Strategic Case Study Examination

November 2024 – February 2025

Pre-seen material

Rotomyne

Context Statement

We are aware that there has been, and remains, a significant amount of change globally. To assist with clarity and fairness, we do not expect students to factor these changes in when responding to, or preparing for, case studies. This pre-seen, and its associated exams (while aiming to reflect real life), are set in a context where current and on-going global issues have not had an impact.

Remember, marks in the exam will be awarded for valid arguments that are relevant to the question asked. Answers that make relevant references to current affairs will, of course, be marked on their merits.

Contents

Introduction

Rotomyne is a quoted company that mines lithium for sale to manufacturers, which then use the metal in the manufacture of various products, including rechargeable batteries.

You are a senior manager in Rotomyne's finance function. You report directly to the Board and advise on special projects and strategic matters.

Rotomyne's head office is located in Porrland, a developed country that has an active and well-regulated stock exchange. Porrland's currency is the P$. Porrland requires companies to prepare their financial statements in accordance with International Financial Reporting Standards (IFRS). Rotomyne owns and operates lithium mines in six countries.

Lithium mining

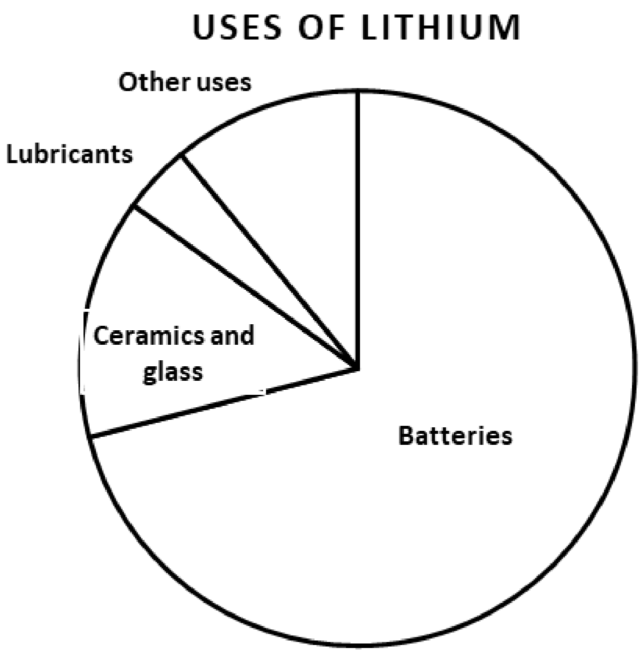
Lithium is a chemical element, an alkali metal, designated "Li" on the Periodic Table of the Elements. It is used in the manufacture of a variety of products, including:

- batteries
- heat-resistant glass and ceramics
- lubricants
- metal alloys
- pharmaceuticals

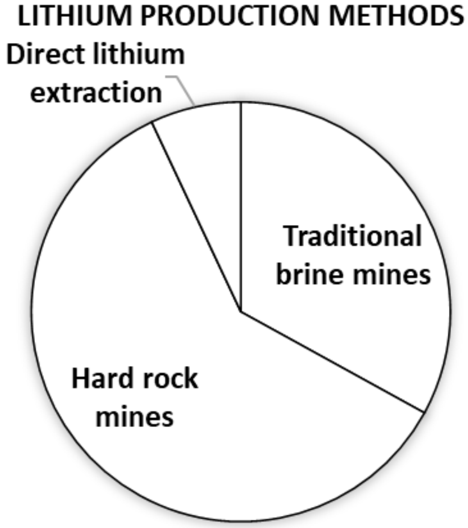
Lithium has been used for many years, primarily in the manufacture of glass and in lubricating grease. Recent growth in demand has been driven by the use of lithium in the manufacture of batteries, in particular for electric vehicles. A typical electric car battery requires 12 kilograms of lithium. The metal is also used in most of the rechargeable batteries used in consumer electronics, such as mobile phones and tablets.

Lithium-ion batteries store a significant amount of energy in a relatively small space. The lead-acid batteries, which have been used for many years to power the starter motor and other electrical components in internal combustion engines, can store only 30 watt-hours of electricity in 1 litre of space. A lithium-ion battery can store 250 watt-hours in the same space.

Global demand for lithium carbonate was 500,000 tonnes in 2021. Annual demand has been predicted to increase to 4 million tonnes by 2030.



Lithium deposits can be found in many locations around the world. It is also present in seawater, although extraction from seawater requires too much energy to be commercially viable. Three main methods of lithium extraction are in common use:



Hard rock mines

Lithium is contained in a number of different rock types, most commonly in spodumene, which is an ore that can be mined in several parts of the world. Lithium can constitute up to 8% of the content of spodumene.

