prospects.

Price Forecasting

In this section we do not attempt to provide an exhaustive or definitive review of all the forecasting methods employed in commodity analysis; instead, our discussion is limited to those methods which, subject to the constraints of resources and time, we have found to be particularly useful. The commodity unit at Johannesburg Consolidated Investment has never had more than two members, and the commodity analysts have thus had to cover a wide range of commodities and lack the resources to undertake highly sophisticated in-depth commodity studies. Where it is felt that these are required, overseas research consultants are employed for the purpose. However, the commodity unit makes its own forecasts of metal prices on a regular basis for the Group's annual budget, and also when it is felt that this is warranted by special circumstances.

Price forecasting is becoming an increasingly complicated task owing to the growing number of factors and interrelationships that affect commodity markets. In addition to high inflation rates, the very foundation of pricing, i.e. currency values themselves, has recently been called into question. For example, the traditional reference price for copper has been regarded as the L.M.E. cash price in sterling. After the 1976 sterling collapse, several price-forecasting bodies moved away from sterling and began giving their price forecasts in U.S. currency. However, the collapse of the dollar in 1977–1978 showed that, in a world of floating exchange rates with no fixed international currency yardstick, prices expressed in current money terms do not provide an accurate indicator of changes in the real value of a commodity. Thus, forecasts must increasingly be made in 'constant' currency terms rather than in 'current' currency terms. This implies the making of forecasts not only of commodity prices but also of exchange rates.

The effect of inflation on prices must also be taken into account.

Price theory states that a product's price is a function of the supply–demand balance. More specifically, in commodity analysis the classical cobweb adjustment mechanism is highly relevant. In other words, cycles in commodity prices and output occur owing to the lagged-response behaviour of producers, with prices consequently oscillating round the long-term equilibrium price.

Under conditions of perfect competition, demand and supply are in equilibrium at a price that equals the marginal cost of production. In practice, many factors apart from the behaviour explained by the cobweb theorem will cause the price of a commodity to fluctuate above and below its equilibrium level; it is a prime task of commodity analysts to determine, analyse, and, if possible, quantify these factors. The most important reasons for disequilibrium include the following:

(1) Violent fluctuations in demand due to cyclical changes in the international economy.

(2) The prices of most commodities are determined in terminal markets, usually marginal markets, representing only a small proportion of the total trade in each commodity. Hence, any short-term disruptions in the supply–demand equilibrium have a more than proportional effect on prices.

(3) Factors extraneous to the market may also impinge on the natural interaction between supply, demand, and prices. These would include government intervention (such as cartel action, tariff policies, price and production controls), natural disasters, strikes, and transport problems. Such factors cannot usually be quantified, but should not be ignored.

In practice, the amount of research that could be expended on the myriad of variables that affect production costs, demand, supply, and the non-economic factors affecting the market for a commodity, is virtually infinite. However, from our experience it appears that the law of diminishing returns operates in price forecasting: beyond a certain point, extra time and sophistication of research will improve the probability of accuracy only marginally, so that a trade-off often has to be made between the probability of accuracy on the one hand, and the depth of research and the time involved on the other.

The following are some methods that we have found to be successful in price forecasting. A combination of different methods reduces the risks of relying too heavily on certain assumptions that must be made in forecasting. In the final analysis, forecasts depend on judgements based on adequate research.

(i) *The Demand–Supply Balance*

Commodities can be used in a wide range of applications. In the forecasting of demand for a commodity within a specific market, the size of the total market has to be forecast, together with the share of the market that the particular commodity will obtain. In the case of uranium, for example, the total market in a specific country or group of countries is represented by the total energy requirements, and the share of this market that uranium obtains is determined in competition with other energy sources — coal, oil, hydrothermal energy, solar energy, etc.

