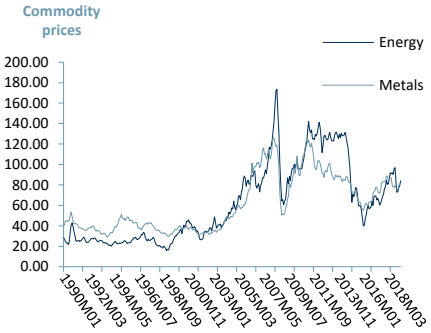
Spotlight

Extractives



The World Bank

Thursday, 30 May 2019

Commodity Prices	**USD**
Brent Crude Oil (bbl)	
Currrent Price	71.83
52 Wk Lo	49.93
52 Wk Hi	86.74
WTI Crude Oil (bbl)	
Currrent Price	62.55
52 Wk Lo	42.36
52 Wk Hi	76.90
Metal Prices	
Copper (lb)	
Currrent Price	2.71
52 Wk Lo	2.55
52 Wk Hi	3.30
Iron Ore (US/t)	
Currrent Price	96.56
52 Wk Lo	66.77
52 Wk Hi	86.99
Gold (t/oz)	
Currrent Price	1,272.00
52 Wk Lo	1,161.40
52 Wk Hi	1,344.00

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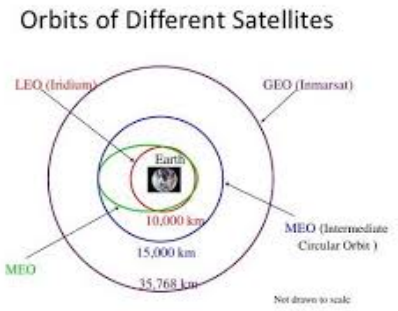
Technological Innovations

New and Emerging Extractives Innovations

In our spotlight note for small and mid-caps we set up the natural resources market background and introduce the current and mid-term technological innovations that likely will have the greatest impact on the sector. We believe the new element in this mix is based upon the launch of up to 5 new LEO satellite constellations. We propose data can become a new revenue stream for extractives, accessible to small and mid-caps it is an opportunity to raise funds. Our favoured technologies are AI robotics, spatial data visualisation, wearable tech and IoT (connecting kit, people and vehicles and data to the net via LEOs). If we are right, Alaska will have LEO internet in 2020.

- Technological innovations in the resources market are disrupting the supply chain and data, though no longer unicorn, is current;
- Space X launched 60 LEO birds in 2019, plans 1600, licenses for 12k;
- Global commodity markets underwent sustained price increases for the better half of two decades, but the time of easy money is over;
- Now the market is characterised by price volatility driven by economic and geopolitical uncertainty;
- OPEC and Russia have lost their energy price dominance now the US is a net oil exporter, thanks to the Bakken and Permian shale fields.



Market Background – The Tech Drivers

Why would small and mid-cap extractives want to invest in tech now?

- Revenue generation potential – volume data resale;
- Cost cutting potential – connect it all up via LEOs;
- Money raising potential – data becomes another reason to invest in its own right.

Much of the technology innovation that we review (largely at the top-line) in this spotlight is already in early stage or later adoption. What we think changes the adoption rate of the data-based technologies in this report is the actual and planned launch of LEO satellite constellations "en-masse". We are aware of plans for 5 new constellations, one of which, SpaceX, has already put 60 birds into orbit during 2019, has plans for 1,600 and licenses for 12,000.

In our view, this changes the accessibility of costs savings, new revenue lines and money raising potential for small and mid-cap miners. LEO effects should become real in 2020.

Achieved so far 2019 LEO birds 60
Planned 1,600
Licenses for 12,000
Data from Alaska by 2020

Ties data, kit and IoT together and makes it accessible for mid and small cap natural resources firms

Super cycle

Kondratiev super cycles 20-70 years

Global commodity markets underwent sustained price increases over the past 20 years, in part, driven by emerging economies' growth prospects, particularly those of India and China. During the super-cycle, China's push to industrialise its economy supported global commodity demand. During the last 20 years China has accounted for half of all global hard commodity demand.