Hard rock deposits of lithium are mined mainly by the open pit method. Blocks of rock containing lithium are dug out of the earth. They are then crushed and milled to create a fine powder. The powdered rock is mixed with water. Bubbles of air are injected into the mixture. The bubbles attract lithium while they rise to the water's surface. The resulting foam is skimmed off and sent to a plant where it is processed to produce lithium carbonate.

Open pit mining has significant adverse environmental impacts:

- soil erosion
- destruction of natural habitats
- water pollution
- emissions from the operation of heavy mining equipment

Traditional brine mines

Lithium can be found dissolved in underground lakes. That lithium can be extracted by pumping this fluid (called “brine”) to the surface, where it is transferred to evaporation ponds. The evaporation ponds are huge, with surface areas of up to 25 square kilometres. The brine is exposed to heat and sunlight for 12 to 18 months, causing evaporation and thereby concentrating the lithium.

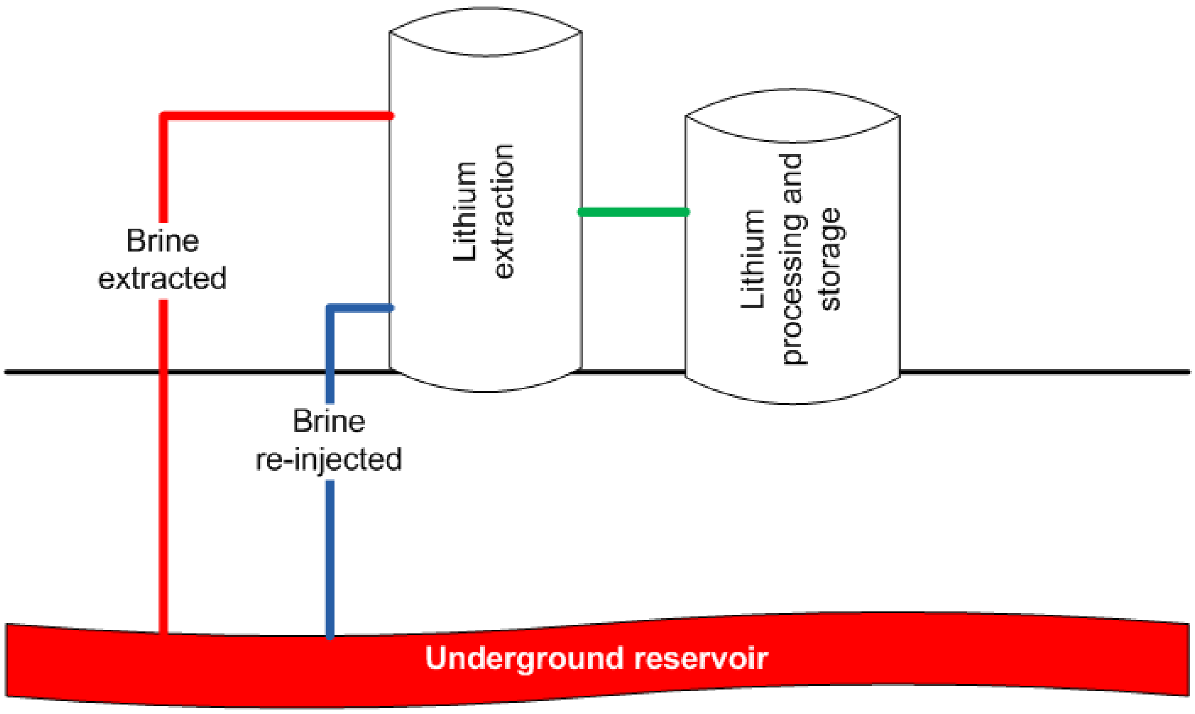
The concentrated brine is further processed using chemical processes to extract the lithium, initially in the form of lithium carbonate.

Brine mining is cheaper than alternative methods, but it can cause environmental damage. Each tonne of lithium requires 500,000 litres of water to process. That is a particular problem when mines are located in areas that have limited water supplies.

Evaporation ponds can also pollute local water supplies. The brine can leak into the earth and contaminate water that would otherwise be used for human consumption or agriculture.

Direct lithium extraction

Direct lithium extraction (DLE) reduces the environmental impact of lithium extraction by pumping brine to the surface, where it is processed to remove the lithium before returning the brine to its underground source.



This process is essentially an alternative to traditional brine mines. It is more expensive, but it avoids the environmental damage associated with storing brine in evaporation ponds. It also uses solvents to extract the lithium from the brine, so the extraction plants use much less fresh water.

