More money for your mineral

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Abstract

Industrial minerals contribute about 50% of the NZ$1.2 billion generated annually by the minerals industry in New Zealand. The value is supplemented by a further NZ$500 million of minerals imported to supply our vital agricultural and industrial activity. As globalisation of the world's economy proceeds, sources of minerals are being processed by fewer companies giving an ever-increasing control over global markets. If only to protect its primary production New Zealand needs to aggressively develop its mineral resources. The successful development of a deposit requires identification of the preferred market. While low-value aggregates dominate New Zealand industrial mineral production it is more specialised minerals supplied to the manufacturing and industrial sectors that provide more value per tonne. Minerals that have highly desirable intrinsic properties, or through value-added processing provide desirable properties, have the ability to fill niche markets both locally and overseas. Research and development towards enhancement or creation of desirable mineral properties could benefit New Zealand with both increased mineral potential and export of technological information. But, it is nearly always the market not the resource that dictates the viability of an industrial mineral and with the globalisation of industrial mineral markets, resulting in fewer but larger companies, any supplier must be ready to explore niche markets in order to compete on a more global basis.

Introduction

The mineral industry contributes a substantial amount of wealth to the New Zealand economy (Figure 1). As a percentage of New Zealand's Gross Domestic Product the mineral industry is comparable to other primary industries (Figure 2). The majority of mining production by tonne is dominated by the industrial mineral sector and in dollar terms makes up 50% of New Zealand's mining production (Figure 3).

Industrial mineral production in New Zealand mainly supplies the roading and construction sectors (Figure 4). Although minerals supplied to the industrial and manufacturing sector make up a lower percentage in both tonne and dollar terms they provide a much higher value per tonne.

The development of a deposit requires identification and analysis of the market as the first step. Large volume markets can offset logistical costs that would normally render a deposit uneconomical. As is characteristic of the industrial mineral industry, much of the early decision-making relates to logistics rather than mineral processing. When identifying potential customers, it is not what mineral is desired that is important, but what properties or effects are desired. Then one can identify minerals that can provide these effects. Deposits of minerals that have highly desirable intrinsic properties, such as New Zealand China Clay's halloysite in Northland, are well situated to capture both local and export markets. Alternatively it may be possible for a mineral be processed to either provide

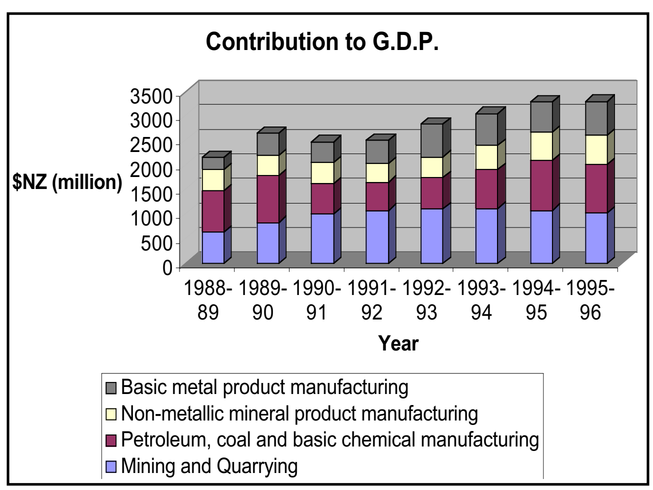


Figure 1. Contribution of the minerals industry to the New Zealand economy.