At the same time, OPEC's strategy to carefully manage or even cut oil and gas pushed up energy prices. Crude oil prices rose from $25 bbl to $160 bbl between 1999 and 2008, before falling precipitously to around $40-45 bbl for a sustained period. More recently oil has traded between $55-65 bbl, a long way off its highs but above lifting costs for many producers.

The majority of commodity prices (excepting Uranium prices and some other thinly traded specialist metals) are determined by prevailing market demand and supply, therefore global GDP growth promotes higher commodity consumption, increasing prices as a result.

In 2009 commodity prices fell sharply in response to the collapse of global economies after the 2008 banking crisis. Prices then recovered quickly(ish) in tandem with the global markets' recovery.

During 2014 prices plunged again, wiping out the commodity markets' headway. post the 2008/9 crash. This was driven by demand side emerging economies such as China, India and Russia reducing their commodity consumption as their economies decelerated.

On the supply side Saudi Arabia's hopes of driving the US and Canadian shale producers out of the energy market by increasing traditional well-based oil production by pushing down oil prices lead to a confluence of supply and demand factors that crushed energy prices.

Saudi's strategy also had the effect of stimulating economic growth by lowering energy input costs and so provided a brighter, theoretical, horizon for other hard commodity prices or at least an improvement in the demand equation.

The Saudi strategy was largely fruitless and showed that shale produces could become swing producers reasonably easily, thereby increasing both their actual and perceived influence on oil prices and weakening the perception of OPEC's and Russia's power in terms of price setting.

Commodity prices have since recovered from their 2014 lows but can still be characterised by persistently low-prices and high volatility.

There are forces to support a view that commodity prices are again entering an upcycle phase.

However, it is a volatile low-price environment and this in turn drives companies to reduce costs.

If we disregard for a moment the role of market forces over the last four decades, we see that OPEC and Russia were effective and dominant oligopolist players. These oligopolists drove price trends and eliminated competitors by synthetically pulling prices downwards (though notably this strategy has been relatively ineffective with respect to US and Canadian shale producers).

In spite of Saudi's and Russia's production strategies in recent years, we have seen a shift in market conditions. US shale oil production has risen in tandem with Saudi Arabia's and Russia's production and in so doing has created a race to the bottom for oil prices.

As a result of the rapid rise in US shale oil production, the US has become one of the three key crude oil producers globally.

Technological innovation is stimulated by the need to cut costs and maintain margins in a volatile environment.

Over the early part of the decade, US companies employed innovative technologies to develop new drilling and production techniques - hydraulic fracturing or fracking - to extract oil in the basins in Texas (Permian basin), North Dakota (Bakken Formation) and other states.

Innovation created a star world producer from a an "exhausted" oil basin

US oil industry technological advancements in these 'mining' and production processes has opened up billions of barrels of oil in shale rock formations, reversing decades of dwindling US production output. These innovations have allowed the US to emerge as a global net energy exporter and given it the second most productive field in the world – the Permian.

Innovation changed the once exhausted Permian basin straddling Texas and New Mexico into the 2nd most productive field in the world.

Even as energy prices underwent huge swings and savage falls, the innovations that lead to increased efficiency and cost reductions have meant that US shale companies have been able to withstand sinking prices. In the light of these innovations and so the revival in US production, it is unsurprising that the EIA raised its 2020 April production forecast by 2.2 percent. During 2020 US oil production is expected to average at 13.38m b/d up from the previous forecast of 13.1m b/d.

Excepting Gold and Uranium, most commodities track energy prices.

The future may well be brighter for basic materials and energy producers. Supply disruptions, geopolitical uncertainty, increased adoption of anti-oil and mining environmental policies are the counter driving forces potentially adding to the scarcity value of energy and other hard commodities, which one might expect to push up prices. Geopolitical uncertainty is also good for Gold prices. Typically, Gold does not track the energy price, which sets it apart from most commodities. In current conditions however, Gold will temporarily give the impression that it does track the energy markets.

