Statistics
NEW ZEALAND
Te Tari Tatau

MINERAL
MONETARY AND PHYSICAL STOCK ACCOUNT

1994 – 2000

Environmental Accounts Series

Acknowledgement

This report was prepared by the Environmental Statistics Team and published by the Information and Publishing Services Division of Statistics New Zealand.

Further information

For further information on the statistics in this report, or on other reports or products, contact our Information Centre.

Visit our website:	www.stats.govt.nz
or email us at:	info@stats.govt.nz
or phone toll free:	0508 525 525

Auckland	**Wellington**	**Christchurch**
Private Bag 92003	PO Box 2922	Private Bag 4741
Phone 09 920 9100	Phone 04 931 4600	Phone 03 964 8700
Fax 09 920 9198	Fax 04 931 4610	Fax 03 964 8964

Information Centre

Your gateway to Statistics New Zealand

Each year, we collect over 60 million pieces of information. New Zealanders tell us how and where they live; about their work, spending and recreation. We also collect a complete picture of business in New Zealand. This valuable resource is yours to use. But with all the sophisticated options available, finding exactly what you need can sometimes be a problem.

Giving you the answers

Our customer services staff provide the answer. They are the people who know what information is available, and how it can be used to your best advantage. Think of them as your guides to Statistics New Zealand. They operate a free enquiry service where answers can be quickly provided from published material. More extensive answers and customised solutions will incur costs, but we always give you a free no-obligation quote before going ahead.

Table of contents

List of figures 4

List of tables 4

Preface 5

1 Summary 6

1.1 Highlights from minerals and energy reports 6

2 Methodology 7

2.1 Valuing subsoil assets 7

2.2 Resource rent 7

2.3 Discount rates 8

2.4 Lifespan 8

2.5 Data sources 9

2.6 Future developments 9

3 New Zealand minerals: history and occurrences 10

3.1 Metallic minerals 10

3.2 Other metallic minerals 11

3.3 Non-metallic minerals and rocks 12

4 Mineral stocks 14

4.1 Physical stocks 14

4.2 Monetary stocks 15

5 Glossary 19

6 Bibliography 20

List of figures

Figure 4.1 Cumulative mineral asset value 17
Figure 4.2 Asset value of aggregate, gold, limestone and ironsand 17
Figure 4.3 Asset values of silver, clay, dolomite and other 17

List of tables

Table 2.1 The effect of discounting stocks with large Lifespans 9
Table 4.1 Metallic minerals actively extracted in New Zealand 14
Table 4.2 Other metallic minerals found in New Zealand 14
Table 4.3 Non-metallic minerals in New Zealand 15
Table 4.4 Summary of monetary mineral stocks 16

Preface

Statistics New Zealand, in association with the Ministry for the Environment, is preparing stock and flow estimates for New Zealand's most significant natural resources: energy, forestry, minerals, and water. Technically, physical estimates are called natural resource accounts, and monetary estimates are called environmental accounts. These terms are commonly used interchangeably. Natural resource and environmental accounts are being developed to gather information on the complex relationships between the economy, the environment and society. Work started on the accounts after the Budget 2000 provided funding for natural resource accounts.

This report seeks to provide information on the asset value, and physical quantity, of minerals stocks in New Zealand. Coal and mineral petroleum stocks are excluded from valuations in this report as they are already evaluated in the Monetary Energy Stock Account. Mineral stock and flow accounts are based on an international framework called the System of Environmental and Economic Accounts (SEEA). This framework is an extension of the System of National Accounts (SNA), which Statistics New Zealand uses to compile the national accounts, including gross domestic product (GDP). The SEEA is designed to measure the use of natural resources and the effect natural resource consumption has on the environment.

The methodologies used to assess minerals stock levels are consistent with those used to assess energy resources and other natural resource monetary stock estimates. This is important as it allows consistent comparisons between New Zealand's natural resource asset values. In the future, energy and minerals estimates will be combined into a single report.

The release of natural resource and environmental accounts reflects an international trend towards compiling information beyond the traditional measures of economic activity. The accounts reflect the view that the environment has a finite capacity to supply materials and absorb waste. Environmental information is collected under a framework that allows for adjustments to conventional calculations of GDP to reflect environmental depletion. Existing measures of GDP do not currently account for the depletion of environmental assets.

By using the SEEA framework, New Zealand can compare its stock position with other countries, as the SEEA is used internationally. Countries using the SEEA in whole or in part include Australia, Canada, Japan, the Philippines, and the United Kingdom.

For more information regarding the role of natural resource accounts in New Zealand please refer to "Natural Resource Accounts for New Zealand – Overview Document" (Statistics New Zealand, 2002. www.stats.govt.nz).

1 Summary

The purpose of this report is to add to the range of natural resource and environmental accounts for analysis by government and the wider community. These accounts show valuation changes in New Zealand's natural resources over time and can be used for the analysis of trends in asset value and the utility of natural resources.

This report includes sections on methodology, background to New Zealand minerals, tables and figures for production statistics, physical stock estimates (Christie and Brathwaite, 1999) and asset valuations. Calculated asset valuations only include minerals which are presently economically utilised in New Zealand. These economic mineral resources include metallic minerals (gold, silver and ironsand concentrate) and non-metallic minerals (aggregate, clay, limestone, dolomite and others). Coal and petroleum stocks are excluded from calculations in this report as they are assessed in the Energy Monetary Stock Account.

Asset valuations are produced using a Net Present Value approach. This methodology is used internationally and is recommended by the System of Environmental and Economic Accounting (SEEA).

