Lepidico

Caesing the opportunity

Karibib resource update

Metals & mining

On 21 October, Lepidico announced that it had produced a high-specification sample of caesium-rubidium formate brine from its pilot plant, which employs its proprietary process technologies, including L-Max® (hereafter L-Max). The brine is reported to have low levels of deleterious elements and to meet key specification criteria for use in the oil and gas industry, where such solutions have properties suitably unique for use as completion fluids (see pages 3–4). Following its acquisition of Desert Lion Energy (DLI) in July, Lepidico intends to produce a revised mineral resource estimate for the Karibib Lithium Project in Namibia in early December, including grades for both caesium and rubidium, which will allow production estimates for these metals to be calculated for the first time.

Year end	Total revenues (A$m)	PBT* (A$m)	Cash from operations (A$m)	Net cash/ (debt)** (A$m)	Capex (A$m)
06/18	0.2	(7.2)	(3.0)	4.9	(3.1)
06/19	0.0	(5.1)	(3.5)	10.4	(6.3)
06/20e	0.0	(9.6)	(13.9)	(7.5)	(44.8)
06/21e	41.1	2.7	6.9	(47.0)	(46.5)

Note: *PBT is normalised, excluding amortisation of acquired intangibles and exceptional items. **Includes Desert Lion Energy convertible.

Karibib reserve and resource update early December

A total of 2,157m of diamond drilling has been completed at Helikon 1 in 35 holes (average 61.6m/hole) and a further 3,007m in 51 holes (average 59.0m/hole) at Rubicon. Approximately 30% of assay results have been received in respect of drilling at Rubicon, including 16.98m at 0.58% Li_2O, and approximately 60% at Helikon 1, including 14.23m at 1.27% Li_2O. Once all assay results have been received, it is Lepidico's intention to update its mineral resources at Karibib (including value adding mineral resources in the measured and indicated categories) and a maiden ore reserve for incorporation into the feasibility study for the vertically integrated Phase 1 L-Max project.

Valuation: 6.04 Australian cents per share

In our last report, Lepidico: Valuation updated, published on 8 July 2019, we valued Lepidico at A$0.0692/share, after assuming US$30m (then A$41.8m) of equity funding at the then prevailing share price of 2.6c. For the purposes of this note, we have left all of our immediate assumptions unchanged, with the exception of Lepidico's updated share price of 1.7c and an updated (but ostensibly unchanged) forex rate of A$1.4472/US$, to result in a valuation of A$0.0604/share – although all of the decline may be accounted for by the recent decline in Lepidico's share price (and the consequent assumption of higher future dilution in respect of equity raised). To this, we estimate, could be added up to a further A$0.0068/share (11.3%) to reflect the potential maximum value of the income that could be derived by Lepidico from the mining and production of (in particular) caesium formate from the Karibib ore body. Note that neither of these valuations attribute any value to Lepidico from the Phase 2 Plant nor any other development options.

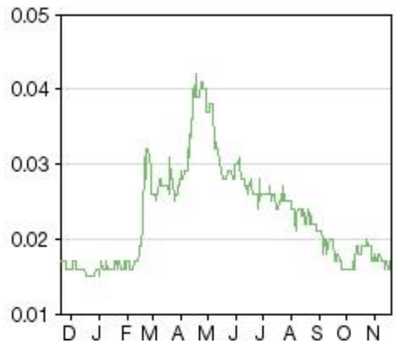
19 November 2019

Price	**A$0.017**
Market cap	**A$75m**
	A$1.4472/US$
Net cash (A$m) at end June 2019*	13.7

*Excludes Desert Lion Energy convertible

Shares in issue	4,403.7m
Free float	68%
Code	LPD
Primary exchange	ASX
Secondary exchange	N/A

Share price performance



%	1m	3m	12m
Abs	(10.5)	(22.7)	1.2
Rel (local)	(12.0)	(27.1)	(14.2)
52-week high/low		A$0.04	A$0.01

Business description

Lepidico provides exposure to a portfolio of lithium mica assets via its Karibib project and IP in Australia, Canada and Europe. Uniquely, it has successfully produced lithium carbonate from non-traditional hard rock lithium-bearing minerals using its registered L-Max® process technology.

Next events

Karibib updated resource	Early December 2019
Pilot plant results	Q3 and Q4 CY19
Feasibility study	Q1 CY20
Q3 activities report	January/February 2020

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Edison profile page

Lepidico is a research client of Edison Investment Research Limited

Caesium and rubidium

Of all of the world's production of metals and minerals, two of the most secretive are caesium and rubidium. Little verifiable data exists for either regarding production or consumption. China is believed to be the world's largest producer, but is also believed to consume more than it produces, resulting in its being a net importer of caesium, in particular. Against this background, the western world's erstwhile supplier of caesium formate (the principal caesium product used as a completion fluid by the oil and gas industry), Cabot Specialty Fluids (NYSE: CBT), which operates the Tanco Mine at Bernic Lake in Canada, has recently been sold to China's Sinomine. One of the two other caesium mines is Bikita in Zimbabwe, which is some 100 years old and is primarily a tantalum and petalite mine that is now believed to have depleted its pollucite resources, such that it is no longer producing caesium products. The other is Pioneer Resources' small-scale Sinclair pollucite mine in Western Australia, which is scheduled to be depleted this year and now has an offtake agreement with Sinomine (following its acquisition of Cabot Specialty Fluids).