Some underground reservoirs are heated by geological processes to temperatures of up to 50 degrees centigrade. Liquid at that temperature can power thermal electricity generation, which would enable a DLE plant to be self-sufficient in terms of power and to operate without carbon emissions.

Very few underground brine deposits are hot enough to be viable producers of geothermal electricity. None are presently being used to generate electricity on a commercial basis.

The three methods of extracting lithium have significantly different environmental impacts:

	Hard rock mining	Traditional brine mining	Direct lithium extraction
Carbon dioxide emissions per tonne of lithium	15,000kg	5,000kg	Powered by electricity, so emissions depend on power source.
Fresh water used per tonne of lithium	170,000 litres	500,000 litres	3,000 litres
Use of land per tonne of lithium (annual capacity)	460 square metres	3,200 square metres	1 square metre

The above figures are indicative but are also affected by specific circumstances such as the locations of the mines, the purity and chemical composition of the ore or brine and the required purity of the end product that is being extracted.

All three methods yield lithium carbonate as the initial product. That can be further processed to create lithium hydroxide or lithium chloride. Lithium carbonate is the most common product in manufacturing, but the other products are also used in the manufacture of advanced batteries and in some other industrial processes.

Lithium carbonate can also be processed into butyllithium, which has a number of applications ranging from the production of synthetic rubber to pharmaceuticals.

It is possible to extract lithium metal from lithium carbonate. The pure metal has some industrial applications, primarily in the manufacture of strong but lightweight metal alloys for use in aerospace. Lithium is highly volatile in this form, being difficult and dangerous to handle. It can also deteriorate very quickly if not stored correctly.

The lithium industry has significant barriers to entry because it can be difficult to obtain access to viable sources of ore or brine deposits. Governments are often reluctant to grant permission to mine for lithium because of the environmental damage associated with open pit mining and evaporation ponds. Direct lithium extraction has fewer environmental concerns, but it is expensive to buy suitable sites and to build and operate processing plants.

The four largest lithium producing companies, one of which is Rotomyne, account for more than 50% of global sales of lithium by value.

Spot v future markets

Most transactions involving lithium are normal commercial credit sales and purchases, with prices and terms of business being agreed at the time of sale (spot price).

Lithium is mined and processed into compounds by mining companies. Any given compound, such as lithium carbonate, is a generic product regardless of the mine from which it was obtained or the mining company who processed it. Lithium is a commodity that has an observable market. Prices for the commodity itself are set by supply and demand, although selling prices on individual transactions will take account of transportation costs.

There is a futures derivative that allows buyers and sellers to trade in lithium hydroxide contracts. Lithium hydroxide is used primarily in the manufacture of batteries for electric vehicles. Both buyers and sellers can use this derivative to manage the risk of price movements in lithium hydroxide for periods ranging from 1 month to 15 months. For example, a car manufacturer could buy futures contracts that mature in 6 months, guaranteeing the price that will be paid for lithium at that date.

Lithium futures contracts are cash-settled. Market participants pay or receive cash to the value of the difference between the market price when the contract is closed out and the price set by the contract.

This derivative enables buyers and sellers to fix prices in advance, although the pricing of the contracts will reflect market expectations. They can be used as part of a risk management strategy, but they cannot eliminate risk altogether.

Rotomyne

Rotomyne was founded in the 1950s and was quoted on the Porrlandian stock exchange in 1972. Initially, Rotomyne owned and operated a single large open pit lithium mine with an adjacent processing plant that supplied lithium carbonate to a wide range of industrial customers. The company has grown steadily since. Rotomyne now owns and operates six hard rock mines and three traditional brine mines, located in a total of six different countries. Rotomyne is one of the world's four largest lithium producers.

Rotomyne acquired its newest mine in 2004. Each mine was acquired on the basis of a geological survey; the results of which suggested that there were substantial deposits of lithium that could be mined and processed economically. It is unlikely that Rotomyne will acquire any further new mines:

- Lithium can be mined in several regions of the world, but it is difficult to find viable new mines. There are relatively few promising sites available for sale. Any potential mines that remain available are likely to offer low quality ore or brine that will be expensive to process.
- Lithium mining can be damaging to the environment. Many governments are reluctant to permit new mining operations for that reason, despite the fact that lithium is necessary for the expansion of production of electric vehicles.
- Seven of Rotomyne's mines are located in stable and well-developed countries. The other two, the most recent acquisitions, are in relatively high-risk countries that lack political and economic stability. At the time of their acquisitions, there were no other mines that met Rotomyne's geological criteria.