1.1 Highlights from minerals and energy reports

- In 2000 the total asset value of New Zealand's economically utilised mineral resources (excluding coal and petroleum) was $223 million.
- Of this, $130 million was non-metallic minerals and $93 million was metallic minerals.
- In 2000, aggregate had the highest asset value of all utilised minerals, valued at $105 million.
- Gold recorded the second highest asset value of all minerals at $77 million, the highest for metallic minerals.
- By comparison (Energy Monetary Stock Account, 2004) in 2000, coal stocks were valued at $398 million, oil stocks at $793 million, gas stocks at $2,770 million, and renewable hydro-electrical energy was valued at $3,670 million.
- Physical stocks of aggregate and limestone in New Zealand cannot be measured exactly but are known to be very large.
- Of metallic minerals only gold, silver and ironsand concentrate are currently economically utilised at significant rates. However, physical stocks of other metallic minerals exist and have the potential to be economically utilised in the future.

2 Methodology

Physical stocks are presented in tables showing stocks of economically utilised metallic minerals, other metallic minerals and non-metallic minerals, as at 1997. Information for these tables comes from “The Mineral Potential of New Zealand” report (Christie and Brathwaite, 1999). This report assesses stocks (where possible) as proven plus probable reserves. Tables showing physical production figures are also presented. Physical reserves and extraction rates are used to estimate the ‘lifespan’ variable, as discussed below.

The minerals monetary stock account shows asset values of New Zealand’s economically exploited mineral resources and changes in value over time. Annual balance sheets are provided for the period 1994 to 2000 for metallic minerals (gold, silver and ironsands) and for non-metallic minerals (aggregate, clay, limestone, dolomite and other). The ‘other’ category includes decorative pebbles, diatomite, perlite, greenstone (pounamu), pumice, recycled material, serpentinite, amorphous silica, silica sand, sulphur, talc and zeolites. All in the ‘other’ category have intermittent or little production.

The difference between opening and closing stocks is split into two components. The first component is resource rent, which has been calculated for the stock accounts. The other component is a residual that implicitly accounts for other changes affecting asset levels and values, including discoveries and reappraisals of mineral resources, changes in the rate of extraction, technological changes, and changes in the capacity to utilise minerals resources.

2.1 Valuing subsoil assets

The asset value of a natural resource is conceptually the market value of the asset if it was sold. The SEEA states that where possible, market prices should be used to provide an estimate of an asset’s value. However, in practice, market values may not always be readily available.

When no market prices exist, an asset value can be estimated as the Net Present Value (NPV) of discounted resource rent. This can be estimated from the formula:

$$NPV = RR\sum_{k=1}^{n}\frac{1}{(1+r)^k} = RR\frac{(1+r)^n - 1}{r(1+r)^n}$$

NPV = net present value

RR = resource rent

r = discount rate

n = lifespan

It is important to note that asset valuations calculated using the NPV approach only include resources which are currently utilised for economic gain. This does not mean that mineral resources which are currently not economically utilised have no future value, just that they have no present value that can be assessed, due to lack of information.

2.2 Resource rent

The annual resource rent owing to a natural resource can be estimated as the revenue generated from the use of the resource, less all costs incurred in generating that revenue, including return on capital. Revenue generated from the use of energy resources may be captured by the Crown, through royalties and levies, and by the industry, in operating surplus. Levies and royalties collected by the Crown are added to the mining industry’s net operating surplus to estimate the total resource rent owing to the natural resource.

$$RR = NOS * -\tau V$$

RR = resource rent

τ = rate of return

V = capital stocks

NOS* = net operating surplus plus royalties and levies

The rate of return on capital used in the above calculation is estimated to be 8 percent in real terms, which is in line with Eurostat recommendations, and is also the rate other countries (United Kingdom, Denmark, Norway) are using in practice. It is worth noting that the resulting valuations are very sensitive to variation in this estimate. Future resource rent is dependent on assumptions about how prices, extraction costs and extraction will vary over the life of the asset. These variables cannot be known with certainty, therefore for the calculation of asset values, the extraction rates are assumed to remain constant. Future resource rent for year t is calculated as the three-year symmetric moving average of years t-1, t and t+1 (Eurostat, 2003). If specific information about resource rents and extraction rates was available this could be incorporated to modify asset valuations.

2.3 Discount rates

Discount rates express a time preference by the asset's owner, for money generated now or in the future (Pearce, 1989). By discounting future income so it is comparable with income earned today, an asset's value, based on future income, can be estimated. The choice of the discount rate to be used in estimating an asset's value is a pivotal variable and is often the subject of considerable debate (Eurostat, 1999).

The discount rate used in this account was established after reviewing rates for valuing subsoil assets used by other countries. Eurostat recommends that discount rates for subsoil assets should be close to long-term borrowing rates of 3.5 to 5 percent (country dependent) (Eurostat, 1999). The New Zealand Treasury suggests that a discount rate of 10 percent should be used whenever there are no other agreed sector discount rates for costing policy proposals (Young, 2002). The government's long-term after-tax discount rate is set at 4 percent (Government Superannuation Fund, 2003), and is consistent with the range of discount rates used by other countries for subsoil asset accounting.

In this report Statistics New Zealand uses a 4 percent discount rate to assess minerals asset values, which is consistent with international practice (United Kingdom, Norway, Denmark, France, Netherlands) for subsoil asset accounting and with discount rates used in the Energy Monetary Stock Account.

2.4 Lifespan

The lifespan of mineral assets cannot be known with certainty. It depends on production decisions, the extent to which new reserves are discovered, and changes in technology and price. What can be estimated is the expected lifespan of the resource at a given point in time (SEEA, 2003). The expected lifespan of subsoil assets are estimated as:

$$Lifespan = \frac{\text{stocks}}{\text{extraction}}$$

Information on mineral stocks comes from the Institute of Geological and Nuclear Science (GNS) report "The Mineral Potential of New Zealand" (Brathwaite and Christie, 1999) and from the Ministry of Commerce report "Mineral Resources of New Zealand" (MacFarlan and Barry, 1991). Due to uncertainties and costs associated with defining mineral resources, precise stock estimates are generally unavailable. For low-cost bulk non-metallic minerals such as aggregate, precise stock levels are not evaluated accurately because of the large quantities available. In these reports stock levels are generally given in tonnes for precious and semi-precious minerals, but low-cost bulk minerals are evaluated as "large", "very large" or "undefined but deemed to be significant".

