Are Ionic Adsorption Clay Deposits a Game-Changer for the Supply of Rare Earths

written by Ian Chalmers | May 2, 2023

Rare earths are a key building block in critical components found in modern technologies such as electric vehicles, wind turbines, and smartphones.

Over the last two years, there has been an abundance of discoveries of rare earths mineralization called Ionic Adsorption Clay (IAC), characterized by the extensive low-grade deposits in Southern China. Australia leads the way due to its long-lived and continent-wide deeply oxidized weathering environment considered necessary for these deposits to form. Barely a week goes by without a new discovery. But are these deposits genuinely IAC and does it matter?

While the abundance of these deposits has sparked investor interest, questions remain about their true nature and the economic viability of development.

The types of rare earths deposits

We need to set the scene for rare earths (REE) deposits to answer that question. REE deposits are well documented and are dominated by:

- Alkaline igneous rocks such as carbonatites, granites, and felsic volcanics;
- Hydrothermal altered calc-silicate sequences; and,
- Secondary regolith clay-hosted deposits.

Reworked alluvial accumulations rich in monazite are clearly a separate type but becoming increasingly important as a competing source of REEs.

Regolith clay hosted deposits and the formation of IAC deposits

Regolith deposits develop by the weathering of the underlying host rock to form a variety of secondary clays and other oxidized products. Important source rocks typically have a relatively high background in rare earths and rare earth bearing minerals in these rocks will include monazite, xenotime, bastnaesite, allanite, titanite, and apatite.

Minerals like bastnaesite, allanite, and titanite are most susceptible to the acidic ground waters that develop in the upper levels of humus-rich soils in temperate or tropical climates, with moderate to high temperatures and rainfall. The REEs from the decomposed minerals migrate downwards as REE-ions in solution which can adsorb onto clay minerals such as kaolinite and become IAC deposits.

Alternatively, the percolating solutions can combine with phosphate or carbonate to form secondary minerals (often in a colloidal phase) in a neutralization step. The more resistive minerals such as monazite and xenotime remain unaltered and can accumulate physically with partial removal of the surrounding oxidized rock by the weathering process.

The “does it matter” question

So we have the three types of rare earth accumulations in a regolith profile which gets us to the “does it matter” question.

The geometallurgy, capital expenditures (CapEx), and operating expenditures (OpEx) of a mining and processing facility, and the marketability of any products produced drive the economic development of any rare earths deposit.

In regolith deposits, the Chinese found that weakly acidic ammonium sulphate or sodium chloride solution readily reclaims the rare earths from the ionic bonded clays allowing the resulting crude solution to be chemically treated to eliminate contaminants for further solvent extraction separation and refining. This processing can be in-situ leaching; heap leaching; or in-tank leaching with increasing cost and all with significant environmental impact.

Generally, Chinese costs for REE reclamation from IAC deposits are low and despite the low recoveries peaking at around 30% to 40% in final products, these projects appear to be economic.

Economic challenges of other regolith deposits

The other regolith deposits require more sophisticated processing with higher costs from increased upfront chemical consumption (sulphuric acid) after mining from open-cut operations and subsequent processing, including removal of significant contaminants from the acid leaching. There have not been many colloidal-type deposits identified to date, and it appears many of the new group of announced deposits could be clay-hosted, residual monazite-xenotime accumulations and not true IAC. Solubilizing monazite and xenotime is a known commercial process and the costs are well-defined but are significantly greater than for IAC extraction. The processes to recover REs from resistate minerals in the near horizontal deposits at depth will require environmentally sustainable mining, potentially covering large areas.

If this is the case then it will be very interesting to see how many of these low-grade, sub 2,000 parts per million (ppm) or 0.2% of total rare earth oxides, will be economical to produce or do they have a touch of hype at present.

Final thoughts

The economic viability of IAC deposits remains uncertain, with questions about their true nature and the costs of mining and processing. While the Chinese appear to have developed a low-cost method of reclaiming rare earths from IAC deposits, other regolith deposits require more sophisticated processing with higher costs and the potential for significant environmental impacts.

So, yes investors would be wise to understand the deposit type and geometallurgy before investing.

Hunting the big North American rare earths elephant

written by Jack Lifton | May 2, 2023
“Amazing discovery… I keep making this point that there is a deficit of rare earths worldwide and Appia is the premier rare earths discovery in North America.” – Jack Lifton, Global Critical Materials Expert

A mineral discovery is the natural occurrence of a specific chemical compound or a mix of chemical compounds, which may be processed mechanically and chemically to isolate one or more forms of individual chemical elements, and then be purified and converted into useful forms for industrial use. If the discovery is extensive enough and the contained chemical compounds are of a sufficiently high enough grade for efficient and economical separation of them from each other and then can be further processed into forms that can be utilized industrially, then the large-scale production and concentration of the initial mineral concentrate is called mining.