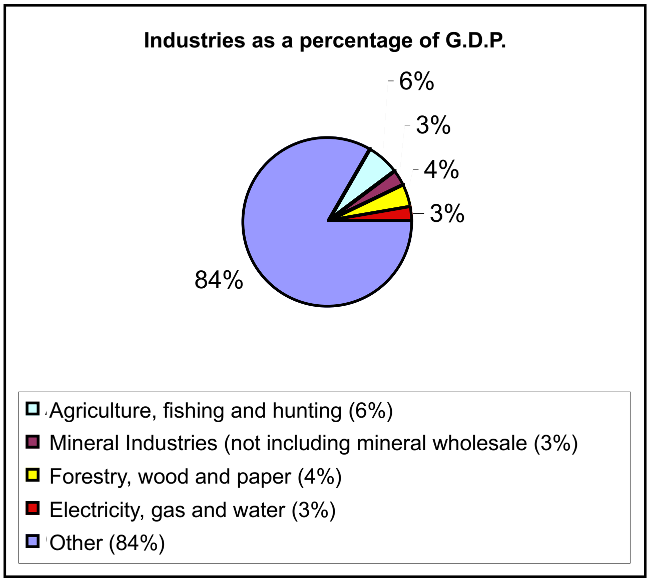


Figure 2. Minerals industry as a percentage of G.D.P.

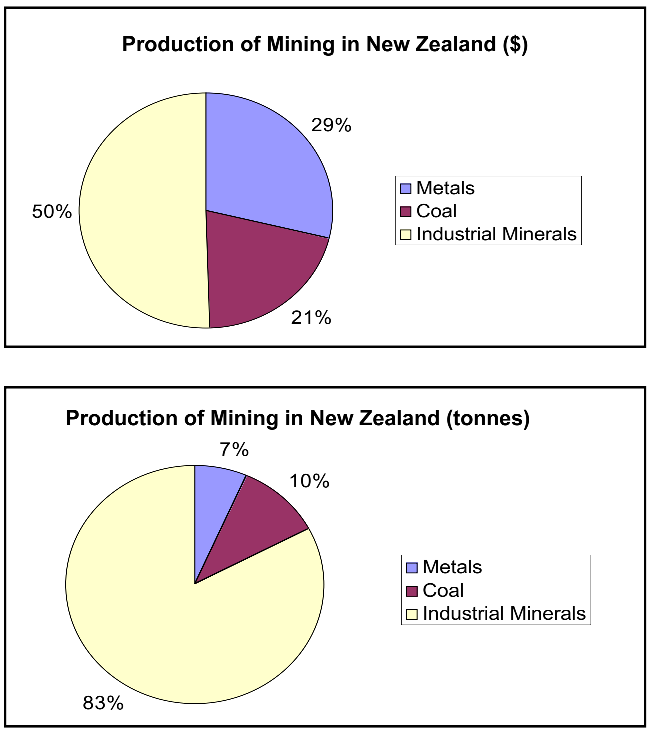


Figure 3. Mining production in New Zealand.

or enhance these effects and create a highly desirable product. The creation of one or more desirable properties to fill a niche within the market can make what would otherwise be an uneconomic resource a "bankable" deposit. One needs to identify potential customers, the volumes involved, logistics, and arguably most importantly the price that the market can sustain.

The areas for development are large volume markets where a high standard of one or more properties is essential (i.e. colour, strength, chemical reactivity, etc), such as plastics, paints, steel, paper, and agriculture.