Based on data from these reports, estimated lifespans for individual mineral resources are all greater than 100 years, with the majority having lifespans greater than 300 to 500 years at current extraction rates. Combining these lifespans with those of the “very large” resources, we get a very long lifespan for mineral resources.

The NPV formula requires a lifespan to calculate asset values. However, due to discounting, increasing the lifespan of mineral resources from 100 to 1000 years (a range which includes lifespans for all minerals) has very little influence on the net present value of the asset.

Table 2.1 The Effect of Discounting Stocks with Large Lifespans

	Net Present Value $million				
Resource rent	Lifespan (years)				
	100	200	300	500	1000
50	1,225	1,250	1,250	1,250	1,250
100	2,450	2,499	2,500	2,500	2,500

The above table shows that there is little change in asset value by increasing the asset’s lifespan from 100 through to 1000 years when using a 4 percent discount rate. If the discount rate was increased, this would further reduce the influence of increasing the lifespan of the mineral assets.

This implies that for monetary stock valuations using the NPV of resource rent, physical stocks do not need to be known with certainty, as long as they are known to be very large (ie a lifespan of 100 years or more).

2.5 Data sources

All monetary data relating to net operating surplus, capital stocks and consumption of fixed capital was obtained from Statistics New Zealand’s National Accounts. Production data regarding individual commodities was obtained from the Crown Minerals website and from Statistics New Zealand’s Official Yearbooks.

Physical data used to estimate lifespans, was obtained from the GNS report “The Mineral Potential of New Zealand” (Christie and Brathwaite, 1999), the Ministry of Commerce report “Mineral Resources of New Zealand”, Statistics New Zealand’s Official Yearbooks and from the Crown Minerals’ website. The discount rate was set at 4 percent (see section 2.2).

2.6 Future developments

The accounts produced in this report are developmental, using standard methods and assumptions in line with international precedent. However, monetary resource stock estimation techniques are still evolving. Statistics New Zealand, working within the OECD’s subsoil workgroup, intends to further investigate and develop these methodologies and assumptions. Areas in which investigation is being undertaken are highlighted below.

The NPV methodology potentially produces volatile asset valuations. Investigations into methodologies to reduce this annual variability will be undertaken. This includes back calculating NPVs using available data, and reviewing the return to capital stocks in years of sub-optimal production.

Asset valuations are highly sensitive to the choice of discount rate and rate of return, and therefore these are areas which will be under constant review. In these accounts Statistics New Zealand intends to keep the choice of discount rate and rate of return in line with international precedent, currently a 4 percent discount rate and a constant 8 percent rate of return for subsoil asset accounting. Detailed analysis of the choice of rate of return will be undertaken. This includes a sensitivity analysis of different rates of return, including a variable rate.

At present, totals are disaggregated into individual commodities based on the share each commodity has in the total output value of the industry, an assumption in line with Eurostat recommendations. A more detailed analysis of National Accounts industry data will be undertaken. This should lead to more accurate estimates at the commodity level, through more accurate allocation of operating surplus and capital stocks to commodities.

3 New Zealand minerals: history and occurrences

The New Zealand landmass lies on a collision boundary between the Indo-Australian plate and the Pacific plate. Processes involved in this collision have had a profound effect on the size, shape and geology of New Zealand. The oblique component of the collision has produced the elongate northeast/southwest lying landmass. The convergent component of the collision has led to rapid mountain building, bringing minerals from within the crust to the surface (Statistics New Zealand, 1995).

Rapid uplift, combined with New Zealand's often extreme climatic conditions, has lead to substantial erosion, producing large amounts of sediment. Reworking of this sediment by glaciers, rivers, wind and the sea has created economic mineral deposits.

Volcanic activity over the past few million years has also played an important part in determining mineral occurrences in New Zealand, especially in the Taupo Volcanic Zone (Statistics New Zealand, 1994). Volcanism is important in mineral occurrences as it concentrates heavy minerals, such as gold, through hydrothermal activity.

Uplift and changes in relative sea level in the geological past have also produced economic mineral deposits. An example of this is limestone, which results from deposits of shells and foraminifera tests at water depths of 30–80 metres. These limestone deposits are able to be utilised for agricultural and building purposes when exposed by uplift and sea level changes.

Information for individual mineral descriptions below (sections 3.1 and 3.2), comes from "The Mineral Potential of New Zealand" (Christie and Brathwaite, 1999), "Mineral Commodity Reports" (Christie and Brathwaite, 1996 and 1997), "Mineral Resources of New Zealand" (MacFarlan and Barry, 1991) and "Explore New Zealand Minerals" (Crown Minerals, 2001) reports.

3.1 Metallic minerals

Gold is a precious metal, sought for thousands of years because of its scarcity and physical properties. Gold is a heavy, soft metal that is the most malleable and ductile of all metals, and whose conductivity of heat and electricity is exceeded only by silver and copper. It is one of the least reactive metals, being unaffected by air, heat, moisture and most solvents. Gold was initially used for jewellery, and subsequently became the basis for currencies worldwide. Gold has more recently been used in electronics and medicine.

The discovery of gold in Otago, the West Coast and the Coromandel supported the development of New Zealand in the pioneering days. Mining activity created wealth and encouraged the development of farming to support mining communities. Gold was first discovered in New Zealand at Coromandel in 1852. Later Gabriel Read discovered rich gold deposits near Lawrence in Central Otago, which led to gold rushes from 1861 to 1895.

Gold occurs primarily in quartz veins deposited from hydrothermal fluids in fault zones at medium or shallow depths in the crust. Because of gold's high density and chemical stability, when eroded from vein deposits it can become concentrated by flowing water and form placer deposits. It was these placer deposits, along with small amounts of hard rock extraction, which were exploited in the early gold rushes.