The company's Board and Senior Management Team are based at its head office in Porrland. Porrland's Capital City is a convenient location from which to manage multinational business operations, although none of Rotomyne's mines are located there. Head office provides strategic planning and oversight for the company's mining operations. The mines and their associated processing plants are managed locally.

Rotomyne has a reputation for innovation, particularly in terms of developing processes for rapid and reliable extraction and delivery of lithium products:

- Rotomyne has a research and training facility that is associated with a leading university. This is used to develop new ways to use lithium in an industrial setting and also to develop new extraction and conversion techniques.
- Academic staff at the university use the facility for research into the chemical properties of lithium. Some of the findings from this research have led to commercial applications that have benefitted Rotomyne.
- Rotomyne collaborates with customers on research studies into the development of improved batteries and other products that require lithium.
- The research and training facility is also used to provide training in the safe handling and management of lithium for Rotomyne's professional chemists and engineers as well as for the university's academic staff and students.

Rotomyne manufactures the following products:

Products	Application	% of total revenue
Battery grade lithium hydroxide and lithium carbonate	Batteries for electric vehicles and electronic devices	45%
Non-battery grade lithium hydroxide	High temperature grease for use in engines	26%
Butyllithium	Tyres and pharmaceutical products	23%
High purity lithium metal	Alloys used by aircraft manufacturers	6%
		100%

Manufacturing takes place at processing plants adjacent to the mines. It is rarely cost-effective to ship unprocessed ore or evaporated brine to remote locations because of the volumes of waste product that they contain.

The mines are all highly automated. Automation reduces the need to expose workers to dust and fumes associated with mining and processing lithium.

Operations are managed centrally from Rotomyne's Head Office, which tracks inventory levels and anticipated shipments of products. Lead times vary according to the type of mine. Ore from hard rock mines can be processed within days, while brine takes up to 18 months in evaporation ponds before it is ready for processing.

Rotomyne sells its products globally. It ships products to more than 90 different countries. That creates a significant exposure to currency risks. The company has a treasury department based at its Head Office to manage foreign currency transactions and to address the associated currency risks.

Rotomyne's customers vary in terms of size and importance. Sales to its largest customer, a major vehicle manufacturer, accounted for 22% of Rotomyne's company's revenue during the year ended 30 September 2024.

Extracts from Rotomyne's annual report

Rotomyne's mission, vision and values

Our mission

Rotomyne's mission is to power consumers' lives in a world that is clean, healthy and sustainable.

Our vision

Rotomyne's vision is to meet customers' needs for the reliable supply of good quality materials. In particular, Rotomyne wishes to transform the delivery of power through its support for customers who depend on lithium for their products.

Our values

- Rotomyne acts ethically and honestly.
- Rotomyne operates in a sustainable manner.
- Rotomyne provides a safe working environment.
- Rotomyne constantly innovates.
- Rotomyne is responsive to customer needs.

Rotomyne's Board of Directors

Professor Iresh Jayawardena, Non-Executive Chair

Iresh had a successful career in the legal profession. He spent several years as managing partner of a major law firm, before retiring from law in order to pursue other interests. Iresh is a visiting professor of law at Capital University, in addition to serving on Rotomyne's Board.

Iresh was appointed as Rotomyne's Non-Executive Chair in 2022.

Shaista Shameem, Chief Executive Officer (CEO)

Shaista is a chemist. She holds BSc and MChem degrees from Capital University and has held senior positions in a number of chemical manufacturers. She joined Rotomyne in 2011 as a senior chemist at one of the processing plants adjacent to a brine mine, then subsequently was promoted to Plant Manager. She was transferred to a managerial role at Rotomyne's head office in 2018.

Shaista was promoted to Rotomyne's Board as Production Director in 2020 and was further promoted to CEO in 2022.

Dr Andrey Prokhorov, Production Director

Andrey graduated with distinction with a chemistry degree from Glentown University. He went on to complete a PhD on the behaviour of lithium-based alloys in deep space before embarking on a successful career in manufacturing. He has worked for several leading chemical companies, primarily on the development and manufacture of alloys. He joined Rotomyne as head of the research and training facility in 2018.

Andrey was promoted to Rotomyne's Board as Production Director in 2022.

Cecilia Battistelli, Human Resources Director

Cecilia has had a distinguished career in the management of human resources. Her first job was with the HR Department of an international bank, based in Porrland. She has since worked several major corporations. Cecilia served as HR Director of a major vehicle manufacturer before she joined Rotomyne.

Cecilia was appointed to Rotomyne's Board as Human Resources Director in 2020.