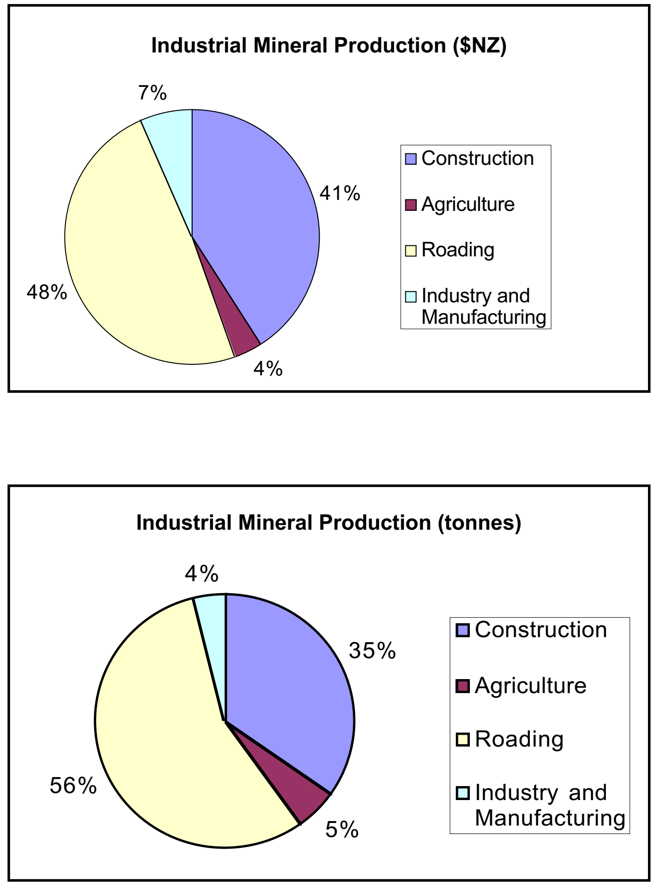


Figure 4. Industrial mineral production in New Zealand.

Industrial minerals in New Zealand

Aggregates

New Zealand currently produces around 20 million tonnes per year of aggregates, of which almost 75% is utilised in the North Island. The most commonly used high quality aggregates are indurated sandstone (greywacke), basalt, and andesite. In areas were these lithologies are scarce or absent, limestone, if available, is often used. Quartz sands and gravels are used in masonry and concrete. Some aggregates with a perceived aesthetic quality, such as Walton Park Sand extracted by Fulton Hogan Ltd, are used as decorative chip or exposed aggregate. It is considered that there are adequately extensive deposits of high quality aggregates to supply the foreseeable future demands of the New Zealand market, although there may be shortages in areas of high demand and/or low supply. These areas will have to incur extra expense as they look further afield for their supplies of aggregate with the corresponding increase in freight cost. Long distance transport of low value, high volume material such as aggregates is seldom economically viable. It will become harder for population centres such as Auckland to service their aggregate requirements as local potential resources are designated for alternative land uses and existing quarries reach their life expectancy. Sourcing granite from the South Island has already been tried and may well be a long-term solution. The sourcing problem is more one of logistics than of resource.

Clays

Halloysite, bentonite, and various clays (predominantly kaolinite, smectite, and illite) used in the brick, pottery or industrial manufacturing are extracted from various locations throughout New Zealand (Figure 5). With the exception of halloysite and bentonite, these minerals are predominantly consumed locally.

Bentonite

The Canterbury bentonite deposit located near Coalgate, 64 km west of Christchurch (Figure 5), is quarried and processed by Omya New Zealand Limited. The non-swelling calcium bentonite was formed by the weathering of basaltic ash erupted during the Miocene and deposited in a freshwater lake environment. Chemical analysis has shown the bentonite deposit to comprise mainly of non-swelling iron rich beidellite with minor iron rich montmorillonite. For the majority of end users, a swelling bentonite with good thixotropic properties is required. For this reason the majority of material processed is modified with soda ash to a swelling sodium bentonite. Beidellites are unusual bentonites, with some properties that differ from montmorillonite and it is the difference that represents the area for research and the development of nanocomposites.

Bentonite rich marine sediments occur along the east coast of New Zealand. Clay has been extracted at Mangatu and Porangahau (Figure 5), and continues to find local markets.