With technological advances and increases in gold prices, large-scale hard rock mining became attractive. New Zealand's largest identified gold resource is at Macraes in east Otago, an area which has been mined since 1991. Other significant gold resources are located in Hauraki, the West Coast and Otago.

Officially, New Zealand's gold production to the end of 1995 was 958 tonnes; however much of the gold extracted in the early gold rushes is believed to be undeclared. Current annual production ranges between 9 and 12 tonnes.

Silver has been valued as an ornamental and decorative metal since ancient times. Its continued extraction is the result of its physical properties. Silver in pure form, has a brilliant white metallic lustre and a high specific gravity. It has the highest electrical and thermal conductivity of all metals and is extremely malleable and ductile.

Internationally, about 30 percent of all silver produced is used for photographic materials. A further 30 percent is used for silverware and jewellery. The remainder is predominately used for electrical components, batteries, dental alloys, catalysts, water purification and as monetary reserves of silver bullion and coins.

The most significant occurrences of silver in New Zealand are associated with gold in the epithermal gold-silver-quartz veins of the Hauraki goldfield and are extracted as a by-product of gold extraction. Historically, more than 1,000 tonnes of silver has been produced from this region.

Ironsands, in the form titanomagnetite-rich coastal sands, occur in the onshore dunes, beach sands and offshore marine sands on the west coast of the North Island. These sands are mined for their iron content and for their by-product vanadium content. Attempts to smelt these ironsands began in 1849 but the high titanium content and fine grain size defeated the technology of the period. Smelting of these ironsands became possible by 1964, and the Glenbrook Steel Mill was commissioned in 1970 to utilise them. At present, approximately 1 million tonnes per year (Mt/yr) of concentrate is produced from the Waikato North Head mine for steel making at Glenbrook. From this, a vanadium-rich slag is also produced as a by-product, and is exported. Other significant extraction of ironsands occurs at the Taharoa mine, which produces about 1.2Mt/yr of titanomagnetite concentration for export.

Ilmenite beach placers are mainly found along the South Island's West Coast, where ilmenite is present in coastal sand deposits. The deposits are potentially a large source of titanium dioxide. However, these sands contain large quantities of silicate minerals and therefore have lower titanium dioxide concentrations than do Australian ilmenite sands. This relatively low titanium dioxide content reduces the effectiveness of standard techniques for recovering the titanium. So far this has precluded mining of the ilmenite.

3.2 Other metallic minerals

Other than gold, silver and ironsands New Zealand has few potentially economic metal resources. Some were worked on a small scale in part to meet wartime needs. None are currently worked and there is little active exploration for metallic minerals other than gold.

Aluminium, in the form of bauxite, is present in small quantities in Northland. Because of the relatively small size and high iron content of the deposits, no attempts have been made to utilise them. New Zealand has potential resources of about 20 million tonnes.

Antimony, in the form of stibnite (antimony sulphide), occurs in association with gold-bearing quartz lodes in Westland and in the schist of Marlborough and Otago. Stibnite was mined from Endeavour Inlet between 1872 and 1908, with several thousand tonnes being produced. There is no current production.

Chromium, in the form of chromite, is associated with the ultramafic rocks of Nelson's Dun Mountain Ophiolite Belt. This chromite has historically (1860s) been extracted but there has been no recent production.

Copper is found in small quantities in porphyry copper, copper skarn and massive sulphide deposits in Northland and Coromandel and in smaller amounts within the Dun Mountain Ophiolite Belt in Nelson. A few thousand tonnes were produced historically, but there is no current production.

Lead and zinc were extracted from sulphides at the Tui mine near Te Aroha (Coromandel). Between 1967 and 1973, the mine produced 13,000 tonnes of zinc concentrate and 7,700 tonnes of copper-lead concentrate. The mine closed because the small mercury content of the concentrate made it unacceptable for the Japanese market.

Manganese occurs widely as small irregular bodies within the greywackes of the Torlesse (Canterbury) and Waipapa (Northland) terranes. Manganese was worked in several small-scale mines in the Northland and Auckland regions between 1878 and 1911, with a total production of about 19,000 tonnes of ore.

Mercury deposits at Puhipuhi in Northland were worked between 1927 and 1945. These deposits were formed by recently extinct or current hydrothermal activity.

Molybdenum occurs in west Nelson and Buller (West Coast) in the form of molybdenite. All the occurrences are associated with small mid-Cretaceous quartz-porphyry stocks. Several prospects were investigated between 1967 and the early 1980s, but no ore-grade material was found.

Platinum group metals have been found as trace amounts associated with the Riwaka, Rotoroa (Nelson) and Longwood (Southland) igneous complexes and the Dun Mountain Ophiolite Belt. Apart from small quantities which were recovered along with gold in mining placer deposits in Southland, no commercial deposits have been found.

Tungsten (scheelite) has been recovered in small quantities in quartz lodes in the Haast Schist, with the most important deposits being at Wakamarina, Glenorchy and Macraes. Production of scheelite has been highly variable and at present is nil.

3.3 Non-metallic minerals and rocks

Aggregate and sand is used in large quantities for roads and building, and in lesser quantities for reclamation, harbour protection and railway ballast. Sand also has several industrial uses. Stock levels of this resource have not been estimated due to there being very large quantities nationwide. However, the quantity of aggregate available for specific purposes is variable from area to area. Due to the low value per tonne, transport costs are a major factor in the economics of supply, and sources are required to be close to demand.

Barite has been reported in small quantities in northwest Nelson, with a potential resource of less than 3,000 tonnes of ore. No barite has ever been mined in New Zealand.

Bentonite is generally used as a foundry sand-binder, for drilling mud, for sealing drillholes and in civil engineering for dam sealing and in fibre cement. Production of bentonite in New Zealand is highly variable as New Zealand's distance from markets and high transport costs restrict exports.