In May 2018, the US Department of the Interior cited caesium as a critical mineral, raising the possibility that, via its elevated caesium and rubidium grades at the Karibib project, Lepidico could control the only significant, viable and unencumbered reserves/resources beyond the influence of China and the Chinese state.

Caesium and rubidium background

Caesium

Caesium is a soft, silvery-golden alkali metal with a melting point of 28.5°C, making it one of only five elemental metals that are liquid at or near room temperature. Otherwise, as a Group 1 alkali metal it has physical and chemical properties that are very similar to those of rubidium and potassium. It has only one stable isotope, caesium-133. Nevertheless, it is the most reactive of all metals, with the result that one of its earliest applications was as a 'getter' in vacuum tubes/electrical valves since it was almost guaranteed to react in some form with any contaminants or damp that entered the tube.

History

Caesium was discovered in 1860 by Robert Bunsen (he of the eponymous 'burner') and the physicist Gustav Kirchhoff and was the first element to be discovered by the method of flame spectroscopy. On account of the bright blue lines characteristic of its emission spectrum, the metal was given a name caesium from the Latin *caesius*, meaning sky blue. Bunsen and Kirchhoff produced around 7g of caesium chloride, but were unable to produce a sample of the new metal itself, the credit for which goes to Carl Theodor Setterberg at the University of Bonn in 1882, who obtained it by the electrolysis of molten caesium cyanide, CsCN.

Chemistry and toxicity

Chemically, caesium is similar to other alkali metals and in particular rubidium, the element above caesium in the periodic table. The pure metal is highly explosive in the presence of water. Caesium hydroxide (CsOH) is strongly basic and used to be regarded as the strongest base (analogous to, but stronger than, caustic soda), rapidly etching the surface of glass and, more latterly, the surfaces of silicon (and other) semiconductors.

The pure metal's tendency to react explosively with water means that caesium metal is considered a hazardous material, and radioisotopes present a significant health and ecological hazard in the environment. However, non-radioactive caesium compounds are only mildly toxic – the median lethal dose for caesium chloride in mice, for example, (measured by mass) being comparable to that of common salt.

Applications

Time

In 1967, acting on Einstein's proof that the speed of light is the most constant dimension in the universe, the International System of Units (SI) defined the second as the duration of 9,192,631,770 cycles at the microwave frequency of the spectral line corresponding to the transition between two hyperfine energy levels of the ground state of caesium-133 undisturbed by external fields. The first accurate caesium clock was built by Louis Essen in 1955 at the National Physical Laboratory in the UK and, since then, caesium has been widely used in so-called atomic clocks. In their most recent guises, these can be accurate to one part in 10^{15}, or about one second in 20 million years and play a vital role in aircraft guidance systems, global positioning satellites and internet and mobile phone transmissions.

Oil and gas

Caesium formate is the heaviest of the monovalent alkali metal salts and, since the 1990s, its largest application has been in the form of completion and drilling fluids in the extractive oil industry and, in particular, high temperature, high pressure (HTHP) wells. The primary function of these fluids is to maintain pressure on the formation during the drilling and/or completion of the well as well as to lubricate drill bits and bring rock cuttings to the surface. Completion fluids assist the emplacement of control hardware (eg Christmas trees, blow-out protectors etc) after drilling but prior to production by maintaining pressure in the well and reducing the risk of compromising well integrity and productivity.

Aqueous solutions of caesium formate (Cs^+ $HCOO^-$) may be formulated simply by reacting caesium hydroxide (a strong base) with formic acid (a weak acid). The high density of the caesium formate brine (up to 2.3g/cm^3 – ie comparable to some lighter rocks), coupled with the relatively benign nature of most caesium compounds, reduces the requirement for toxic high-density suspended solids in the drilling fluid, which is a significant technological, engineering and environmental advantage. Drilling fluids composed of formate brines need no solid weighting agents, as the density is a property inherent to the fluid itself. Alternative drilling fluids require up to 40% by volume of solids (eg barite) to obtain an equivalent density. In addition, formate fluids may be viscosified with conventional biopolymers, which are stable to 160°C. They also have a low coefficient of friction and beneficial lubricity, making them superior in performance to oil-based fluids and water. Prior to 1999, the only comparable solids-free brine available at such a density was zinc bromide brine, which is classified as both corrosive and hazardous. By contrast, caesium formate is relatively environment-friendly and can be blended with rubidium, potassium and sodium formates to decrease the density of the fluids to that of water, if desired, and has an expanded performance range. In addition, it is safe to handle, stable, biodegradable, non-corrosive towards the metals used in the construction of casing, production tubulars and packers and may be recycled, which is important in view of its high price (see pages 7–9). Formate brines also require less environmental remediation and incur lower disposal costs. As a result, they have almost completely replaced zinc bromide as a completion and workover brine in Europe. They have also allowed operators to create new health, safety and environmental standards.