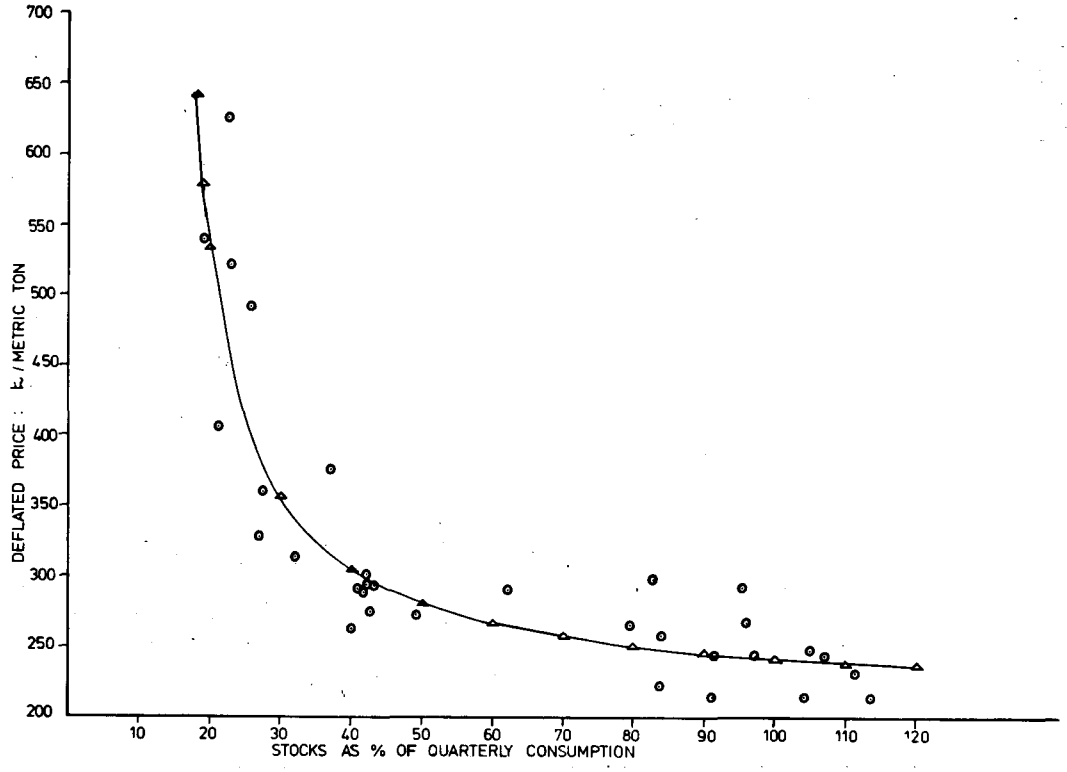

Fig. 3—Refined copper in the non-Communist World: relationship of stocks to deflated prices 1970 to 1978

Thus, forecasts of demand must take into account the competitive position of the commodity within a market with respect to price, technical considerations, and (particularly in the case of uranium) the social and political climate affecting the market in which the commodity is used.

Forecasts of production must take into account expected new capacity, closure of existing capacity, and the capacity utilization rate at various hypothetical price levels. When the probable demand–supply balance has been determined, this must be related back to the price. However, two factors extraneous to the particular commodity market — currency instability and general inflation — can obscure this relationship, and these influences must be removed as far as possible in order to reflect the price influences originating within the industry itself. The movements of the price, adjusted for inflation and currency instability, are then related to the demand–supply balance over a period of years in order to establish a historical relationship that can be extrapolated into the future. Following from this, in certain metals where adequate and reliable stock figures are available, e.g. the L.M.E. metals, we have found method (ii) below to be particularly useful.

(ii) *Stocks: Consumption Ratio*

Stocks are a function of the demand–supply balance: when stocks are rising, supply is exceeding demand, and *vice versa*. The level of stocks is more meaningful when expressed in relation to consumption than as an absolute figure; the significance of stocks at a specific level alters in relation to the changes in the rate of consumption. Therefore, inasmuch as the stock level represents the interaction between demand and supply, there is a strong relationship between stocks and prices (adjusted for inflation and currency instability).