Clays are extracted for brick making, tiles, pipes, pottery and industrial purposes. Halloysite clay, reputed to be "the world's whitest clay", is produced from deposits at Matauri Bay in Northland. The clay is formed by hydrothermal alteration and subtropical weathering of Pliocene and Pleistocene age rhyolite. About 80,000 tonnes per year of raw clay is mined from two deposits. High-value processed halloysite product is exported to more than 20 countries for the manufacture of high-quality ceramics, principally porcelain, but also fine bone china and industrial ceramics.

Dolomite occurs in marble formations at Mt Burnett in northwest Nelson. Annual production has been about 24,000 tonnes with an in-ground resource of approximately 70 million tonnes. Dolomite is extracted for use as a magnesium fertiliser and has also been used for riprap.

Diatomite is used as a pozzolan cement, a filtration medium and as a filler in insulating material. Most diatomite has been produced from deposits at Whirinaki (Rotorua) and Middlemarch (Otago).

Feldspar is widely used as a flux in ceramic and glass making. It is not currently extracted in New Zealand, though potential resources of 240 million tonnes have been estimated in Northland coastal sands.

Fluorite has never been mined in New Zealand, but occurs as low-grade ore in veins with barite at Thompson Hill.

Greenstone (Pounamu) is a culturally important mineral for the people of New Zealand, especially Maori. Historically pounamu was highly sort after and used for tools, weapons and jewellery. Today it is the basis of a thriving jewellery and souvenir industry. In 1997, under the Ngai Tahu Settlement Act between the Government and iwi, settling historic claims under the Treaty of Waitangi, the Government agreed to vest all ownership of the pounamu resource with Ngai Tahu (Crown Minerals, 2001). Significant greenstone resources occur in the Pounamu Ultramafics of Westland, and at Anita Bay in Milford Sound, Fiordland.

Limestone is an important raw material for New Zealand agriculture and industry. It is abundant in several parts of the country. Although reserves are rarely quantified, they are sufficient to far exceed demand, except possibly for the highest grades of industrial lime.

Limestone's uses include as a fertiliser to reduce acidity, as a mineral filler, in cement production, as a building material and as burnt lime (calcium oxide), which is used in the steel industry.

Marble is metamorphosed limestone and occurs in Ordovician-age sedimentary rock sequences in northwest Nelson and in Fiordland. The production of marble is highly variable; most comes from quarries on Takaka Hill.

Perlite is hydrated rhyolitic volcanic glass used as an inert insulator and filler, and for horticultural pot plant mixes. Current production is around 2,000 to 3,000 tonnes annually from a quarry at Atiamuri in the Taupo Volcanic Zone.

Phosphate was mined for use as fertiliser. The only phosphate mines in New Zealand were at Claredon, south of Dunedin. Mining began in 1902 and ceased in 1924, briefly reopening during the Second World War.

Pumice is found in extensive outcrops associated with the rhyolitic volcanoes in the Taupo Volcanic Zone. It is quarried in several places and dredged with sand in the lower reaches of the Waikato River. Major uses include as lightweight fillers for wallboards, as drainage material and as a soil conditioner for horticulture. Some pumice is exported.

Sulphur production in New Zealand has been small in quantity and comes from surface and lake deposits associated with geothermal activity in the Taupo Volcanic Zone.

Serpentinite is quarried in considerable quantities for use in magnesium superphosphate. The serpentinite is a magnesium source, which is important in magnesium-deficient soils such as those in Southland. However, the development of granulated fertilisers and the recognition of asbestos within serpentinite have led to a major decline in its use as a fertiliser. Reserves are limited in the North Island, but are very large in parts of the South Island. Currently, extraction is limited to the Te Kuiti and Southland areas.

Talc-magnesite was extracted for many years from altered ultramafic rocks in northwest Nelson. It was used as a magnesium fertiliser, principally for tobacco growing, and as a mineral filler. None has been extracted since 1986, but significant resources remain.

Wollastonite is a fibrous calc-silicate mineral used in the production of ceramics. The only known resource of significant size is situated west of Motueka, near Nelson.

4 Mineral stocks

4.1 Physical stocks

Stock data reproduced below are summarised from the Geological and Nuclear Science (GNS) report by Christie and Brathwaite (1999). The tables show physical mineral stock levels as at 1997.

Currently, gold, silver and ironsand concentrate are the only metallic utilised at a significant scale for economic purposes. However, New Zealand also has resources of other metallic minerals which could potentially be economic if technologies and/or prices became favourable.

Table 4.1 Metallic Minerals Actively Extracted in New Zealand

Mineral	Stock
Gold	372t
Silver	308t
Ironsand concentrate	874Mt

t = tonnes, Mt = million tonnes

Source: "*The mineral potential of New Zealand*" Christie and Brathwaite, (1999).

Table 4.2 Other Metallic Minerals Found in New Zealand

Mineral	Stock
Antimony	Undefined
Chromium	Undefined
Copper	Undefined
Ilmenite	30Mt
Lead	Undefined
Mercury	402t
Molybdenum	Undefined
Nickel	Undefined
Platinum group	Undefined
Rare earth minerals	Undefined
Tin	Undefined
Tungsten	Undefined
Zinc	Undefined

t = tonnes, Mt = million tonnes

Source: "*The mineral potential of New Zealand*" Christie and Brathwaite, (1999).

Many of New Zealand's non-metallic mineral resources are high-volume, low-value commodities and stocks are abundant (though they may be locally restricted). Due to the large size of these stocks the majority of them have not been accurately estimated.