As a result, caesium formate brines are used increasingly across the well development spectrum, from reservoir drilling, completions and workovers to packing and long-term well suspension. A summary, highlighting some of the advantages of using caesium formate brines in well development, is as follows:

- Drill and complete faster and easier than alternatives. Pipe and casing running speeds are faster and mud conditioning and flow check times shorter. Caesium formate also helps to eliminate well control and stuck pipe incidents and allows open hole completion with screens. Also, in deep, hard, abrasive rock drilling, the rate of penetration may be in excess of 100% faster. Typically, completion times for wells drilled using caesium formate are 50% lower than for those using oil-based mud, leading to accelerated production.
- Improves well safety and reduces risk. Clean well bores mean that there are no tool/seal failures or blocked screens.
- Caesium formate has good hydraulic properties. Also, inasmuch as the drilling fluid is the same as the completion fluid, its use simplifies (or even eliminates) displacements.
- Maximises well performance. In particular, the use of caesium formate reduces the need for future well interventions.
- Since it is conductive, the use of caesium formate allows for the possibility of running high-quality resistivity logs, which provide enhanced definition and imaging of the precise definition of reservoir fractures, for example, and providing information regarding the structural dip, depositional environment, sedimentary features, facies and geological correlation of the well.

In general, conventional filtration equipment may be used to reclaim used formate based fluids, supplemented by chemical treatment in combination with mechanical separation (eg centrifuges, high pressure filter presses and/or fine screen shakers) for solids/polymer removal. Alternative methods, such as ultrafiltration and evaporation followed by condensation may also be used. Typically, the total volume of brine lost during a well re-entry campaign may be in the order of 10–11% of the total volume handled on a rig, of which the largest portion (c 22%) is typically the unrecoverable brine abandoned below the packers. The cost of using caesium formate brine in a multiple well re-entry programme may be of the order of US$1m per well.

Other

Other applications of caesium include caesium metal in photoelectric cells and caesium carbonate in energy conversion devices, such as fuel cells.

Occurrence and production

Caesium is a relatively rare element. In addition, owing to its large ionic radius, it is also one of the so-called 'incompatible elements'. During magma crystallisation, caesium crystallises last and is concentrated in the liquid phase. Hence, it is found in few minerals and the largest deposits are zone pegmatite ore bodies formed via this enrichment process. Moreover, since it does not substitute for potassium as readily as rubidium does, the alkali evaporite minerals sylvite (KCl) and carnallite ($KMgCl_3 \cdot 6H_2O$) may contain only 0.002% caesium. Hence, it is only 3.3% as abundant as rubidium (see below). Overall, it is the 45th most abundant element in the Earth's crust (out of c 78) and the 36th among the metals with a crustal abundance estimated to average 3 parts per million (ppm). Nevertheless, it is more abundant than elements such as antimony, cadmium, tin and tungsten, and two orders of magnitude more abundant than mercury and silver.

The only economically important ore for commercial caesium production is pollucite $Cs(AlSi_2O_6)$, which is associated with the more commercially important lithium minerals, lepidolite and petalite. One of the world's most significant sources of caesium is the Tanco Mine at Bernic Lake in Canada, which is estimated to contain 350kt of pollucite ore, representing more than two-thirds of the world's reserve base. Although the stoichiometric content of caesium in pollucite is 42.6%, pure pollucite samples from this deposit contain only about 34% caesium, while the average content is 24% (by weight). However, the Tanco mine ceased large-scale operation at the end of 2015 and supplies caesium products from stocks now only – typically on a rental basis. Elsewhere, the Bikita pegmatite deposit in Zimbabwe is mined for its tantalite and petalite. Historically, it also contained a significant amount of pollucite, which was produced as a by-product. However, this is now believed to have been depleted. Another notable source of pollucite is in the Karibib Desert, Namibia.

Reserves and resources

The main pollucite zone at Bernic Lake in Canada is estimated to contain c 120,000t of caesium oxide in pollucite ore at an average grade of 23.3% Cs_2O. As the mine stopped producing in 2015 however, these are no longer considered as reserves. Elsewhere, global reserves are estimated as follows:

Exhibit 1: Estimated global reserves of contained caesium (t)

Country	Reserves
Namibia	30,000
Zimbabwe	60,000
Other	Unknown
Total	**90,000**

Source: US Geological Survey

No estimate exists for possible global resources of caesium.

Rubidium

Rubidium is a very soft, silvery-white metal, similar in character to both potassium and caesium. Like caesium, it cannot be stored in air as a highly exothermic reaction will ensue, and therefore, in its metallic state, has to be kept either in sealed ampoules in an inert atmosphere or under dry mineral oils.

History

Like caesium, rubidium was discovered in 1861 by Robert Bunsen and Gustav Kirchhoff at the University of Heidelberg in Germany in the mineral lepidolite through flame spectroscopy. It was the second element, after caesium, to be discovered via this method and, on account of the bright red lines in its emission spectrum, was given the name rubidium after the Latin *rubidus*, meaning deep red. However, it was not until 1928 that a sample of pure rubidium metal was eventually produced.