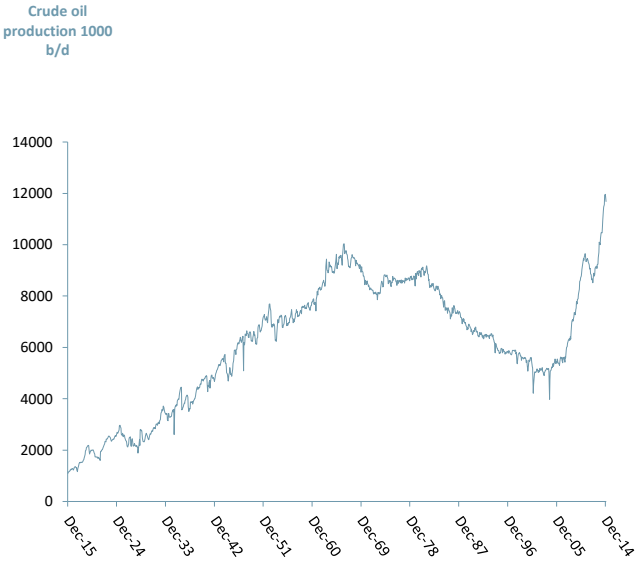
Current conditions could make it appear that Gold is tracking the energy price – temporarily.

Against the general backdrop of persistently low prices, high price volatility (making investment decisions and planning extremely difficult) and increasing production costs, the need for technological breakthroughs or accelerated innovation adoptions in the extractives sector has intensified.

Tech revenues and opex cuts from innovation again in reach of small and mid-Caps.

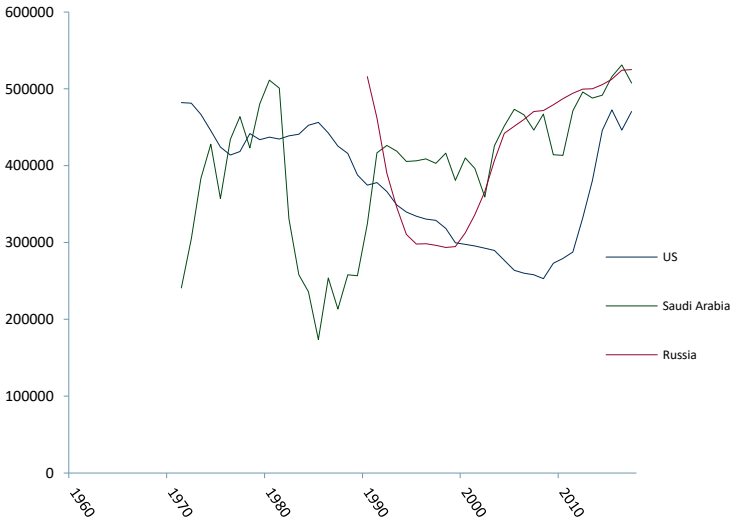
In our view, technological innovations that will cut costs and potentially provide new revenue opportunities for small and mid-cap extractives are now in reach. This change in conditions is underpinned by two factors, firstly the networking of remote areas such as Alaska via LEO orbit satellite constellations planned or being launched throughout 2019, secondly, this is how the current waves of tech innovation change markets, they bring efficiencies and opportunities to smaller companies. This is happening in all sectors, it seems unlikely that the extractives sector can or would escape such a global trend.

Exhibit 1: **US monthly crude oil production, 1000 b/d**



Source: EIA

Exhibit 2: **Annual crude oil production - US, Russia and Saudi Arabia**



Source: OECD

How Technology is Changing Market Conditions

US technological innovations in extracting crude oil have served to re-write the global supply equation, bringing significant changes to both the market and political landscapes. These changes are forcing extractives companies to look for new cost savings, new ways of extracting and milling and new revenue streams (as in the end cost savings only delay the inevitable, companies need growth).

OPEC's strategy of sustaining prices by limiting its supply is significantly weakened and OPEC's ability to force competing producers out of business has also lost its lustre.

Data - a new revenue stream?

The weakening of OPEC is attributable to technological innovation. This innovation (fracking) has also led to surging US shale output, driving prices down but without putting shale produces out of business and showing they are capable of being swing producers. This has left other oil market producers grappling with plunging prices, and rising costs.

Data - a new reason for small caps to raise equity?