Martin Jacobs, Chief Finance Officer (CFO)

Martin spent much of his career to date working for a major international accounting firm, specialising in financial management. During that time, he had two overseas secondments, the first in a developing country and the second in a major trading centre. Martin was promoted to partner in 2008, subsequently spending 4 years as partner in charge of the accounting firm's operations in Porrland.

Martin joined Rotomyne's Board as CFO in 2019.

Onwaba Makanjana, Marketing Director

Onwaba has had a varied career in commercial sales. She has worked for Porrland Steel, reaching the position of Senior Sales Manager by the age of 30. In 2001, she joined Skaylane Aviation as Head of Sales and was promoted to Sales Director in 2010.

Onwaba joined Rotomyne as Marketing Director in 2019.

Pierre Forcier, Senior Independent Director

Pierre studied politics, philosophy and economics at university. He entered government service and had a successful career in a variety of administrative and advisory roles. His final role involved advising Porrland's Minister for Industry on the development of environmental legislation.

Pierre joined Rotomyne's Board as Senior Independent Director in 2020.

Caroline Nguyen Ngoc, Independent Non-Executive Director

Caroline was a chemist in a major oil company. Her responsibilities included health and safety and product quality. She held several senior roles with that company, including the management of operations at an oilfield.

Caroline retired from the oil industry in 2021 and joined Rotomyne's Board as an independent non-executive director.

Professor Lemi Baruh, Independent Non-Executive Director

Lemi had a career in academia. He taught electrical engineering at several prestigious universities in Porrland and overseas. His final appointment before retiring was as Dean of Engineering at South University. Lemi is the convener of the Education Committee at the Institute of Electrical Engineering.

Lemi joined Rotomyne's Board in 2021.

Board responsibilities

Shaista Shameem Chief Executive Officer			
Andrey Prokhorov Production Director	Cecilia Battistelli Human Resources Director	Martin Jacobs Chief Finance Officer (CFO)	Onwaba Makanjana Marketing Director
• Mine operations • Lithium extraction and conversion plants • Environmental protection	• Employee recruitment • Employee remuneration • Employee training • Health and safety	• Financial reporting • Management accounting • Treasury	• Sales and customer relations • Distribution channels

	Board committees			
	Audit	Risk	Remuneration	Nomination
Professor Iresh Jayawardena Non-Executive Chair	♦	♦		♦
Pierre Forcier Senior Independent Director	♦		♦	♦
Caroline Nguyen Ngoc Independent Non-Executive Director	♦	♦	♦	
Professor Lemi Baruh Independent Non-Executive Director		♦	♦	♦

Rotomyne's Chief Internal Auditor reports to the convener of the audit committee.

Rotomyne's Principal risks

Risk impact	Risk mitigation
Market prices of lithium compounds are volatile. Prices are affected by demand from industries such as vehicle manufacturing and consumer electronics. Prices are also affected by the supply of lithium, as determined by the actions of major producers, including Rotomyne.	Rotomyne pays close attention to movements in the market for lithium. The company aims to be responsive to emerging market changes by managing production levels in response to commodity prices and volume of demand. Rotomyne maintains a close relationship with customers, offering a reliable supply of good quality lithium.
Future production levels are constrained by the availability of exploitable reserves in Rotomyne's hard rock and brine mines. It may prove impossible to expand production through the acquisition of commercially-viable mines with permission for mining operations.	Rotomyne employs experienced and highly-qualified professionals to monitor reserves in existing mines and to search for any viable potential acquisitions that become available. Rotomyne aims to minimise the environmental impact of its existing mines.
Lithium mining and the manufacture and sale of lithium products are controlled by strict environmental regulations that can constrain operations and attract penalties if breached.	Rotomyne complies fully with all relevant regulations. In many cases, it exceeds local regulations by complying with the strictest requirements on a global basis.
Lithium is mined and sold worldwide. Rotomyne has mines in six different countries and makes sales to customers based in 90 countries. Exchange rate fluctuations affect costs and revenues.	Rotomyne has an in-house treasury team that monitors exchange rate risks and acts accordingly to ensure that risks are managed.
Rotomyne's mining operations are located in six countries which vary in terms of the stability and the integrity of their governments. Two of the company's mines are located in countries that suffer from political instability.	Rotomyne takes care to comply with all local regulations in the countries in which it operates. The company maintains close relationships with host governments, endeavouring to promote the benefits of its operations in terms of providing employment and foreign trade.
Mining operations and the operation of processing plants creates the risk of industrial accidents. These could lead to injuries to employees and environmental damage to local communities.	Rotomyne complies with all rules and regulations relating to the safe operation of mines and chemical plants. In some cases, it exceeds the formal requirements in order to provide even greater assurance of safety. Rotomyne maintains a close relationship with all regulators. It offers transparency through the proactive reporting of potential problems.