Fig. 3 shows the relationship between deflated copper prices and the ratio of stocks to consumption in the non-Communist World over the period 1970 to 1978. The prices are the average quarterly cash prices on the L.M.E., expressed in terms of a constant sterling–dollar exchange rate deflated by the U.S. consumer price index. The stocks: consumption ratio is the ratio of stocks at the end of each quarter to consumption during that quarter. The points plotted as circles show the actual average prices at different stock levels: the curve represents the 'best-fit' curve, and the points on the curve shown as triangles represent the theoretical deflated prices at specific values of the stocks: consumption ratio. The correlation between deflated prices and the stocks: consumption ratio is a hyperbolic relationship that has a coefficient of correlation of 0,9; this coefficient represents a high degree of correlation between the two variables since the numeral 1 represents a perfect correlation and 0 no correlation. The hyperbolic relationship means that the price becomes progressively more sensitive to changes in stocks at lower levels; or, expressed in a different way, the lower the stock level, the higher the increase in the deflated price resulting from a decline in stocks by a specific tonnage or percentage of consumption.

Changes in the demand–supply balance are reflected in the stock level, and anticipated stock levels resulting from forecasts of the demand–supply balance can therefore be used to forecast the theoretical deflated price from this graph or similar graphs for other commodities.

(iii) *Production Costs (Both Capital and Working Costs)*

Some idea can usually be obtained of the average international production costs of a particular commodity from company reports and literature surveys. This knowledge assists in the forecasting of the long-term price trend.

(iv) *The Relationship of Consumption and Prices to Economic Cycles*

Consumption of the major base metals tends to correlate with the general level of economic activity —usually measured by industrial production indexes.

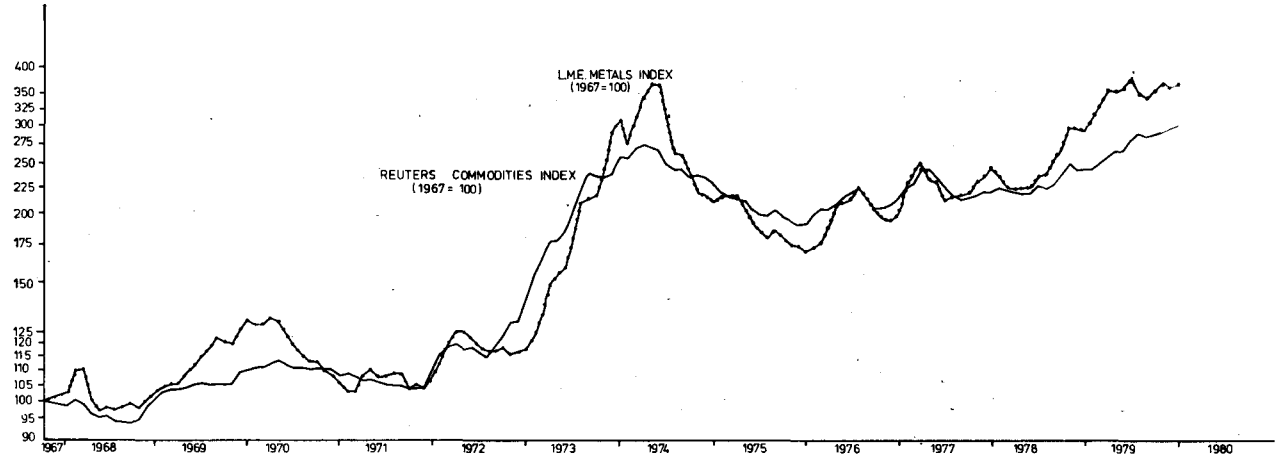

Fig. 4—L.M.E. metals index and Reuters commodities index from a constant 1967 sterling–dollar base (1967=100)