Chemistry and toxicity

Rubidium reacts violently with water to form rubidium hydroxide (a strong base). Like sodium and potassium, it almost always has +1 oxidation state when dissolved in water, even in biological contexts with the result that rubidium ions are treated by animal cells in similar ways to potassium ions and taken up in the same manner, concentrating them in the body's intracellular fluid (ie inside cells). The ions are not particularly toxic; a 70kg person contains on average 0.36g of rubidium, and an increase in this value by 50 to 100 times does not appear to show negative effects in test subjects.

Applications

Other

The most important use of rubidium is in research and development, primarily in chemical and electronic applications. It is also used as a bio-marker since, in nature, it is found only in small quantities in living organisms and, when present, replaces potassium. As a result, one of its main applications is in myocardial perfusion imaging, whereby brain tumours can be located and imaged as a result of changes in the blood–brain barrier that result in rubidium collecting more in brain tumours than in normal brain tissue, allowing the use of the radioisotope rubidium-82 as a marker. In 1995, rubidium-87 was also used to produce a Bose–Einstein condensate (extremely low-temperature fluids that have zero viscosity and the ability to spontaneously flow out of their containers), for which the discoverers, Eric Allin Cornell, Carl Edwin Wieman and Wolfgang Ketterle of the University of Colorado, won the 2001 Nobel Prize in Physics.

In this respect, one particular application that has the potential for relatively high consumption of rubidium is in the field of quantum mechanical computing, which utilises rubidium's ability to achieve ultra-cold temperatures to perform more complex computational tasks than traditional computers by calculating in two quantum states simultaneously and is expected to be in prototype phase by 2025.

At the same time, rubidium's photoemissive properties make it ideal for the generation of electrical signals in motion sensor and night vision devices, solar panels and photomultiplier tubes. More traditionally, on account of their high dielectric constant, rubidium rich feldspars are used in the ceramics industry for spark plugs and electrical insulators. Other potential or current uses of rubidium include as a working fluid in vapour turbines, as a getter in vacuum tubes and as a component in speciality glass. Rubidium carbonate is also used to reduce electrical conductivity, which improves the stability and durability of optical fibre telecommunications networks.

Perhaps ironically, on account of the radioactive qualities of rubidium-87, which has a half-life of 49bn years (ie just under four times the age of the universe), rubidium has been used extensively to date rocks.

To date, rubidium formate has only been used in limited trials as a completion fluid, owing to its limited availability. Rubidium formate has a specific gravity of 2.0 and therefore could be substituted for caesium formate in certain applications should commercial quantities be available.

Time

The resonant element in atomic clocks may utilise the hyperfine structure of rubidium's energy levels (although it is considered less accurate than caesium). It is also used as the main component of secondary frequency references (rubidium oscillators) in mobile phone transmitters and other electronic transmitting, networking and test equipment. These rubidium standards are often used with GPS to produce a primary frequency standard that is less expensive than caesium standards. Such rubidium standards are often mass-produced for the telecommunication industry.

Occurrence

Rubidium readily substitutes for potassium in minerals, and is therefore fairly widespread. As such, it is the 23rd most abundant element in the Earth's crust, roughly as abundant as zinc and rather more common than copper, and has a crustal abundance of 90ppm. It occurs naturally in the minerals pollucite, leucite, carnallite and zinnwaldite, which contain as much as 1% rubidium oxide. Lepidolite contains 0.3–3.5% rubidium. Some potassium minerals also contain substituted rubidium in commercially significant quantities. In general, however, rubidium does not occur in concentrations sufficient to be of primary commercial interest. While lepidolites tend to carry the highest concentrations of rubidium, historically they have rarely been mined commercially since (before the advent of L-Max) no process has been available by which to extract the valuable elements from the mineral. With lepidolite now having become a viable ore for lithium; however, rubidium may now be mined for the first time in commercial quantities.

Seawater contains an average of 125µg/l of rubidium cf 408mg/l for potassium and 0.3µg/l for caesium.

Like caesium, on account of its large ionic radius, rubidium is one of the 'incompatible elements'. That is to say, its ions are of an unsuitable size/charge for the cation sites of the minerals of which they are a constituent part. Consequently, rubidium ions (like caesium ones) are concentrated in the melt (liquid) phase of magma. As a result, the largest deposits of rubidium are zone pegmatite ore bodies. However, since rubidium also substitutes for potassium (which caesium does not) in the crystallisation of magma, the enrichment is far less effective than that of caesium. Zone pegmatite ore bodies containing mineable quantities of caesium as pollucite or lepidolite are also a source for rubidium as a by-product.

Two notable sources of rubidium are the rich deposits of pollucite at Bernic Lake in Canada (see *Caesium*, above) and the rubicline ($(Rb,K)AlSi_3O_8$) found as impurities in pollucite on the island of Elba (Italy), with a rubidium content of 17.5%.

Reserves and resources

Although rubidium is more abundant in the Earth's crust than caesium, the limited applications and the lack of a mineral rich in rubidium limits the production of rubidium compounds, typically as a by-product of caesium (pollucite), lithium (lepidolite) and strontium mining. Production at Tanco has reduced to a mere 11–19% of historical production levels, but is known to take place periodically in Namibia and Zimbabwe and is thought to take place in China.