Rotomyne Group
Consolidated statement of profit or loss
for the year ended 30 September

	2024	2023
	P$ million	P$ million
Revenue	7,815	8,203
Operating costs	(5,074)	(4,841)
Operating profit	2,741	3,362
Finance costs	(500)	(500)
	2,241	2,862
Tax expense	(359)	(458)
Profit for the year	1,882	2,404

Rotomyne Group
Consolidated statement of changes in equity
for the year ended 30 September 2024

	Share capital	Retained earnings	Currency reserve	Total
	P$ million	P$ million	P$ million	P$ million
Opening balance	3,000	2,054	(217)	4,837
Profit for year		1,882		1,882
Dividend		(1,684)		(1,684)
Loss on translation			(221)	(221)
Closing balance	3,000	2,252	(438)	4,814

Rotomyne Group
Consolidated statement of financial position
as at 30 September

	2024 P$ million	2023 P$ million
Assets		
Non-current assets		
Property, plant and equipment	7,270	7,344
Goodwill	1,814	1,814
Other intangible assets	326	294
	9,410	9,452
Current assets		
Inventory	845	866
Trade receivables	765	879
Bank	857	852
	2,467	2,597
Total assets	11,877	12,049
Equity		
Share capital	3,000	3,000
Currency reserve	(438)	(217)
Retained earnings	2,252	2,054
	4,814	4,837
Liabilities		
Non-current liabilities		
Borrowings	5,000	5,000
Current liabilities		
Trade payables	1,700	1,755
Tax liability	363	457
	2,063	2,212
Total equity and liabilities	11,877	12,049

Extract from competitor's financial statements

Lithdig is one of Rotomyne's direct competitors, with ten lithium mines operating in seven different countries.

Lithdig's head office is located in Porrland.

Lithdig Group
Consolidated statement of profit or loss
for the year ended 30 September

	2024	**2023**
	P$ million	**P$ million**
Revenue	9,691	10,254
Operating costs	(6,237)	(6,119)
Operating profit	3,454	4,135
Finance costs	(300)	(300)
	3,154	3,835
Tax expense	(505)	(614)
Profit for the year	2,649	3,221

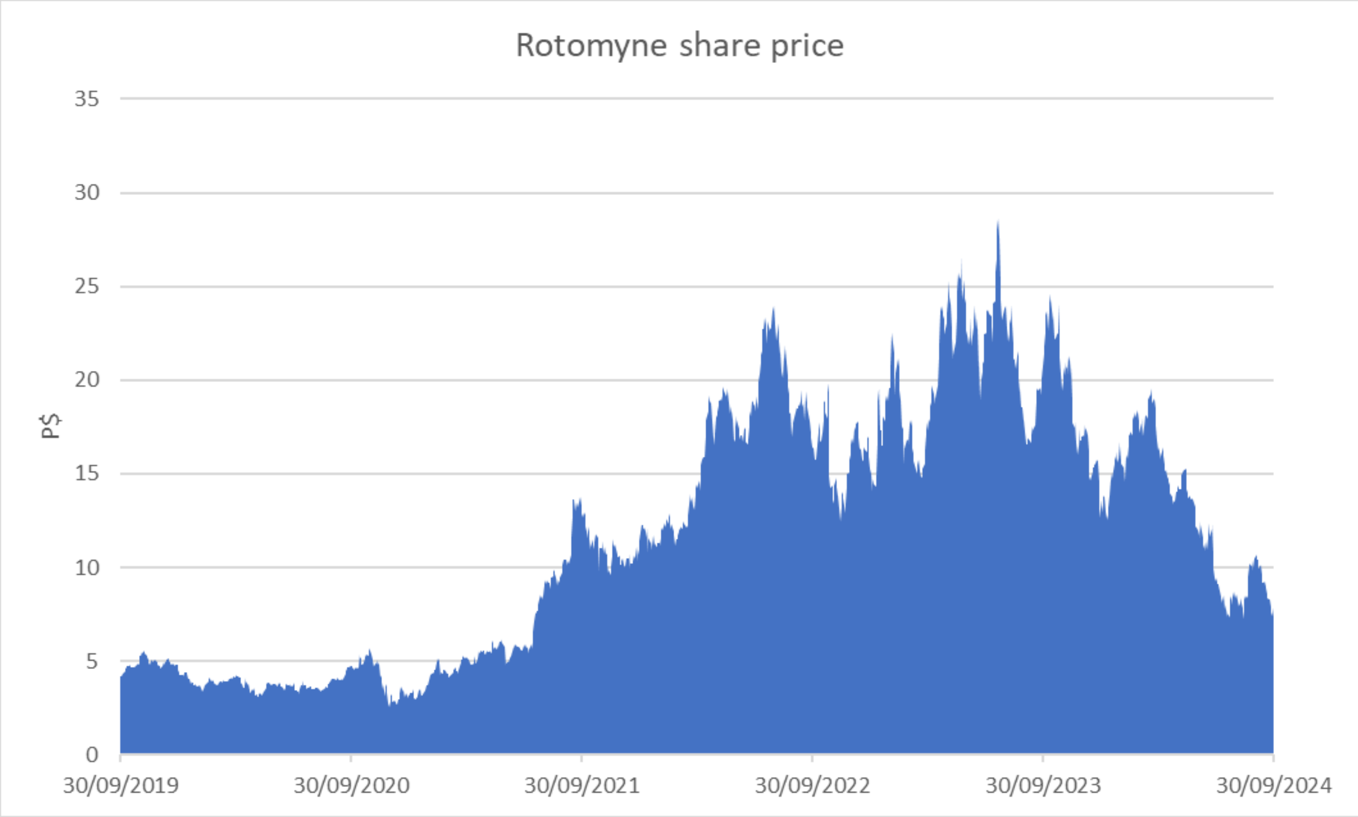
Lithdig Group
Consolidated statement of changes in equity
for the year ended 30 September 2024