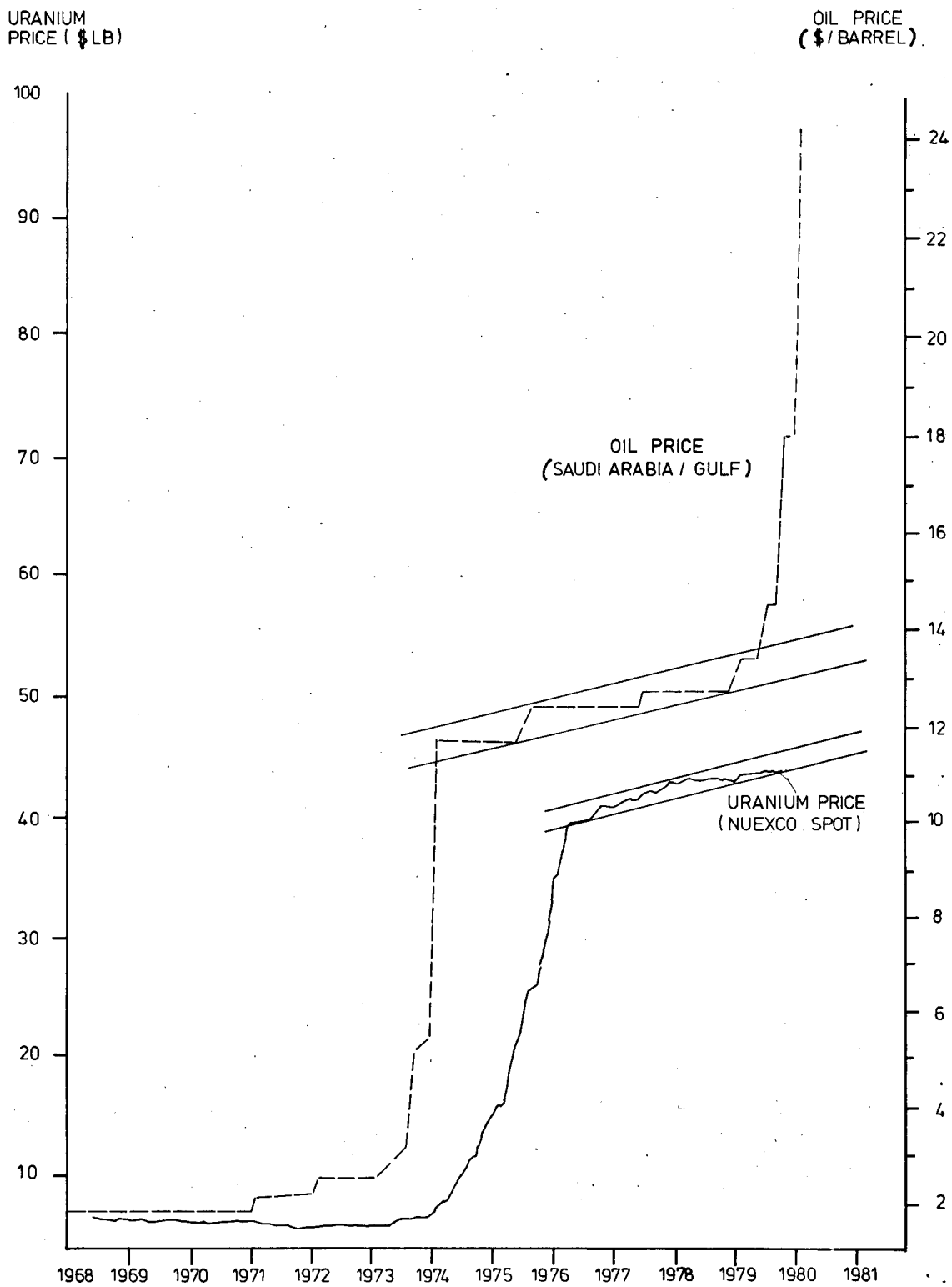

Fig. 5—U_3O_8 (NUEXCO) and oil prices

In this approach, however, various factors must be taken into account: firstly, different national economies are often in different phases of their respective economic cycles; secondly, certain metals tend to respond to economic recovery early in the cycle while others pick up only late in the cycle; thirdly, there are anomalous commodities such as gold and silver that tend to be counter-cyclical to commodities in general; finally, a rise in consumption is not always translated immediately into higher prices owing to high stock levels and/or variations in the level of supply.