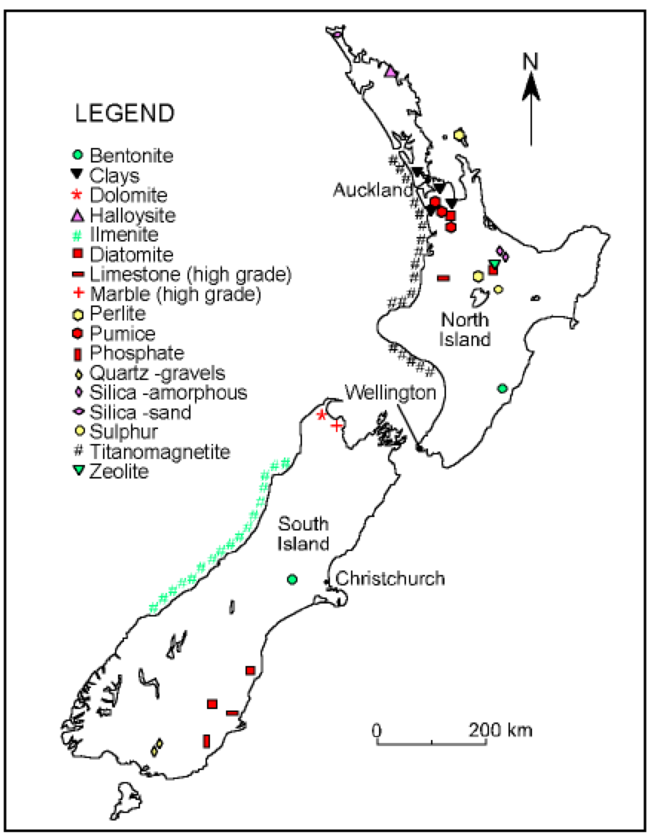


Figure 5. Location of selected industrial mineral deposits in New Zealand.

Halloysite

New Zealand China Clays (now part of the Imerys Group) currently extracts about 80,000 tonne per annum of halloysite from two deposits, situated within 3 km of each other at Matauri Bay and Mahimahi Rhyolite domes in Northland (Figure 5). New Zealand China Clays also controls, but are not currently exploiting, other halloysite deposits at Shepards Hill and Maungaparerua in Northland.

The clay was formed by hydrothermal alteration and subsequent subtropical weathering of Pliocene/Pleistocene rhyolites. The unprocessed material typically contains 50% halloysite, 50% silica and occasional minor feldspar. Using careful grade controls at the mine site, clay is extracted using open cast quarrying methods and stockpiled into various plant feed grades. Approximately 50% of the plant feed is supplied from each quarry. The clay is processed using crushing, grinding and fine gravity separation techniques. The purified clay products are dried, packaged and containerised for export shipment

The fine particle size, high brightness and purity of the processed products has enabled the development of niche overseas markets in the high quality segments of the international tableware industry. The halloysite is mainly used in the production of porcelain and bone china, however it is also used in technical ceramics for the manufacture of molecular sieves and honeycomb catalyst supports. The combination of a very special product, consistent high quality and a high level of technical marketing support has enabled penetration into very competitive markets. With the recent addition of Imerys technical and marketing expertise, continued growth can be anticipated.

Diatomite

Diatomaceous lake deposits, interbedded with volcanic sediments, occur in Northland, Auckland, South Auckland, Waikato and Rotorua (Figure 5). Marine deposits that occur near Oamaru are currently mined by Rosebery Enterprises Limited for use as pet litter. Featherston Resources are currently developing lake bed diatomite at Middlemarch in Otago. Diatomite Products Limited are currently redeveloping a high-grade diatomite (90% diatomite with pumicite as the other major mineral) at Ngakuru, in the Taupo Volcanic Zone. Drilling carried out in 1998 showed a reserve of 3.5 million m^3 of diatomite and production is expected to be about 20,000 m^3 per annum. About 2000 tonnes per annum of diatomaceous earth is imported predominantly from the U.S.A. and consists of both calcined and flux calcined grades for use in filtration and other minor applications.

Dolomite

The only commercial deposit of dolomite in New Zealand is situated on Mt Burnett in Golden Bay (Figure 5). The Mt Burnett dolomite deposit was formed in saline near shore conditions and represents an estimated resource of more than 70 million tonnes. The complexly deformed Paleozoic rocks that host the dolomite are exposed on the east face of the

Wakamarama Fault scarp and in stream valleys that cut the scarp westwards until they disappear beneath a cover of coal beds. The dolomite, while showing a degree of variance, is typically comprised of approximately 36% $MgCO_3$, 60% $CaCO_3$, 0.3-0.5% Fe_2O_3, and 4-6% acid insolubles.

Omya NZ Ltd quarries the deposit and dolomite rock is processed at the Golden Bay Plant for use primarily in the agricultural sector. Dolomite is barged from Tarakohe to either storage facilities at Wanganui or directly to the customer. Large dolomite boulders have been barged to Wellington for use as rip-rap and processed chip has been used as exposed aggregate, such as at Te Tapa Museum, or for roading aggregate. In the past the dolomite has also been used in glass manufacturing and the steel industry.