Significant rubidium-bearing pegmatite occurrences have been identified in the US, Afghanistan, Australia, Canada, China, Denmark, Germany, Japan, Kazakhstan, Namibia, Peru, Russia, the UK and Zambia (source: USGS). Minor quantities of rubidium are reported in brines in northern Chile and China and in evaporites in the US (New Mexico and Utah), France and Germany. However, these have generally not been quantified.

As with caesium, the mineral deposits of rubidium at Bernic Lake are no longer considered to qualify as reserves. Elsewhere, global reserves are estimated as follows:

Exhibit 2: Estimated global reserves of rubidium and caesium

Country	Rubidium reserves (contained metal t)	Caesium reserves* (contained metal t)
Namibia	50,000	30,000
Zimbabwe	30,000	60,000
Other	10,000	Unknown
Total	**90,000**	**90,000**

Source: USGS. Note: *See Exhibit 1.

Caesium and rubidium economics

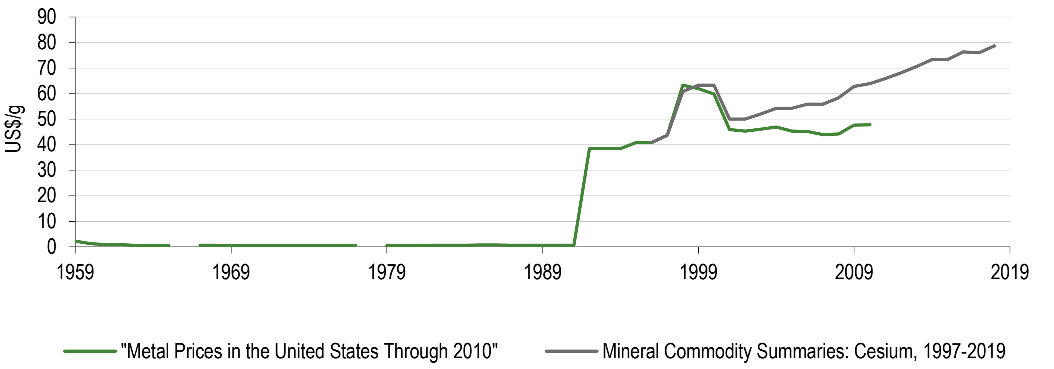
Caesium formate brine has hitherto been provided to the oil and gas industry in the western world by Cabot's Speciality Fluids division on a daily rental basis with the total cost of its use being a function of its brine density, the number of rental days, the amount of brine lost during transport/handling/use, any value loss via dilution and the cost of any brine clean-up at the end of the job. Typically, the total volume of brine lost during a well re-entry campaign may be in the order of 10–11% of the total volume handled on a rig, while the cost of using caesium formate brine in a multiple well re-entry programme combined with potassium formate may be of the order of US$1m per well.

In general however, the caesium market is very small in terms of volumes/tonnages and relatively secretive, with an absence of any hard data or fundamentals available. China is thought to be a material producer. However, it is presumed to consume at least as much as it produces domestically. Cabot's Specialty Fluids division (now sold to Sinomine – see below) is probably the largest producer outside China. Up until 2015, Cabot's Tanco mine and associated caesium formate production facility were believed capable of producing 12,000bbl of caesium formate annually, or approximately 4,400tpa. Since a partial mine collapse in 2015 however, the mine has been estimated to be producing only 500–800tpa. This compares with an inventory of caesium formate estimated to be in the order of 30,000bbl, or approximately 4,770m^3 or 11,000t – ie production equates to 4.5–7.3% of stocks and approximates to slightly more than half of the amount that might be required for replenishment if the whole inventory was rented out during the year with a loss rate of 10.5%.

According to the US Geological Survey (USGS), 'Consumption, import, and export data for cesium [*sic*] have not been available since the late 1980s. Because cesium metal is not traded in commercial quantities, a market price is unavailable. Only a few thousand kilograms of cesium are consumed in the United States every year. The United States was 100% import reliant for its cesium needs.' Nevertheless, the USGS quotes a price/value of caesium formate of US$38.70 for 25g (98% basis) in 2018, which is the equivalent of US$1,548,000 per tonne. However, it notes that there are discounts, which may be significant, for larger quantities.

By contrast, Alibaba quotes a range of prices for caesium formate, from US$10/kg to US$2,000/kg – the upper end of which would approximately correlate to the USGS's US$38.70 for 25g, above. A graph of the caesium metal price is as follows:

Exhibit 3: USGS estimated price of caesium metal (US$/g)



Source: USGS, Edison Investment Research

Within the context of the above graph however, readers' attention is drawn to the USGS's caveat, 'The annual prices presented in the graph and table may not be comparable from year to year owing to differences in purities, quantity of material purchased, and (or) the source of the price. For example, prior to 1960, the prices published in the U.S. Bureau of Mines Minerals Yearbook (MYB) were for purchases of less than 1 pound of cesium metal. From 1960 through 1991, the cesium metal prices published in the MYB were for purchases of at least 1 pound of material and are significantly lower than the pre-1960 prices owing to discounts for the larger quantity purchased. The prices for 1992 through 2010 represent the price charged for a 1-gram ampoule of 99.98-percent-pure cesium metal and are an order of magnitude higher than the 1960 to 1991 prices.'