(v) *Correlation with Other Commodity Prices and Indexes*
Historically, both hard and soft commodity prices (sometimes with the exception of precious-metal prices) have tended to follow a similar trend. On Fig. 4 we have plotted the Reuters commodity index and our own L.M.E. base-metals index. (The average monthly prices of the base metals on the L.M.E. were expressed as indexes based on average annual prices in 1967; the L.M.E. index is the average of the indexes of the four metals, copper, tin, lead, zinc.) In order to eliminate distortions caused by sterling fluctuations, we have plotted both indexes in terms of a constant sterling–dollar rate based in 1967. As can be seen from this chart, both indexes have moved very closely together throughout the period, thus suggesting that the base-metal prices on the free market move very much in line with the overall price trends of commodities as measured here by the Reuters index. This kind of correlation is of considerable significance in forecasting work since it enables an analyst to view price trends of particular metals against the overall price trends of commodities, with the knowledge that deviations between the two will usually be of only a short-term nature.

The price trends of related commodities often show good correlations. Such correlations are not necessarily direct, but sometimes exhibit a significant time lag. In Fig. 5, we have plotted the prices of crude oil (Saudi Arabian–Gulf), together with free-market uranium prices (NUEXCO spot prices). After running five consecutive correlation programmes on the data (based on a direct correlation, and 6-month, 1-year, 18-month, and 2-year lags in uranium prices), we found that the highest correlation existed where uranium prices lagged oil prices by 18 months (a significant 0,91 coefficient of correlation, where 1 would be a perfect correlation).

(vi) *Technical Analytical Tools*
Finally, technical methods such as regression-line analysis, cyclical analysis, and various charting techniques can be useful tools to supplement other methods of forecasting. The latter two especially can be used to provide warning signals of a possible reversal in cyclical trends within particular markets. Regression-line analysis often achieves good results in long-term forecasting. Although prices in the short term may deviate significantly from their long-term trendline, they tend to gravitate back towards this trendline. Hence, extrapolation of a trendline may provde a useful mechanism to show future long-term trends in metal prices.

Similarly, where the possible duration or extent of a cycle in a particular commodity price is required, cyclical analysis of the amplitude and wavelengths of past cycles in the commodity price can be useful. Also useful are techniques such as the crossing of moving averages, point and figure chart breakouts, and trendline breaks on bar and line charts: these provide alert or warning signals where a change of trend is being looked for.

Results of Forecasts

We limit our discussion of past results to our forecasts of copper prices since we have used a fairly wide range of methods in forecasting copper prices, and the discussion of methods and results illustrates the use of some of the forecasting methods described in the previous section. The prices we have used in our forecasts have been expressed in *current* terms, in *constant* terms, or in *deflated constant* terms. Briefly, these expressions can be defined as follows: *current* terms refer to the actual published price on metal markets without taking into account the value of the currency in which the price is expressed; *constant* terms refer to the price in current money terms adjusted for changes in the parity of the currency in which the price is expressed relative to other currencies (usually the dollar); *deflated constant* terms refer to the price in constant money terms deflated by the consumer price index to adjust for the effect of inflation.

These concepts can be illustrated by means of a hypothetical example. The price of a metal was £800 per ton when £1 was equivalent to $2,50. Five years later the price in current money was £1250 per ton, but £1 now equalled only $2,00. In constant terms, the price expressed in sterling is

$$\frac{2,00}{2,50}\times 1250 = £1000.$$

Over the five-year period, the U.S. consumer price index rose from a base of 100 to 120. Thus, the price expressed in sterling in terms of a constant sterling–dollar parity adjusted for inflation is

$$1000\times\frac{100}{120} = £833,33.$$

The object in expressing commodity prices in deflated constant terms is to remove extraneous influences (i.e., the influences that do not originate within the particular commodity market) so that the price reflects as far as possible only the factors that originate within the market itself.