	Share capital	**Retained earnings**	**Currency reserve**	**Total**
	P$ million	**P$ million**	**P$ million**	**P$ million**
Opening balance	3,500	4,614	(595)	7,519
Profit for year		2,649		2,649
Dividend		(1,313)		(1,313)
Loss on translation			(27)	(27)
Closing balance	3,500	5,950	(622)	8,828

Lithdig Group
Consolidated statement of financial position
as at 30 September

	2024	**2023**
	P$ million	**P$ million**
Assets		
Non-current assets		
Property, plant and equipment	8,797	7,344
Goodwill	2,045	2,045
Other intangible assets	418	392
	11,260	9,781
Current assets		
Inventory	1,530	1,074
Trade receivables	786	1,104
Bank	744	1,044
	3,060	3,222
Total assets	14,320	13,003
Equity		
Share capital	3,500	3,500
Currency reserve	(622)	(595)
Retained earnings	5,950	4,614
	8,828	7,519
Liabilities		
Non-current liabilities		
Borrowings	3,000	3,000
Current liabilities		
Trade payables	1,984	1,872
Tax liability	508	612
	2,492	2,484
Total equity and liabilities	14,320	13,003

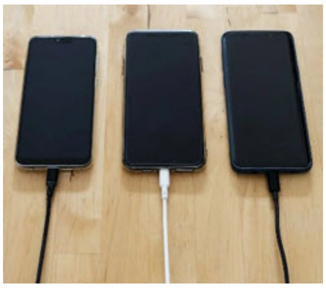
Share price history



Rotomyne's beta is 1.63.

Happy Comic

Readers' questions



Question: How do rechargeable batteries work and why don't they last forever?

Alice, age 10

Answer: All batteries consist of three basic parts: two metal electrodes (the "cathode" and the "anode") and a liquid or paste called the "electrolyte", which separates the two electrodes. Connecting the cathode and the anode from the outside of the battery (perhaps by plugging a battery into your favourite toy) causes a flow of electrons, which is just another term for electricity.

The external flow of electrons is driven by a flow of positively charged ions from the anode to the cathode. The ions are created by a chemical reaction inside the battery and they flow through the electrolyte. The chemical reaction inside the battery continues until the electrodes can no longer create or accept the positive ions. If the battery is single use, then it is now flat and can longer be used as a power source.

Rechargeable batteries differ from single use because it is possible to reverse the chemical process by applying an electrical charge to the electrodes from the outside. The charge sends positive ions from the cathode back to the anode. Unfortunately, this process is not perfect. The electrodes cannot accept as many ions as were lost during their previous use as a power source, which means that the battery's capacity reduces slightly every time it is recharged.

Rechargeable batteries deteriorate slightly with every charge-recharge cycle, until there is no point in using them. That explains why you have to replace the rechargeable battery in your mobile phone after a few years (or buy a new phone if the battery cannot be replaced).

Question: If mining for lithium is bad for the environment, why don't we recover the lithium from batteries when they are no longer able to hold a charge?

Mathew, age 12

Answer: In theory, that would be a great idea, but it isn't really practical. The electrolyte in a lithium-ion battery is held in modules that are made up of large numbers of cells. Recovering the lithium requires the cells to be opened up and emptied, which requires a lot of time and a lot of energy. It wouldn't necessarily benefit the environment to extract the lithium from old batteries instead of mining more.