In June, Cabot Corporation closed the sale of its Speciality Fluids division to Sinomine (Hong Kong) Rare Metals Resources Co Ltd for a consideration of US$135m, made up of US$130m in cash and royalties of up to US$5m for lithium products over a 10-year period. Selected financial information relating to Cabot's Speciality Fluids division, sourced from its FY18 report and accounts (year to September) is as follows:

Exhibit 4: Cabot Specialty Fluids division, selected financial information (US$m*)

Year to end September	2018	2017	2016
Revenues from external customers	45	41	47
EBITDA	10	**11	**16
Depreciation & amortisation	2	2	3
EBIT	8	9	13
Income from continuing operations before tax	8	9	13
Assets	178	140	139
Capex	17	5	1
EDITDA margin (%)	22.2	26.8	34.0
Pre-tax profit margin (%)	17.8	22.0	27.7
Asset turnover (x)	0.25	0.29	0.34
Pre-tax return on assets (%)	4.5	6.4	9.4

Source: Cabot Corporation 2018 report & accounts, Edison Investment Research. Note: *Unless otherwise indicated. **Edison Investment Research estimate.

Readers' attention is drawn to the equivalence between EBIT and pre-tax profit in the above exhibit, implying that there is little or no interest charge attributable to the Specialty Fluids division and therefore no associated debt or cash balances, in which case pre-tax return on assets is likely to approximate return on capital employed (subject to current liabilities being small relative to total assets).

Some alternative observations and calculations regarding the value of caesium formate on an industrial scale are as follows. Although note that these are subject to material uncertainty:

- Of the total consideration of US$135m paid by Sinomine for Cabot's Specialty Fluids division, US$90m is estimated to have been in respect of the latter's stocks of caesium formate. This would reconcile with Cabot's estimate of the book value of its 'assets held for rent' as disclosed in its 'return on adjusted net assets' calculation of US$110m, assuming that its Specialty Fluids division accounted for the majority of those assets. Assuming the estimate of the Specialty Fluids division's inventory of 30,000bbl to be correct, this US$90m estimate implies a valuation of its drilling fluids (a combination of caesium and potassium formates) of US$3,000/bbl. Note that according to Offshore Magazine (John H Hallman, 1 August 1996), although potassium formate is in the price range of some premium synthetic oil-based fluids, the price of caesium formate is estimated to be an order of magnitude higher. While the combined value of US$3,000/bbl cannot, in and of itself, yield discrete values for potassium and caesium formates, it is worth noting that one potential solution (invoking the 'order of magnitude' difference in price between the two, which, for these purposes, is interpreted to mean 10 times) would be for potassium formate to have a value of US$1,579/bbl (an estimated US$6,306/t) and caesium formate to have a value of US$15,789/bbl (an estimated US$43,178/t).
- Alternatively, the estimate of 57m^3 of completion fluid losses in those wells for which the total rental cost was US$1m per well implies a maximum replacement value of US$17,540/m^3 (or US$2,789/bbl) for combined completion fluids in 2007. Once again, with the same caveats as in the bullet point above, this would be consistent with replacement prices of US$92,316/m^3 (an estimated US$40,137/t) for caesium formate and US$9,232/m^3 (an estimated US$5,862/t) for potassium formate. Note that indexing this value according to the estimated caesium metal price in Exhibit 3 could increase the caesium formate prices in particular by 78.9%.
- In the meantime, sales of US$45m distributed over a rental inventory of 30,000bbl of drilling fluids would imply a blended total return (rental plus replacement value) of US$1,500/bbl which (again with the caveats noted above) could be consistent with a caesium formate value of US$7,895/bbl/year or US$49,658/m^3/year or US$21,590/t/year and a potassium formate rental value of US$789/bbl/year or US$4,963/m^3/year or US$3,151/t/year. Note that this calculation assumes 100% utilisation of the entire inventory over the entire year, which is inherently optimistic. Self-evidently, the pure rental value for each fluid may be supposed to be below the numbers calculated and the replacement value above them.

- Anecdotally, Cabot's Specialty Fluids division is reported to have charged as much as US$50,000 per tonne in consideration of operational contamination of caesium formate by oil and gas operators.

A summary of the various sources of (industrial scale) caesium formate pricing and related pricing considerations is as follows:

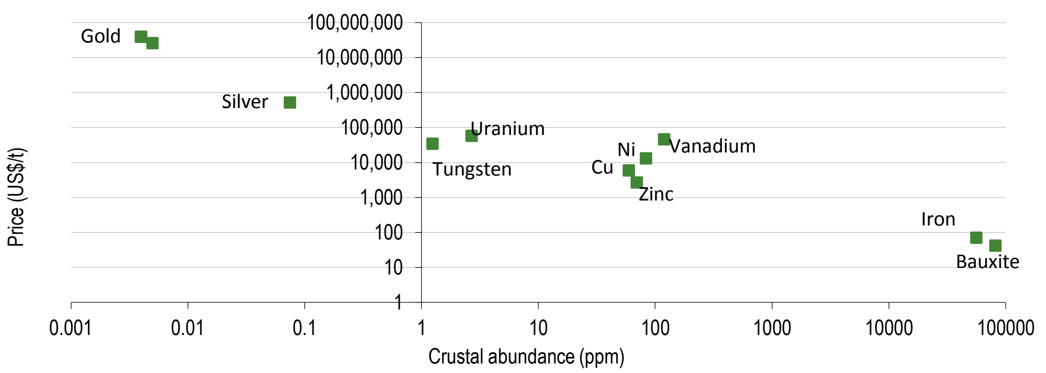
Exhibit 5: Caesium formate pricing sources and considerations

Source	Date	Observed price	Edison's estimated caesium formate value (US$/t)	Comments
Replacement value				
Sinomine acquisition of Cabot's Specialty Fluids division	2019	US$3,000/bbl*	43,178	Relies on four assumptions: the value of the inventory acquired, the size of the inventory, the price differential between caesium and potassium formates and the proportion of each in the inventory. Concentration of caesium formate solution unknown.
IADC World Drilling/Drilling Contractor	2007	US$17,540/m³*	Maximum 40,137	Dated. Based on 'round' numbers. Assumes 10x price differential between caesium and potassium formates. Concentration of caesium formate solution unknown.
Lepidico	2019	US$50,000/t	50,000	Anecdotal.
Average			**44,438**	
Blended rental/replacement value				
Cabot Corp FY18 report & accounts	FY18	US$1,500/bbl*	21,590/year	Relies on four assumptions: the size of the inventory, the inventory's utilisation rate, the price differential between caesium and potassium formates and the proportion of each in the inventory. Concentration of caesium formate solution unknown.

Source: As stated, Edison Investment Research. Note: *Per volume unit of combined drilling fluids.

In addition to the analyses above, caesium's crustal abundance of 3ppm – approximately the same as uranium's (2.7ppm) – would also appear to support a price in the region of US40,000–50,000/t for its most readily accessible derivative salt:

Exhibit 6: Price (US$/t) vs crustal abundance (ppm), selected metals and minerals



Source: Edison Investment Research.

Value to Lepidico

While it is still very early – and thus in its nature, relatively speculative – indications, to date, are that the elevated grades of caesium, in particular, at Karibib, could support production of caesium formate in the order of 150tpa, with a (sale) value up to US$7.5m (maximum) per annum, or A$10.9m, which compares with our long-term steady state forecast for turnover of A$169.2m and average pre-tax profits of A$85.5m in respect of Lepidico's development of the Phase 1 L-Max project.

We calculate that, discounted at a rate of 10% per annum, the (maximum) value of this stream of income to Lepidico (post-tax, post-minority, but assuming a 100% margin) would be A$46.9m, or A$0.0068/share (post-anticipated future dilution – see below).

Accounting, forecasts, valuation and sensitivity

In our last report (Lepidico: Valuation updated, published on 8 July 2019), we valued Lepidico at A$0.0684/share, after assuming US$30m (then A$41.8m) of equity funding at the then prevailing share price of 2.6c. For the purposes of this note, we have left all of our immediate assumptions unchanged, with the exception of Lepidico's updated share price of 1.7c and an updated (but ostensibly unchanged) forex rate of A$1.4472/US$, to result in a valuation of A$0.0604/share – although all of the decline may be accounted for by the recent decline in Lepidico's share price.

Note that this valuation is fully diluted in that it accounts for an assumed US$30m equity issuance (and associated equity dilution) in FY20 (in this case at a share price of 1.7c, rather than 2.6c previously). It also treats the Desert Lion convertible bond as conventional debt. However, the note may be converted into Desert Lion (and thereby, Lepidico) equity at a price of C$0.20/share (equivalent to a Lepidico share price of 4 Australian cents at the time of writing) at any time prior to maturity, which is 10 December 2020. Originally bearing interest at a rate of 12% pa to be settled in cash and shares, in April DLI issued the financier, API, with shares to convert the note into a zero-coupon instrument. Nevertheless, if the convertible is instead fully converted into 108m Lepidico shares, our valuation reduces by fractionally less than 1%, to 6.00 Australian cents per share.

Note that neither of these valuations attribute any value to Lepidico from the Phase 2 Plant or any other development options.

In the meantime, we have updated our financial model to reflect Lepidico's FY19 results, which were published on 23 September for the period to 30 June 2019, and have introduced FY21 estimates for the first time (showing a part year contribution from the Phase 1 L-Max plant project). Since the period end however, Lepidico has successfully concluded its acquisition of Desert Lion Energy on 12 July 2019, with the result that it has issued an additional 633.8m shares and will formally consolidate Desert Lion's financial statements with its own from that date. Given the proximity of 12 July to 30 June however, for simplicity, Edison has assumed that the acquisition closed on 30 June and the balance sheet for FY19 in **Error! Reference source not found.** below therefore reflects Lepidico's known end-FY19 balance sheet consolidated with our estimate of Desert Lion Energy's balance sheet as at 30 June 2019, converted into Australian dollars (ie it is our estimate of Lepidico's *pro forma* balance sheet as at 30 June 2019).