Forecast (a), Dated August 1972

In August 1972 we made a forecast of the average annual L.M.E. copper price for 1977. Briefly the following method was used.

(i) We projected the rise in production costs in the non-Communist World over the period 1970 to 1977 at the same average rate of 5¼ per cent per annum that had prevailed over the period 1952 to 1970. This resulted in a figure of 48,6 cents per

pound (£443 per metric ton) for average working costs in the copper industry in the non-Communist World in 1977.

(ii) According to the theory developed by the American mining economist, Arthur Notman[1], the ratio of the copper price to costs of production averaged approximately 12:7 for the industry as a whole over a period of several decades. On the basis of this ratio, the average price during 1977 would have been 83,3 cents per pound (£759 per metric ton).

(iii) However, this relationship between production costs and price is not applicable to the price over a single year and would be influenced by the demand–supply balance. We forecast an oversupply of copper in 1977 and predicted that the expected oversupply would force the price down to well below £759 per ton, which would represent a price dictated by production costs and the historical relationship of the price to the costs. We therefore forecast that the average price of copper in 1977 would be in the range £600 to £700 per metric ton.

In our forecasts, we assumed that the value of sterling expressed in terms of its parity with the dollar would remain constant. In fact, there was a sharp decline in the value of sterling over the period 1972 to 1977. In August 1972, the monthly average £–$ exchange rate was 2,45; the annual average rate in 1977 was only 1,74. Therefore, expressed in constant August 1972 sterling, the average L.M.E. price during 1977 was much lower than it was in current sterling. Table III compares our forecast prices for 1977 with the actual prices expressed in terms of both current and constant sterling.

Thus, although our forecast of the average price in 1977 was over 13 per cent too low in current sterling, it was nearly 22 per cent too high when expressed in terms of the value of sterling at the August 1972 parity with the dollar. Nevertheless, in view of the length of the period involved and the volatility of the copper market, the degree of accuracy of the forecast must be considered satisfactory. It was also gratifying that our forecast of an oversupply situation proved to be correct.

Forecast (b), Dated January 1974

This forecast also referred to the year 1977. It was made on the basis of a projection of the regression line showing the average annual growth rate in the average price of copper on the L.M.E. over the period 1958 to 1973. On the basis of a straight-line projection, the average price in 1977 would have been £929, but we took into account the historical volatility of the copper price and postulated that the actual price would be somewhere within the range of 25 per cent above and below the trend line, i.e. £929 ± 25 per cent:£697 to £1161.

TABLE III

COMPARISON OF ACTUAL AND FORECAST COPPER PRICES, 1977

	Forecast	Actual		Deviation of forecast, %	
		Current £	Constant £	Current terms	Constant terms
Range	600-700	638,25-902,5	453,29-640,96		
Average	650	750,7	533,15	−13,4	+21,92

TABLE IV

COMPARISON BETWEEN FORECAST AND ACTUAL PRICES OF COPPER, 1978

	Stocks:consumption ratio		Regression Current £
	Deflated constant £	Current £	
Forecast	244,9	839	784
Actual	228,8	710,2	710,2
Deviation of forecast, %	+7,04	+18,13	+10,4

No provision was made for changes in the value of sterling relative to the dollar.

At the time of the forecast, we were more concerned with predicting a floor level for copper prices in 1977 than the actual price. We therefore considered £697 to be the floor level, below which it was extremely unlikely that the average annual price in 1977 would fall. The actual annual average price proved to be £750,70.

This forecast was rendered unsatisfactory, however, by the fact that the value of sterling in dollar terms had fallen drastically over the period January 1974 to 1977. In January 1974 sterling was worth an average of $2,22, but in 1977 the average value of sterling was only $1,74. Therefore, expressed in constant January 1974 sterling, the average copper price in 1977 of £750,70 was only £588 and was substantially less than the floor price of £697, which we had forecast. The unsatisfactory result of this forecast illustrates two points:

(1) forecasts based on past trends that do not take the future demand–supply outlook into consideration are inherently dangerous;

(2) forecasts based on current money values tend to become meaningless in times of currency instability.