Ilmenite and titanomagnetite sands

Ilmenite rich sands occur intermittently along the west coast of New Zealand (Figure 5) and at several locations along the east coast of the Coromandel Peninsula. Lesser amounts of ilmenite are also associated with titnomagnetite sands derived from erosion of felsic volcanics from Taranaki and the Taupo Volcanic Zone, and deposited by longshore currents at intervals along the west coast of the North Island.

Austpac Titanium Ltd have shown a resource of 17-30 million tonnes of limonite at Westport that can, using the patented ERMS process, yield a synthetic rutile with a grade of >90% TiO_2. BHP New Zealand Steel Ltd produces over 2 million tonnes per annum of titanomagnetite concentrate for domestic steel manufacture at Glenbrook, from the Waikato North Head Mine, and produces 1.2 million tonnes per annum of ironsand (containing around 40% titanomagnetite) for export to Japan and China from the Taharoa Mine. Waikato North Head resources are estimated at 200 million tonnes averaging 25% titanomagnetite.

Limestone and marble

Sedimentary carbonate rocks are found in most parts of New Zealand. Limestone, marble, and marl are used throughout New Zealand for cement, burnt lime, glass, agriculture, construction and industrial filler applications. High quality limestone (97-99% $CaCO_3$) suitable for industrial use domestically and overseas is found in the South Waikato Te Kuiti area and in the South Island north of Dunedin (Figure 5). High grade marble (>98% $CaCO_3$) is found in Northwest Nelson (Figure 5) and Fiordland. Limestone and marble in the Nelson Area are of Ordovician age (~450-500 million years ago), with the Mt Arthur Marble Formation well exposed on Takaka Hill.

Miburn New Zealand Ltd, through its subsidiary companies Taylors Lime Company Ltd and McDonalds Lime Ltd, is the largest producer in New Zealand of burnt and hydrated lime for use in metal ore processing (in New Zealand and overseas), paper pulp processing, ground stabilisation, sewerage and waste water treatment, and in the manufacture of sugar.

Taylors Lime operates a plant 60 km north of Dunedin that processes a lens of crystalline limestone hosted by Triassic greywacke, the majority of which is used by Macraes for processing gold ore. McDonalds Lime Ltd and Omya New Zealand quarry part of the Otorohanga Limestone Formation (Waitakian Stage), that contains an economic high-purity white calcium carbonate.

McDonalds Lime operate a quarry 7 km west of Te Kuiti and a calcining plant 6 km south of Otorohanga that produces 124,000 tonnes per annum of burnt lime. The quarry also produces 247,000 tonnes per annum of Ag-lime.

Omya New Zealand Ltd is the major producer of carbonate for industry in New Zealand. It operates a limestone quarry on the outskirts of Te Kuiti and a marble quarry 15 km northwest of Motueka on Takaka Hill. The main plant, situated 5 km north of Te Kuiti, processes both limestone from the Symmonds Quarry and marble trucked from the Ngarua Quarry. The carbonates are processed using Jaw crushers, pulverisers, roller mills, and specialised circuits for a variety of end uses (Table 1).

The Mt Arthur Marble Formation is well exposed on the Takaka Hill and consists of high purity white and cream to grey marbles with interbedded calc-silicate rocks. The Ngarua quarry produces high-grade (>98.6% $CaCO_3$) white marble that is crushed and pulverised on site to make Ag-lime and is further processed at the Omya Coalgate plant, or for specialised or very fine grades at the Omya Te Kuiti plant.

Paper
Interior and exterior emulsion paint
Surface coatings
Textured coating
Grouts
Terrazzo tiling
Specialist concrete
Plastic, plastisols, polyurethane
Oil and synthetic resin systems
Adhesives and sealing compounds
Rubber products
Polyester
Glass manufacturing
Calcium source in stock feed
Welding rods
Pharmaceuticals
Food

Table 1. End uses of Ngarua Marble and Otorohanga Limestone.