Exhibit 7: Financial summary

Accounts: IFRS, Yr end: June, AUD: Thousands		2015A	2016A	2017A	2018A	2019A	2020E	2021E
INCOME STATEMENT								
Total revenues		9	116	127	171	2	0	41,092
Cost of sales		0	0	0	0	0	0	(24,719)
Gross profit		9	116	127	171	2	0	16,373
SG&A (expenses)		(455)	(617)	(912)	(5,284)	(4,006)	(5,155)	(3,146)
Other income/(expense)		0	0	0	0	0	0	0
Exceptionals and adjustments	Exceptionals	(16)	(415)	(878)	(2,171)	(1,150)	0	0
Depreciation and amortisation		(5)	(6)	(6)	(6)	(8)	(4,486)	(9,652)
Reported EBIT		(467)	(923)	(1,670)	(7,290)	(5,162)	(9,642)	3,575
Finance income/(expense)		(18)	(5)	128	70	57	52	(825)
Other income/(expense)		(559)	(448)	(3,815)	0	0	0	0
Exceptionals and adjustments	Exceptionals	0	(888)	0	0	0	0	0
Reported PBT		(1,044)	(2,263)	(5,357)	(7,220)	(5,105)	(9,590)	2,750
Income tax expense (includes exceptionals)		0	0	0	0	0	0	(687)
Reported net income		(1,044)	(2,263)	(5,357)	(7,220)	(5,105)	(9,590)	2,062
Basic average number of shares, m		178	465	1,802	2,624	3,272	5,648	6,925
Basic EPS		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	0.0
BALANCE SHEET								
Property, plant and equipment		9	4	8	27	18,487	58,779	95,620
Goodwill		0	0	0	0	0	0	0
Intangible assets		0	16,204	16,698	19,027	22,925	22,925	22,925
Other non-current assets		1,485	715	1,620	730	9,001	9,001	9,001
Total non-current assets		1,494	16,922	18,326	19,783	50,414	90,706	127,547
Cash and equivalents		53	650	3,307	4,860	13,660	13,660	13,660
Inventories		0	0	0	0	0	0	3,424
Trade and other receivables		4	3,886	706	712	1,869	0	3,377
Other current assets		0	0	0	0	0	0	0
Total current assets		57	4,537	4,013	5,572	15,529	13,660	20,462
Non-current loans and borrowings		0	0	0	0	3,276	21,159	60,707
Other non-current liabilities		0	0	0	0	0	0	0
Total non-current liabilities		0	0	0	0	3,276	21,159	60,707
Trade and other payables		105	614	1,663	804	10,940	259	2,290
Current loans and borrowings		115	0	0	0	0	0	0
Other current liabilities		40	33	46	51	86	86	86
Total current liabilities		260	647	1,709	856	11,026	344	2,376
Equity attributable to company		1,292	20,812	20,630	24,500	53,252	84,473	86,535
Non-controlling interest		0	0	0	0	(1,610)	(1,610)	(1,610)
CASHFLOW STATEMENT								
Profit for the year		(1,044)	(2,263)	(5,357)	(7,220)	(5,105)	(9,590)	2,062
Taxation expenses		0	0	0	0	0	0	687
Depreciation and amortisation		5	6	6	6	8	4,486	9,652
Share based payments		450	40	1,736	2,138	520	0	0
Other adjustments		(451)	1,036	(162)	2,066	664	0	0
Movements in working capital		(10)	132	133	(28)	410	(8,813)	(4,770)
Interest paid / received		0	0	0	0	0	0	0
Income taxes paid		0	0	0	0	0	0	(687)
Cash from operations (CFO)		(1,050)	(1,049)	(3,644)	(3,038)	(3,504)	(13,916)	6,944
Capex		(9)	(63)	(861)	(3,057)	(6,251)	(44,778)	(46,493)
Acquisitions & disposals net		0	32	122	110	0	0	0
Other investing activities		(563)	(80)	0	0	0	0	0
Cash used in investing activities (CFIA)		(572)	(111)	(739)	(2,947)	(6,251)	(44,778)	(46,493)
Net proceeds from issue of shares		1,505	1,872	7,040	7,555	18,462	40,811	0
Movements in debt		100	(115)	0	0	0	17,883	39,548
Other financing activities		0	0	0	0	0	0	0
Cash from financing activities (CFF)		1,605	1,757	7,040	7,555	18,462	58,694	39,548
Increase/(decrease) in cash and equivalents		(18)	597	2,657	1,570	8,707	0	0
Currency translation differences and other		0	0	0	(17)	93	0	0
Cash and equivalents at end of period		53	650	3,307	4,860	13,660	13,660	13,660
Net (debt) cash		(61)	650	3,307	4,860	10,385	(7,499)	(47,047)
Movement in net (debt) cash over period		(61)	711	2,657	1,553	5,525	(17,883)	(39,548)

Source: Company sources, Edison Investment Research. Note: FY19 balance sheet is Lepidico's stated balance sheet consolidated with Edison's estimate of Desert Lion's balance sheet as at 30 June 2019, converted into Australian dollars.

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