Table 4.3 **Non-Metallic Minerals in New Zealand**

Mineral	Stock
Aggregate and sand	Undefined but large
Amorphous silica	Undefined
Barite	Undefined
Bentonite	10Mt
Clay	Undefined but large
Diatomite	200,000t
Decorative pebbles	Undefined but large
Dimension stone	Undefined but large
Dolomite	70Mt
Feldspar	Undefined
Fluorite	Undefined
Limestone	Undefined but large
Marble	Undefined but large
Perlite	Undefined
Phosphate	5Mt
Pounamu	Undefined
Pumice	Undefined but large
Recycled material	Undefined
Serpentinite	Undefined
Silica sand	Very large
Sulphur	5Mt
Talc-magnesite	Undefined
Wollastonite	17,000t
Zeolites	Undefined but large

t = tonnes, Mt = million tonnes

Source: "*The mineral potential of New Zealand*" Christie and Brathwaite, 1999.

4.2 Monetary stocks

Gold, silver and ironsand concentrate are the only metallic minerals actively utilised in New Zealand to a significant degree.

Asset valuations in this report do not include all of New Zealand's minerals, only those which are currently economically utilised. By definition, minerals that are not economically exploited cannot have a resource rent. This does not preclude these minerals from having value in the future.

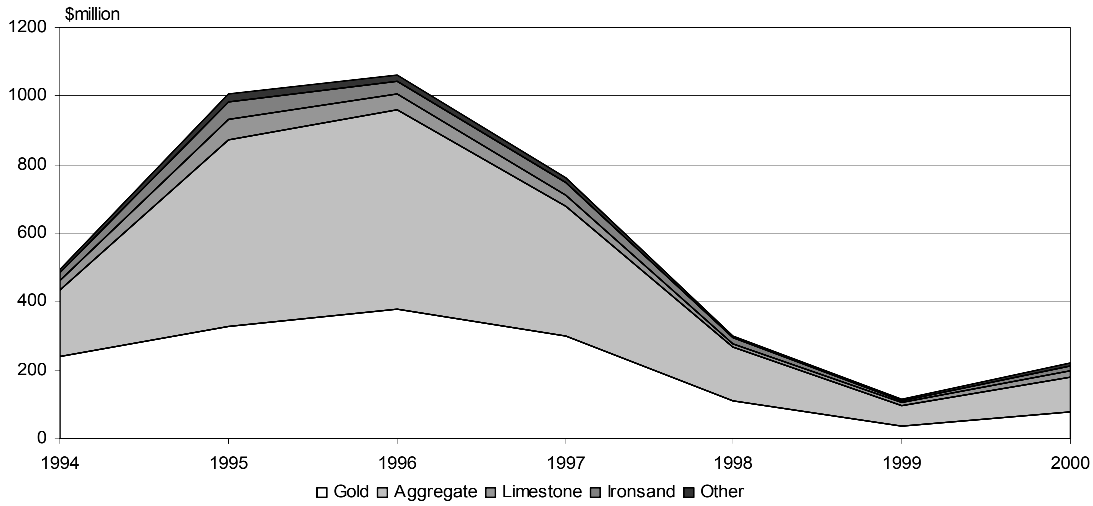
In 2000, the total asset value of New Zealand's economically utilised mineral resources, excluding coal and petroleum was $223 million. Of this, $130 million was from non-metallic minerals and $93 million from metallic minerals. Aggregate had the highest asset value of all utilised minerals, being valued at $105 million in 2000. Gold had the highest asset value of metallic minerals, valued at $77 million, making it the second highest asset value of all minerals.

For the period 1994 to 2000, the total asset value of economically utilised mineral resources, excluding coal and petroleum, has varied from $223 million to $1 billion (see Figure 4.1). These asset valuations reflect variability in the net operating surplus of the mining industry as well as changes in their capital stocks. Since 1995 the asset value of non-metallic minerals has been consistently higher than that of metallic minerals. Over 80 percent of the total asset value of minerals resources is made up by aggregate and gold. The next two major commodities are limestone and ironsand. Gold has a high asset value due to the high price it fetches, whereas aggregate, limestone and ironsand have high asset values because of large quantities extracted.

Table 4.4 **Summary of Monetary Mineral Stocks**

Year to March 31	Metals				Non-metals						Total minerals
	Gold	Silver	Ironsands	**Total metals**	Aggregate	Clay	Limestone	Dolomite	Other	**Total non-metals**	
1994 Stock	**238.0**	**6.0**	**25.9**	**269.9**	**195.1**	**1.3**	**26.6**	**0.3**	**0.8**	**224.0**	**494.0**
Less Extraction	13.0	0.5	2.1	15.6	21.6	0.2	2.4	0.0	0.0	24.2	39.8
Plus Other Changes	102.9	7.4	28.3	138.6	371.5	4.0	35.3	0.8	-0.4	411.2	549.8
1995 Stock	**327.9**	**12.9**	**52.1**	**392.9**	**545.0**	**5.1**	**59.6**	**1.1**	**0.3**	**611.0**	**1004.0**
Less Extraction	20.3	0.6	2.1	23.0	31.3	0.1	2.4	0.0	0.1	34.0	56.9
Plus Other Changes	69.7	-0.7	-11.1	58.0	69.9	-2.6	-12.6	-1.0	1.3	55.0	113.0
1996 Stock	**377.4**	**11.6**	**39.0**	**427.9**	**583.5**	**2.4**	**44.6**	**0.1**	**1.6**	**632.1**	**1060.0**
Less Extraction	12.1	0.4	1.6	14.0	15.1	0.1	1.2	0.0	0.1	16.5	30.5
Plus Other Changes	-63.8	-2.0	1.6	-64.2	-191.4	-0.6	-12.3	0.0	0.4	-203.9	-268.2
1997 Stock	**301.5**	**9.2**	**39.0**	**349.7**	**377.0**	**1.7**	**31.1**	**0.0**	**1.8**	**411.7**	**761.3**
Less Extraction	1.4	0.0	0.2	1.7	2.1	0.0	0.2	0.0	0.0	2.2	3.9
Plus Other Changes	-191.1	-5.5	-22.8	-219.4	-218.3	-1.0	-18.4	0.0	-0.9	-238.6	-458.0
1998 Stock	**109.0**	**3.6**	**16.0**	**128.6**	**156.7**	**0.7**	**12.5**	**0.0**	**0.9**	**170.8**	**299.4**
Less Extraction	0.5	0.0	0.1	0.6	0.8	0.0	0.1	0.0	0.0	0.9	1.5
Plus Other Changes	-72.4	-2.3	-9.6	-84.3	-93.3	0.3	-6.4	0.0	-0.4	-99.9	-184.1
1999 Stock	**36.1**	**1.3**	**6.4**	**43.7**	**62.5**	**1.0**	**6.0**	**0.0**	**0.6**	**70.0**	**113.8**
Less Extraction	2.8	0.1	0.5	3.4	3.9	0.2	0.6	0.0	0.1	4.8	8.2
Plus Other Changes	43.3	1.9	7.8	53.0	46.7	5.2	10.7	0.0	1.7	64.4	117.4
2000 Stock	**76.5**	**3.1**	**13.7**	**93.3**	**105.3**	**5.9**	**16.1**	**0.1**	**2.2**	**129.6**	**222.9**