Two companies, Milburn New Zealand Ltd and Golden Bay Cement Company Ltd, are manufacturing cement for commercial use. The domestic market predominantly consumes the cement, although some is exported to the Pacific Islands. The Golden Bay cement plant situated at Portland, near Whangarei, produces nearly 500,000 tonnes per annum, while Milburn's Foulwind cement plant, 10 km west of Westport, produces around 470,000 tonnes per annum. Both companies operate their own quarries, extracting argillaceous marl from nearby deposits.

Perlite

Industrial Processors Ltd in Auckland process perlite from Atiamuri (Taupo Volcanic Zone) by crushing, screening, and expanding (7-20 times) by heating to 900^{o}C. The material is used in plastering, insulation, textured coatings, concrete, and horticulture. Unexpanded perlite can be used in metal melting as a slag coagulant. Substantial resources of perlite can be found in the Taupo Volcanic Zone and on Great Barrier Island (Figure 5) associated with rhyolite domes and flows. The young age of the perlite makes it reasonably unique and its ability to expand very rapidly without preheating gives it qualities of value to the cryogenic and filtration markets. World production in 1999 was about 2.2 million tonnes with about 70% of that being in the U.S.A., Greece, and China.

Phosphate/potash

Phosphate rich (11% P_2O_5) beds occur associated with the Clarendon Sand, southwest of Dunedin in the South Island (Figure 5). The deposit has been previously mined and remaining reserves are estimated at around 5 million tonnes. At the Clarendon deposit phospate occurs with glauconite rich (7% K_2O) sands. Glauconite can be used in the production of potash fertilisers. The potential of this deposit could be better recognised as a combined phosphate-potash deposit. The fertiliser market for both phosphate and potash is well known and easily defined. The "organic" market for phosphate and potash is expanding rapidly and could be a useful area for development of this resource.

Pumice

Pumice is dredged from the Waikato River to the south of Auckland (Figure 5). The majority of pumice found in New Zealand was originally deposited as large pyroclastic flows associated with the Taupo Volcanic Zone. Annual production of pumice is estimated at half a million tonnes per year. The majority of the pumice is consumed by the domestic construction industry for use in roading, concrete, foundation work and drainage. A smaller amount is extracted and used to manufacture potting mixes. The close proximity of large deposits of pumice located within the Taupo Volcanic Zone to bulk handling facilities at Tauranga could allow for the export of crushed pumice for use as a light weight aggregate in Australia's high-rise buildings.

Silica

Significant amounts of silica are found in four main geological environments.

1. Quartzite resulting from metamorphism of quartz rich sandstones. These occur as chert beds within Northland greywackes and associated with schist at Aorere.
2. Quartz gravels and sands associated with erosional land surfaces. Erosional quartz sands are found in Westland, East Otago, and Southland. Quartz gravels are widespread throughout Southland (Figure 5).
3. Beach, dune, and shallow offshore marine sand along the New Zealand coastline. The largest deposits are located in Northland (Figure 5).
4. Amorphous silica and quartz deposited in hydrothermal systems (Taupo Volcanic Zone and the Coromandel Volcanic Zone). Amorphous silica can result from either the direct precipitation from silica saturated, near neutral pH, chloride waters as subsurface veins and on the surface as silica sinters, or, from acid alteration (argillic – advanced argillic) of near surface rocks where all the original minerals, except primary quartz, are replaced resulting in an amorphous silica + cristobalite ± native sulphur ± alunite ± cinnabar ± barite ± kaolin ± hematite secondary mineral assemblage.

Microsilica New Zealand Limited, now owned by Golden By Cement Limited, currently operates a quarry extracting amorphous silica at Tikitere near Rotorua (Figure 5). The amorphous silica is sold as a pozzolanic cement additive in local and export markets.

Sulphur

New Zealand has imported on average 187,000 tonnes of sulphur per annum over the last four years, primarily for the production of super phosphates. Deposits of native sulphur are found associated with past and present thermal areas in Northland and the Taupo Volcanic Zone. Although deposits of sulphur have been exploited in the past (Rotokawa, Rotorua, Tikitere, and White Island) there is at present little if any production of sulphur within New Zealand.