Geopolitical tensions between China and the US impose an ongoing supply side risk for the market, one that should enhance prices for Gold and depress energy prices. In contrast, instability in the Middle East creates a supply side risk that will push both Gold and energy prices up. On the demand side sluggish global growth and rising environmental policy changes are creating market concern that prices may struggle to remain above production costs and that commodity price falls could be precipitous.

This perceived and actual environment makes investments in extractives uncertain, i.e. greater risk, and so less attractive to investors whose job it is to find investments with lower risk and higher return, so if two projects have the same return but one has a lower risk profile, investors will choose the lower risk project. There are no absolutes in investor choices, only relative ones. This makes for a demanding environment for small and mid-cap companies looking to raise money.

They need a better, stronger, more future based pitch. This is not easy.

The two most obvious upsides for basic materials and oil & gas smaller companies are geopolitical uncertainty and data. The former seems to be on an inexorable rise around the globe, as is the value of the latter.

In our view, data collection and its resale is a potential new revenue stream for explorers in mining and oil and gas. We believe that the potential is great enough to provide small and mid-caps with a second reason to raise funds, outside of digging or piping things out of the ground. It may also mean that no geological surveying cost is entirely wasted – barren or otherwise.

Technology in Use

Newer and emerging technologies in use for the extractives/natural resources/ basic materials/ oil and gas segments.

As is the case with many sectors, we only expect the impact and necessity for the adoption of new technologies to grow. We expect innovation (along with government policy) to transform the extractives landscape in terms of costs and revenues.

New and emerging technologies will enable companies to operate faster and more efficiently. We see cutting costs and delivering greater value for investors, and society in general. We see this as achievable through safer working conditions; more environmentally friendly extraction and processing techniques; a reduction in hazardous incidences; and greater prospecting, lifting and milling efficiencies.

See our guest blogs on AI, AR and VR

The technologies we expect to have an increasing baring on the extractives sector include; artificial intelligence (AI) and robotics, blasting technologies, spatial data visualisation, wearable technology, internet of things (IoT) and autonomous vehicles. Other technologies or interest and increasing potential are chemical leaching and bio-mining.

- **Internet of Things (IoT)**

Analytical data sharing can save comfortably over 10% in production costs, according to Osisoft

IoT is short-hand for the progression and effect of connecting equipment and people to one another and (the transformational part) to the internet – IoT relies on a radio frequency identification devices (RFIDs) and sensor technologies to make these tripartite connections to wireless networks. IoT promotes efficiency, safety, automation, more efficient management and geologic practice.

Our view – collection and analysis of volume micro-economic data is transformation for value generation.

The internet of things permits, transforms and simplifies the collection and sharing of volume micro-economic (business) data for analysis. We are of the view that the mass collection of micro-economic data is transformational for both revenue development and cost reduction.

Sharing analytical data can save 17% in production costs according to Osisoft, a private company specializing in connecting sensor-based data, systems and people together. The company also claims that digital technologies account for up to 15% of efficiency improvements at metals miners.

- **Spatial Data Visualisation (SDV)**

Digital technologies can account for as much as 15% of total efficiency savings for metals miners.

Spatial Data Visualisation (SDV) is defined as data that represents an object's location, size and shape. By translating this data into a visual form - companies can and are constructing virtual buildings, plants and mines, allowing geologists to gain more insights into the above and below ground environments.

SDV It is divided into four viewing scenarios; 2D, 3D, virtual reality (VR) and augmented reality (AR). Note AR currently has the unwanted effect of making users somewhat nauseous, a teething problem that will likely be solved.

See our guest blogs on AR and VR https://acfequityresearch.com/virtual-reality/

2D – the traditional two dimensional 'flat' way of visualising data.

3D - creates life-like three dimensional impressions of anything viewed.

South Africa's STS3D produced the first VR blast wall.

Virtual reality (VR) – a step change and dynamic enrichment of 3D viewing, is created with software using real life data to create an artificial environment. For example, the world's first VR blast wall developed by South African company Simulated Training Solutions (STS3D).

Augmented reality (AR) – a further and significant enrichment of VR. Augmented reality transfers digital data visualisation into real world environments, thereby augmenting the real world with computer generated sound, video, graphic, touch (though we can see the potential to add scent/taste inputs, which could of course be used for safety response training and drilling, amongst other things – geologists still lick minerals for information)!