Figure 4.1 Cumulative Mineral Asset Value



Note: silver, clay and dolomite have been added to “other” for graphical purposes.

Figure 4.2 Asset Value of Aggregate, Gold, Limestone and Ironsand

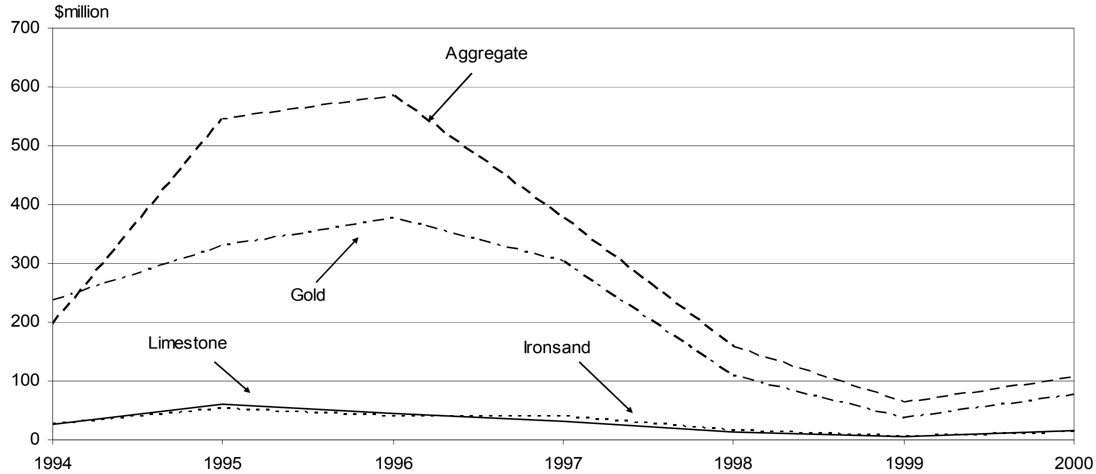
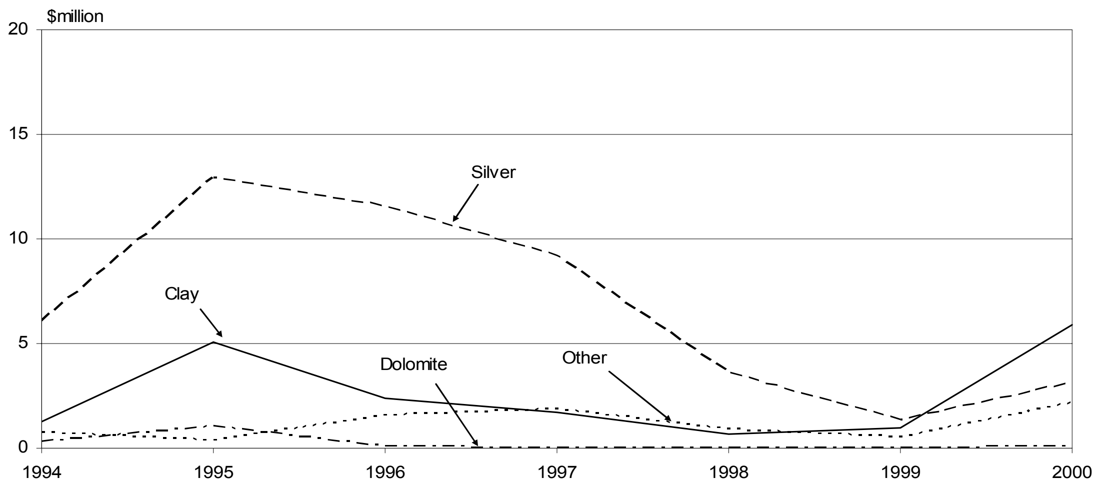


Figure 4.3 Asset Values of Silver, Clay, Dolomite and Other



The total minerals asset value is dominated by the variability of the net operating surplus of the industry and annual changes in capital stocks. As gold and aggregate make up over 80 percent of the total value, the value of total minerals predominately follows trends in these two commodities. Trends in individual commodities are influenced by volumes produced and the price of the commodity.

Trends in aggregate asset value match industry data and comments in annual reports. These indicated strong prices and sales of aggregate in the mid-1990s. The market declined significantly in the late 1990s however, which is reflected in the mineral asset value table.

Production of gold increased with the commencement of the Macraes project, leading to an increase in gold's asset value until peak production around 1996 to 1997 (Statistics New Zealand Official Yearbooks, 1998, 2000). Production then dropped, from around 11 tonnes per year to around 7.5 tonnes (Statistics New Zealand Yearbook, 2000), resulting in a significant drop in gold's asset value. The value began to rise again when production gradually increased (Crown Minerals, 2004).