The most significant sulphur deposit in New Zealand, located at Rotokawa Thermal Area (Figure 5), was discovered in 1968 as a result of core drilling by American Cyanamid Company. Sinclair (1989) noted that there were two sulphur deposits at Rotokawa lacustrine sulphur associated with a buried lakebed and surface mineralisation within a brecciated pumice layer. Rotokawa contains approximately 5 million tonnes of elemental sulphur.

Talc-magnesite

Talc-magnesite is found associated with ultramafic rocks in Northwest Nelson, Westland, Otago, and Southland. The Cobb Valley, Northwest Nelson, contains the most significant talc-magnesite deposit. Exploratory drilling outlined initial reserves of around 300,000 tonnes, but inferred reserves are vast. The deposit, similar to talc-magnesite deposits operated near Timmins in Canada, has a typical composition of 45-55% Magnesite, 30-40% talc, 10-15% quartz, and 2-5% iron oxides. New Zealand currently imports around 3000 tonnes/

year of talc and 32,000 tonnes/year of magnesite and calcined magnesite.

Zeolite

Zeolites are found throughout the Taupo Volcanic Zone associated with hydrothermal alteration of volcanic glass. NZ Natural Zeolite Ltd currently produces approximately 5000 tonnes per annum of zeolite from various deposits around Ngakuru, 20 km south of Rotorua (Figure 5). The major market is for pet litter both in New Zealand and for export markets, where the ammonia absorption ability of zeolite is promoted. Zeolites are used as molecular sieves, ion exchangers and adsorbents, but for this use they can require complex processing which in turn requires large markets with specialist needs. World production is around 3.5 million tonnes per annum, of which about 85% is used in low value construction and agricultural applications.

Geothermal minerals

For many years New Zealand has been in the forefront of development and research of geothermal resources. Thermal systems in New Zealand have been used to provide power generation since the early 1950s. There are a number of minerals (an incomplete list is shown in Table 2) that occur as the result of geothermal precipitation or alteration. The better we understand the mechanisms behind the mineral deposition the more accurate exploration models can be developed and also greater the potential for producing these minerals as a by-product of power generation. This would have a number of benefits including the potential for the creation of a saleable product, the control of geothermal scale deposition, reduce the loss of enthalpy due to re-injection returns, and hopefully more efficient use of the resource. Understanding the parameters of mineral deposition and alteration in nature could result in technological advances in the processing of minerals from other sources.

Potential hydrothermal chemical products (extractives)	
Silica	
Silicates	Ca, Na
Sulphates	Ca
Chlorides	Na, Li, K
Potential hydrothermal mineral products	
Amorphous Silica	
Sulphur	
Zeolite	
Alunite	

Table 2. Geothermal minerals.

The New Zealand industrial mineral market

It is the market not the resource that dictates the viability of an industrial minerals project. Mineral deposits exist in New Zealand that in other larger economies would be the basis for a large and viable mineral business. The size of New Zealand's industrial base is very small and there is little sign any dramatic expansion.

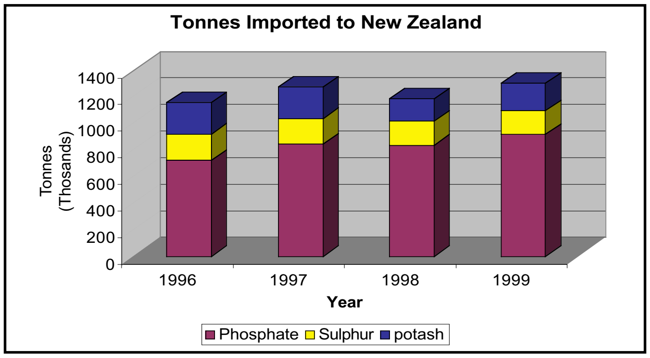
The New Zealand market for minerals is minute by world standards, with one exception: for our size the agricultural market is enormous, and accordingly, so is the demand for fertiliser minerals. On a per-head of population basis, we are the world's largest consumers. Import statistics (Figure 6) show large tonnages of phosphate, sulphur and potash are consumed regularly. But, our agricultural wealth is dependant on the availability of minerals from other countries which is not a desirable position to be in.