Forecast (c), Dated September 1977

Our third forecasting exercise on copper was a far more comprehensive analysis than the previous two. In this exercise we forecast prices over the period 1977 to 1981. We used two separate methods to make our forecasts.

(i) *Relationship of Deflated Price to Stocks: Consumption Ratio*

First, we established a historical relationship between the quarterly average price of copper converted to constant terms and the ratio of stocks to consumption in the non-Communist World for the period mid-1970 to the first quarter of 1977. The hyperbolic nature of this graph is illustrated in Fig. 3. We then forecast the demand–supply balance over the period 1978 to 1981, and the consequent stocks:consumption ratio that would result. We then read off from the graph the deflated prices that would correspond to the anticipated stocks:consumption ratio and inflated these prices according to our own inflation estimates.

(ii) *Regression Lines*

We used the CSSL Curfit programme to calculate regression lines on average monthly copper prices over the period January 1958 to mid-1977. The Curfit programme calculates the best least-squares curve fit for six different functions, and also lists the coefficient of correlation of each. We found that the three functions with the highest correlation

coefficients were exponential, hyperbolic, and linear. We then took the average of these three functions as our forecast. Our forecast for the average annual price for 1978 was £784 — 10,4 per cent too high.

Our forecasts for 1978 are compared with the actual average annual price in Table IV, which shows that our forecasts in current terms had a much larger deviation from the actual price than our forecast in deflated constant terms. The bulk of the error in our forecast of the current price was therefore due to errors in our assumptions of factors extraneous to the copper market, i.e. the value of sterling and general inflation. When expressed in deflated constant terms, our forecast was only 7,04 per cent too high.

Conclusions

In the complex international environment within which large business organizations operate, forecasting is becoming an increasingly central function, and commodity analysis must therefore play a progressively more important role in a Johannesburg mining finance house. The distance from world markets poses special problems for Johannesburg mining houses in following the trends in the commodity markets. Although a mining house must continuously make assumptions concerning the future demand for mineral products and their prices, this is often an *ad hoc* and unsystematic exercise. Individual metals and minerals tend to be looked at in isolation, rather than as related commodities subject to the overall influence of the economy. A commodity unit can provide a more systematic approach and more cohesion to the ongoing process of forecasting. We believe that the development of a greater understanding and awareness of the potential role of commodity analysis within the South African mining industry would contribute to the effectiveness of this function, and it is hoped that this paper will stimulate further debate on the subject.

Reference

1. PRAIN, Sir Ronald. *Copper; the anatomy of an industry.* p. 196.

S.A.I.M.M. diary

14th–18th April, 1980 University of Witwatersrand	Pyrometallurgy Vacation School Course Leader: Professor H. Bell, University of Strath-Clyde, Scotland
30th May, 1980 National Institute for Metallurgy	Colloquium—Mining Projects: Evaluation, Finance and Management
27th August, 1980 Kelvin House	Annual General Meeting
15th–19th September, 1980 Electra Mining Exhibition, Milner Park (Venue to be confirmed)	Colloquium on Mine Fires Colloquium on Project Management in the Metallurgical Industry
2nd–6th February, 1981 (Venue to be announced)	Vacation School on Increased Extraction of Coal by Underground Mining Methods
February, 1981 (Venue to be announced)	Colloquium on Wear and Abrasion in Industry in collaboration with the Institution of Metallurgists (South African Branch)
July, 1981 University of Pretoria	Refresher course on the Heat Treating of Steel — Theory and Practice (organized by the SAIMM Materials Engineering Division)
July, 1981 (Venue to be announced)	Vacation School on Uranium Ore Processing — Extraction of Uranium
August/September, 1981 (Venue to be announced)	Vacation School on Mining, Finance and Taxation Course Leader: Professor B. Mackenzie, Canada.
3rd–7th May, 1982 Carlton Hotel, Johannesburg	Twelfth Mining and Metallurgical Congress in collaboration with the Geological Society of South Africa