VR and AR should raise valuation for extractives companies

VR and AR visual interpretations allow miners and geologists (or more precisely visual arts technologists, with the help of geologists) to imitate real world work scenarios. AR and VR make it easier to develop and understand potential challenges. Augmented reality has the potential to lower project risk and so investment risk, which in turn, ceteris paribus, increases valuations for extractives companies.

- **Robotic Technology**

Robots with AI can perform tasks including; drilling, blasting, loading, hauling, bolting mine roofs, ore sampling and the rescue of trapped miners. There are great hopes for AI and many researchers suspect its significance is currently underplayed rather than overplayed. The dream is the human capacity cyborg – we are a very long way off this outcome, but robots are common place in some industries. As such, the addition of AI is no longer newsworthy in industries such as automotive but it is in extractives.

See our AI blog https://acfequityresearch.com/why-ai-isnt-the-new-oil/

Robotics + AI is still a nascent approach in extractives especially in small and mid-caps. In our view, there is little practical reason why robotics + AI cannot dominate in extractives. We believe the key for small and mid-caps is improved connectivity and so serviceability in remote regions. With the explosion in LEO communications satellite constellations now underway and proposed since the beginning of 2019, connectivity could arrive by 2020.

- **Wearable Technology**

Wearable technology is the combination of sensors and power supplies in clothing and other wearable apparel. We provide some of examples to show how inexpensive mass consumer and some commercial wearable technology could cross pollinate the extractives sector. The key change will be the collection of data from these items in isolated and remote mining territories.

Wearable technology that we believe has applicability in extractives and is **already available** in the consumer and business markets are smart watches (SW); smart eyewear (SE); wearable cameras (WC); smart clothing (SC); fitness trackers (FT) and medical wearable devices (MWD).

The **sensor types** that we suggest are most relevant are inertial measurement units (IMUs); infrared receivers (IRs); electrocardiogram (EGG) and electroencephalogram (EEG).

Below we provide **some examples** of wearable technology that is already being deployed in the extractives industries and in the next exhibit we provide a **table of third-party ideas** for the further development and use of wearables.

SmartCap - a sensor-rigged PPE helmet, that monitors signs of fatigue and measures alertness to cut down distraction related incidents.

Mining specific boots - introduced by Centennial Coal in 2017, its design offers the sole stability, ankle support and waterproofing.

Other technical clothing with body temperature sensitive cooling and warming properties, driven by sensors and batteries, woven into or inserted into the garments is already available.

Various **wrist and necklace devices** with a plethora of activity monitoring and data collection capabilities used in sport and other activities, could, with not much imagination can be tailored to data collection for mining and exploration.

Exhibit 3: **Wearable tech potential applications**

Wearable Device						Sensor	Application
SW	SE	WC	SC	FT	MWD		
X	X	X				*IMU sensor, control sensor, *IR sensor	mining equipment management
X	X	X				camera sensor, navigation module, accelerometer, speed sensor, magnetometer, position sensor	transport and logistics management
X	X	X				proximity/motion sensor, ultrasonic sensor, IR sensor, camera sensor	process monitoring & reporting
X X X	X X X X	X X X X				camera sensor, control sensor, navigation module, IMU sensor	site supervision supply chain management task achievement monitoring conveyor belt monitoring
	X X	X X	X X			camera sensor, IMU sensor, navigation module	labour education and training emergency preparedness
X	X	X				communication module, camera sensor	communication & data management
	X X X	X X X	X X X		X	camera sensor, motion/proximity sensor, temperature sensor, humidity sensor, gas sensor, air pressure sensor, radiation sensor	risk and change management operational safety monitoring mine rescue training/operations
			X X X	X X X	X X X	pulse rate sensor, *ECG sensor, *EEG sensor, body temperature sensor, sound sensor, blood pressure sensor, glucose level sensor, exhalation sensor	occupational health monitoring occupational disease prevention
		X	X			camera sensor, dust sensor, humidity sensor	dust monitoring
		X	X			camera sensor, sound sensor	noise monitoring
		X	X			temperature sensor, gas/fume sensor humidity sensor, exhalation sensor	air flow monitoring (ventilation)
	X	X X	X X			light sensor, camera sensor, control sensor	facility management (lights, pump etc.); mine equipment service and maintenance.