As noted previously, the minerals asset estimates are derived by disaggregating totals based on commodity share of production. This is in line with Eurostat's recommendation but this approach is problematic in the case of minerals, as gold and aggregate have very different economic and physical properties. Gold is a low-volume and high-value commodity, while aggregate has virtually unlimited volume and very low value. Given this, using output share ratios may not be the best way to determine resource rent, despite the Eurostat recommendation.

As described in section 2.6, a more detailed analysis of National Accounts industry data will be undertaken to test this assumption. If successful, this exercise should lead to more accurate estimates at the commodity level, through more accurate allocation of operating surplus and capital stocks to specific commodities. Future editions of the minerals stock account may therefore contain revisions to the gold and aggregate (and other mineral) estimates. Note that the total estimate for minerals asset value should be unaffected. Also, while the levels of individual mineral commodities may change, their trend over time should be similar to the trend indicated in this report.

For the period 1994 to 2000, the asset values of limestone and ironsand have been relatively constant (slightly elevated asset values for these two commodities occurred between 1995 and 1997). These asset values reflect the constant production of these commodities during this period (Statistics New Zealand Yearbooks; Crown Minerals, 2004).

In New Zealand silver is mined and sold as a by-product of the gold industry (predominately from the Hauraki goldfield). Production of silver therefore depends on gold production, resulting in the trend for silver's asset value being similar to that for gold.

The time series asset values of clay resources show two peaks (1995 and 2000) which correspond to years when pottery and ceramics clay recorded high monetary production values (Statistics New Zealand Yearbook, 1994; Crown Minerals, 2004). Production of dolomite was relatively constant from 1994 to 2000, resulting in consistent asset values.

The 'other' minerals category has a small amount of variability in its asset value, depending on what 'other' minerals are produced in a particular period. Production in the 'other' category is generally increasing with time as new minerals are extracted for economic gain. Minerals within this category may be separated out and estimated individually in future, if the category becomes large enough.

5 Glossary

Aggregate

Low cost high quantity mineral such as sand, rock and gravel used for roading, building, and harbour fill etc.

Appropriation method

An observed payment of (part of) the resource rent to the owner of the resource. This method is often used in calculating the value of the resource rent collected by the government, based on the value of levies and royalties collected. International experience shows that royalties and levies are generally set at levels lower than the theoretical market value of resource rent.

Discount rate (r)

The annual percentage by which future income is discounted to give an equivalent value in the present period. The discount rate expresses a time preference for money now rather than in the future.

Lifespan (n)

The estimated time for which the asset will continue to be in use and produce revenue.

Net operating surplus (NOS)

Gross operating surplus, less consumption of fixed capital

Net present value (NPV)

The value of the asset based on the summed value of discounted future earnings from the asset.

Perpetual inventory model (PIM)

This method for calculating net present values of an asset uses a value for resource rent which is calculated from the net operating surplus less the return to produced assets (which is estimated by discount rate multiplied by capital stocks).

Resource rent (RR)

The revenue generated from the sale of a resource asset less all costs incurred in its extraction, included the cost of produced capital.

SEEA

System of Environmental and Economic Accounting, as developed jointly by the United Nations, the European Commission, the International Monetary Fund, the Organisation for Economic Co-operation and Development and the World Bank.

SNA

System of National Accounts 1993, as developed jointly by the United Nations, the European Commission, the International Monetary Fund, the Organisation for Economic Co-operation and Development and the World Bank.

6 Bibliography

Brathwaite, Christie, Gregg and Douch (1998). "Overview of New Zealand's geology and mineral resources". *The Australasian Institute of Mining and Metallurgy Bulletin* no.7, November, 16-23.

Braithwaite and Pirajino (1993). *Metallogenic Map of New Zealand,* Institute of Geological and Nuclear Sciences, monograph 3, Wellington.

Christie and Brathwaite (1996). "Mineral commodity report 13 – silver", http://crownminerals.med.govt.nz/ [1 June 2004].

Christie and Brathwaite (1997). "Mineral commodity report 14 – gold", http://crownminerals.med.govt.nz/ [1 June 2004].

Christie and Brathwaite (1999). *The Mineral Potential of New Zealand,* Institute of Geological and Nuclear Sciences report, Wellington.

Christie, Douch, Winfield and Thompson (2000). "Industrial minerals in New Zealand", *New Zealand Mining,* 27, 14-25.

Crown Minerals (2001). "Explore New Zealand minerals", Ministry of Economic Development, Wellington.

Crown Minerals (2004). http://crownminerals.med.govt.nz [15 June 2004]

Dixon J A and Meister A D (1986). "Time horizons, discounting and computational aids", in *Economic Valuation Techniques for the Environment. A Case Study Workbook*, eds J A Dixon and M M Hufschmidt, The Johns Hopkins University Press, Baltimore.

Eurostat (1999). "Eurostat Task Force on Subsoil Assets Summary of Conclusions and Results", Eurostat B1, discussion document, Luxembourg.

Eurostat (2003). "Subsoil Asset Accounts for Oil and Gas – Guidelines for the Set of Standard Tables", Eurostat B1, discussion document, Luxembourg.

"Government Superannuation Fund (GSF) Financial Statements to 31 December 2003" www.gsf.govt.nz/ [20 March 2004].

MacFarlan and Barry (1991). *Mineral Resources of New Zealand*, resource information report 11, Ministry of Commerce, Wellington.

Pearce D W, *et al* (1989). "Discounting the future" in *Blueprint for a Green Economy*, Earthscan, London, 139-159.

SEEA (2003). "Asset accounts and the valuation of natural resource stocks", in *Integrated Environmental and Economic Accounting*, final draft, UN, European Commission, IMF, OECD, World Bank.

Statistics New Zealand (1994). *Statistics New Zealand Official Year Book*, Wellington.

Statistics New Zealand (1995). *Statistics New Zealand Official Year Book*, Wellington.

Young L (2002). *Determining the discount rate for government projects*, New Zealand Treasury working paper 02/21, http//www.treasury.govt.nz/ [20 March 2004].