Question: We have been studying batteries in chemistry. One of my classmates says that her home country produces the best lithium in the world. Could that be true?

Jiayi, age 11

Answer: No. Lithium is mined in several different countries. It comes from the earth as either rocks or brine that contain lithium compounds. The rocks and brine are processed to extract lithium carbonate, which is a chemical compound that can be further processed to give different compounds.

It does not matter where lithium was mined once it has been processed. Lithium carbonate produced in one country is identical to lithium from any other. It is sold as a commodity and the price of lithium as a raw material is the same regardless of its source.

Location can make a difference to the mining companies because their operating costs will be affected by the purity of the mined rocks or brine. If the material from the mine is of a higher purity, then it will be cheaper and easier to extract the lithium carbonate. Location also affects transportation costs.

Question: We are still learning about batteries in chemistry. We found out today that the electrolyte used in lots of rechargeable batteries is either lithium carbonate or lithium hydroxide. They still get called "lithium" even though they are compounds of the pure lithium metal. Isn't that confusing?

Jiayi, age 11

Answer: It is common practice to refer to different compounds of lithium in this way. For most purposes, the context in which the word is used makes its meaning clear. It is possible to extract lithium in its pure metal form, but it is difficult to store because it is highly volatile and deteriorates quickly if it comes into contact with the atmosphere. It is unlikely that any mention of "lithium" is referring to pure lithium metal.

Obviously, companies who buy lithium compounds (or pure lithium metal) will be very specific about the material that is being ordered and so there will be no confusion.

Porrland Telegraph

OT is the new threat vector

Factories used to be operated by engineers, many of whom worked on the factory floor. They checked dials and adjusted levers to ensure that factory operations were safe and consistent. Work in progress was carried from machine to machine by pipes or by conveyor belts and processes were monitored constantly to ensure that everything worked as it should.

Factories are now more likely to be controlled by Operational Technology (OT) rather than by human intervention. OT consists of the combination of hardware and software that monitors and directs the operation and control of equipment, processes and events in the workplace.

OT enables factories to be managed centrally, with processes being managed by automation rather than human operators. Machines are not simply automatic; they can pass instructions to adjacent equipment, activating valves and carriers to transfer materials to the next stage in the process and sending the correct settings to the machinery that will conduct the next stage of manufacture.

The Industrial Control Systems (ICS) that enable this communication and coordination are not new, they were developed decades ago. They were designed to enable safe and efficient operations, with little concern for security because there was rarely any external connectivity. What is new is that ICS is being integrated with IT systems, despite the lack of security features in ICS software. Connecting ICS systems to IT networks creates opportunities for unauthorised breaches that can be motivated by a desire to access confidential data or to disrupt manufacturing operations.

Porrland Telegraph

Scientists debate battery storage options

This year's annual academic conference on carbon-free energy generation has focussed its attention on the security of electricity supplies. This has been a significant concern because many of the alternatives to fossil fuels rely on energy sources that can be inconsistent in their delivery of power.

Wind and solar energy are excellent when winds blow and the skies are sunny, but not all locations can provide consistent power. One solution is to capture excess energy that is not required for immediate consumption. There are several technologies that can be used to store surplus electricity, including arrays of the same lithium-ion batteries that are used to power electric vehicles.

Demand for lithium-ion batteries for energy storage is limited because the batteries are too expensive for this purpose. Alternative battery types are under development, some of which will be suitable for the efficient storage of surplus electricity. Sodium-ion batteries are much cheaper to produce because they use more abundant materials. They should be commercially available by 2030. They are larger and heavier than equivalent lithium-ion batteries, making them unsuitable for use in electric vehicles. That greater bulk is not a problem if the batteries are to be located in a windfarm as a means of storing electricity that is not required for immediate consumption, perhaps on a windy day.

Porrland Daily

Careers - geologists are in demand

Geology is the study of the earth's structure and its substance. Geologists analyse rock samples and use equipment to study activity under the earth's surface. They are often looking for resources that can be extracted by mining or by drilling wells.

Continuing demand for natural resources means that demand for geologists frequently exceeds supply. An experienced geologist can expect to be well paid.

A career in geology can be challenging. There are many techniques for studying what lies beneath the earth's surface, but it is rarely possible to be 100% certain of what is there. A geologist may be confident of the presence of, say, iron ore, but the only way to be certain is to sink a test drill to collect samples. Iron ore may be present, but the ore could be low grade or the deposit may be insufficient to justify mining. There is also a possibility that the earth's structure in that area is not sufficiently stable to mine safely.