SW - smartwatch; SE - smart eyewear; WC wearable cameras; SC - smart clothing; FT - fitness trackers; MWD - medical wearable devices;
*IMU sensor - inertial measurement unit sensor; *IR - infrared receiver sensor; *EGG - electrocardiogram; *EEG – electroencephalogram

Source: ACF Research; Department of Energy Resources Engineering, Pukyong National University, Korea

- **Automation**

Drones - some of their uses include evaluating terrain, inspecting equipment and filming blasting. Drones are inexpensive, provide safe access to aspects of operations that are otherwise inaccessible and enable blast data collection.

Autonomous vehicles (trains and trucks) - improve onsite safety and increase productivity. An Example of such an autonomous truck is the Autonomous Load Haul Dump (LHD) employed by Atlas Capco.

Autonomous drilling - allows the operator to carryout drilling from a remote location. Global miner Rio Tinto is the leading autonomous driller. Autonomous drilling technology can improve the yield of precious metals (silver and gold) from complex ores by 1,000 %

Autonomous drilling can improve yields by 1000%

- **Diffraction Technology**

Diffraction technologies create diffraction patterns from various parts of the electromagnetic spectrum (laser, x-ray) when they are passed through objects. They take measurements in nano to millimetre ranges. The diffraction patterns allow users to establish the geometry of particles.

Bingham Canyon (Rio Tinto) uses Copper Nuwave diffraction technology for mineral sorting. It is a large open cast mine producing 1% of the world's copper

Diffraction technologies identify the amount of useful resources in a given piece of ore. Rio Tinto first trialled a diffraction technology in 2013, that it refers to as Copper Nuwave, to carry out mineral sorting. The company is now using Nuwave at its Kennecott Copper mine (Bingham Canyon) in Utah, USA. Bingham Canyon is a large open-pit mine producing 1% of the worlds copper production.

Copper Nuwave uses microwaves to excite copper atoms within individual rocks. Computer processing power is used to interpret the data to determine the grade of the ore. Ore with no or too low mineral content is taken out of the processing system. This saves water and energy that would otherwise have been expended on milling barren rock.

- **Plasma Technology**

Toss Plasma Technologies (TPT), a company based in the US and founded in 2002, developed a new radio frequency plasma technology with which ores like zinc, copper and lead are heated applying ultra-high temperatures of 8,000 - 12,000 degrees Celsius in order to break down the ore structure and free up the latent materials for recovery and purification.

TPT – private company in mining services producing plasma torch to recover Ag and Au from complex ores – no website.

Chemical and Biochemical Technologies

- **Blasting technologies**

Blasting is the use of rapidly expanding gas creating sudden pressure to break bulk ore into loose forms suitable for extraction and then milling. Blasting is effected using chemical, mechanical and nuclear explosives. Detonators used to trigger the blasts can be chemical, mechanical or electrical in character.

The central aim of innovation in blasting in mining is to use less explosives and reduce energy wastage in the explosive process, thereby reducing costs. In addition, a blasting technology should aim to minimize explosive or blast-related vibration and the scattering of materials. These last two characteristics help reduce accident risk and increase overall mine stability.

Blasting was the only technique barring 'pick and shovel' before the advent of Tunnel Boring Machines (TBM) for breaking up rock bodies.

Blastboss claimed in 2017 that its patented ultra-high viscosity plasma gel cut explosive requirements by 25-50%.

In September and November 2017 mining.com and The Australian Mining Review featured a blasting innovation from Australia using an ultra-high viscosity plasma gel that is placed in a blast hole as decking that creates a hydraulic shockwave effect when detonated. The private Australian company, Blastboss, that holds the patents described the effect of the innovation as attenuating, redirecting and extending explosive energy. In turn, the company claims, the shockwave's higher energy reduces cap rock issues and delivers even rock fracturing but uses less explosive and thereby delivers cost savings.