To make the position even less tenable is the current globalisation of industrial mineral resources. We have seen over the last few years a natural development of global communication with the recognition that if a company can exchange data, buy proven quality raw materials, manufacture at a preferred global location, sell its products, and bank its money without moving from a high rise office, then the supplier must compete by having its products available also on a more global basis. The sources of mineral supply such as calcium carbonates, kaolin, bentonite, and talc have all been restructured resulting in fewer but larger companies operating a number of deposits strategically situated in relation to their major markets.

A further reason for this trend is the need to protect investment from the continual concerted attacks by the politically expedient. By operating on a wide spread global resource base, there is some ability to cope with uncompromising myopic clamour that surrounds any debate on environmental issues. With the good lifestyle (that is provided by minerals) there is an increasing drive to protect all comfort zones by insisting that minerals must be quarried somewhere else and controlled more vigorously by political forces. Prior to the 1970s Governments were generally supportive of the minerals industry and recognised minerals as creating wealth. The contribution to society by minerals was publicly acknowledged as immense. Although recognition is now selective the contribution of minerals is still enormous and includes:

- the use of the mineral and the products made from them;
- taxes are paid;
- jobs are provided together with a multiplier effect;
- landowners are compensated;
- investors are rewarded; and
- the national economy benefits.

But since the 1970s the attitude of Governments has become adversarial as the environmental movement drives public opinion and the industrial society haemorrhages towards an



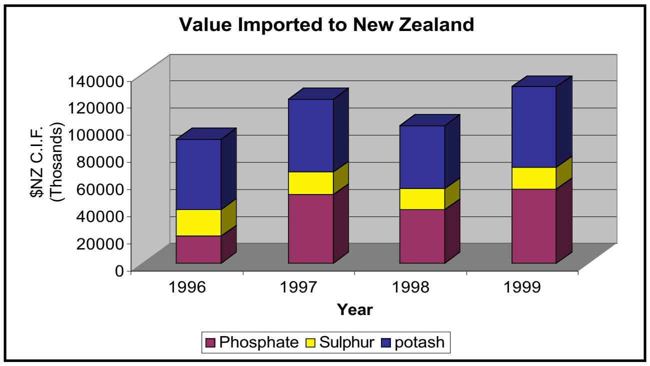


Figure 6. Agricultural mineral imports.

information and service society. But, global population is increasing, a higher standard of living is the universal aim, and this guarantees an increasing global demand for minerals. Already every New Zealander uses over 10 tonnes of minerals every year.

There is a need to enhance and make available base geologic data to facilitate the identification of mineral potential within New Zealand. The New Zealand Government's intention to create a knowledge economy should fit in well with the need for research and development, especially with regards towards enhancement or creation of desirable mineral properties. There is the potential for research in partnership between Government, primary processors and manufacturers. But once we have the "know-how," will the Government assist or even allow the "can-do", especially with sensitive issues regarding access to New Zealand's mineral wealth. There is always a degree of uncertainty when developing any mineral resource, but this is compounded by a number of factors including:

- a lack of public recognition that minerals are of any value to New Zealand;
- no Government advocate for the $1.1 billion minerals industry; and
- a short-term (3 year) horizon for an industry that requires long-term strategies.

Despite the clear government mandate to develop tourism and a "knowledge" economy as the future direction for New Zealand, and little if any mandate for mineral resources, there will be a demand for minerals on which the wealth of this country depends.

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JOHN CLARK graduated from the University of Auckland with a MSc (hons) in Geology. He wandered aimlessly through the cold Siberian waste that was the post gold-price crash world of contract/consultant geology. He eventually saw the light and joined the industrial mineral sector when he was employed by Omya New Zealand as a Technical Sales Executive in 1999.