- **In-situ leaching (ISL)**

In-situ leaching is the process by which deep or narrow solid ore bodies are mined by dissolving the minerals out of the ore body. This is in contrast to brine mining in which dissolved minerals are recovered from solution. Typically, either salt-water or acid solutions (lixiviants) are pumped into an ore body after it has been blasted or hydraulically fractured.

The so-called lixiviant is injected via one borehole, dissolves the wanted mineral in the fractured ore body and is then extracted via a second borehole. There is research work underway aimed at devising a universal lixiviant. ISL is used commonly in Uranium mining. Copper has been mined by the Chinese using ISL for at least 1,000 years and possibly 2000 years.

- **Biomining**

Bio mining uses microorganisms to extract metals from minerals from ore bodies or more typically low-grade tailings. Typically, the organisms used are prokaryotic cells or fungi which oxidise the minerals. The minerals can then be dissolved in water from which the metals can be more readily and economically extracted.

See our biomining blog – what kind of future?
https://acfequityresearch.com/biomining-what-kind-of-future/

The technique is generally used for higher value metals such as copper, uranium, nickel and gold, which are often found in sulfur-bearing minerals. Microorganisms are particularly good at oxidizing sulfur-bearing minerals.

AiM listed Australian Tungsten and Cobalt miner Thor Mining has a 25% (with option to raise to 30%) stake in unlisted EnviroCopper, which runs the Kapunda Copper ISR project, an in-situ leaching project.

Emerging Technologies

- **Asteroid Mining**

Refers to the extraction of minerals from asteroids. Hard rock minerals such as gold, silver and platinum group metals, could be mined from an asteroid and transported back to Earth. Carbon (C-type), (silicon) S-type and (metal) M-type are the three types of asteroids identified as potential mining sites.

C-type asteroids are thought to have high levels of phosphorous and organic carbon. C-types also hold high quantities of water – essential in mining processes.

S-type asteroids are believed likely to have a wide range of minerals for extraction.

M-type asteroids are harder to find, but they hold ten times the amount of metal found in an S-type asteroid.

So far, scientists have narrowed the search to 17,000 asteroids for mining. Telescope and spectrographic analysis are used to further narrow the search. To date no asteroid has been directly sampled, however observations have been taken and analysis carried out. A spectrograph determines the composition of an asteroid via analysing the sunlight reflected from the surface of an asteroid by breaking it down according to wavelength. For example, if the light from an asteroid appears reddish, it suggests the presence of clusters of iron and nickel on the surface.

- **CO_2 Fracturing**

The traditional method of fracking involves extracting resources by injecting water mixed with sand into the rock formation, thereby fracturing the formation in order to release the resources within it. This poses environmental concerns since 30% to 50% of the fluids injected during extraction remain in the rock formation.

The application of carbon-dioxide (CO_2) in shale hydraulic fracturing presents an alternative fracking technique with obvious environmental benefits (water fracking resulted in blockages in the rock formation). CO_2 also makes dry environments a feasible option for oil extraction.

Further research is underway but CO_2 fracturing may become widespread in the sector.

- **Radio Frequency (RF) mining**

A technique designed to recover oil and gas from shale rock formations wherein electromagnetic energy is used to heat heavy oil reservoirs. Radio frequency heating (microwave heating) uses antennas or electrodes to heat the formation. This allows a quick and efficient heating of hydrocarbons by coupling antennas in the reservoirs. The advantage of microwave heating is its penetration capability and high heating speed. The drawback is high electricity consumption and the associated cost implications.

There are 400 billion barrels of estimated shale reserves globally, which is 5.4x the world's current crude oil reserves horizon. While crude oil world reserves are probably depleting, shale oil presents a huge opportunity for an alternative fossil resource.

Glossary

Short-run	Wherein price cycle will last between 3-6 months
Long run	Wherein Price cycle will last between 3 years and 10 years
Super-long run	First introduced by Kondratieff, he argued that price cycles could last more than 70 years but typically last 20-40 years.
OPEC	Organisation of the Petroleum Exporting Countries
EIA	Energy Information Administration
OECD	Organisation of Economic Co-operation and Development
WEF	World Economic Forum
bbl	Barrel
b/d	Barrel per day

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