How do you evaluate a rare earth discovery? The best way is to determine if it contains "valuable" rare earth elements, which can be economically and efficiently recovered in the jurisdiction in which it is located, in such quantities that the capital expended can be recovered at a profit.

The old-timers (aka, experienced exploration geologists and mining engineers) have just two simple metrics they use in first determining whether or not there is any point in answering this question: Grade and accessible tonnage.

Appia Rare Earths & Uranium Corp.'s (CSE: API | OTCQB: APAAF) rare earth discovery at Alces Lake, Saskatchewan, meets the first of the above requirements, and the company is now in the process of a comprehensive drill program to determine if the second one is met as well.

The Appia discovery is of the mixed rare earth mineral, monazite, the most desirable rare earth bearing mineral on the planet. Monazite was the original rare earth mineral mined commercially in the late nineteenth century, not for rare earths, but for its contained thorium, which was heated, as an oxide in the form of a mixed ceramic mantle, with natural gas, to produce a brilliant white light for illuminating the stage in theatrical performances. Monazite fell out of favor as a mineral resource after World War II because of thorium's natural radioactivity being highlighted as a danger in the early atomic age. Of course, electric lights, had by then long eclipsed the need for thorium.

In the 1950s though, thorium again became of interest when it was discovered that nuclear reactors for the commercial production of electricity could be fueled with thorium, which could not easily be used to make nuclear weapons. Anglo-American Mining in that period discovered the highest-grade thorium and rare earths deposit then known in the world in South Africa and began producing thorium for the UK's civilian nuclear reactor program. Thorium reactors fell out of favor by the mid 1960s and thorium (monazite) mines were shut down, even though they were associated with high grade rare earths, because of the problems of disposing of the thorium and the then extremely expensive processes for separating the rare earths from each other, ion exchange, and fractional crystallization.

The discovery of a huge primary, accessible, mineable deposit of the rare earth mineral bastnaesite at Mountain Pass, California, in the late 1940s, and the development in the 1960s of the commercial application of solvent extraction to the separation of the rare earths, led to the eclipse of the use of high thorium monazites by bastnaesite as the primary mineral for rare earth mining.

The development of the rare earth permanent magnet in the late 1970s, at first using the rare earth element, samarium, and the rare earth elements neodymium and praseodymium, revived interest in monazite, because monazite contains 50% more, by weight, of neodymium and praseodymium, than bastnaesite.

However, the low thorium bastnaesite in California, because of its accessibility, became the world's largest source of the magnetic rare earths, samarium , neodymium and praseodymium by the early 1980s. It was eclipsed by the bastnaesite recovered, more economically, as a byproduct of iron mining in China's Inner Mongolia by the late 1980s. The Chinese iron deposits also contained some monazite, and this was processed there also to recover the rare earths. The thorium co-produced was stored, but its radioactivity ultimately led China to bring its control under the aegis of its China Nuclear Corporation (CNC), which stored it along with any other thorium produced as a byproduct of rare earths or its own uranium minerals processing.

Today, as Chinese bastnaesite grades seem to have declined from high grading and as pollution (environmental) consciousness has come of age in China, monazite, as a source of magnetic rare earths has revived dramatically in China. And China has become the world's largest processor of monazite. Chinese mining and processing companies already import nearly 40% of their rare earth ore needs annually. They get bastnaesite from California and CNC is licensed to process up to 5o,ooo tons per year of monazites containing up to 30,000 tons of rare earths. All monazite imported into China must first go to CNC for thorium and uranium removal, before it goes to the Chinese purchaser, which will then recover the rare earths contained. China buys monazites as ore concentrates from the USA (until very recently), Brazil, Madagascar, Australia, and Myanmar, and Chinese companies are scouring the world seeking more.

The Chinese had the use of monazites as a source of magnetic rare earths to themselves until 2017, when Australia's Lynas Rare Earths (ASX: LYC) went into commercial production and separation of the individual rare earths from its massive monazite mine at Mt. Weld, Australia. Then. in 2020, the only privately owned licensed uranium ore processor and thorium storage facility in the USA, Energy Fuels Inc. (NYSE American: UUUU | TSX: EFR), began a project to process monazite for its rare earths and to stockpile and sell the uranium recovered and store the thorium. Energy Fuels is and remains the sole such facility in the Americas. Its business plan is to become vertically integrated by building, on-site, a separation facility, and a rare earth metals and alloys operation also.

Energy Fuels has acquired domestically produced American monazite from the heavy mineral sands operations of The Chemours Company, and is actively seeking additional materials both domestically and internationally. Energy Fuels has already produced and sold commercial quantities of mixed rare earth carbonates cleaned of uranium and thorium.

Now, at last, we come to Appia and Canada’s entry into the rare earths’ mining and processing arena.

Australia’s Vital Metals Limited (ASX: VML | OTCQB: VTMXF) is now mining bastnaesite just outside of Yellowknife in Canada’s Northwest Territory from a high-grade deposit discovered by Avalon Advanced Materials Inc. (TSX: AVL | OTCQB: AVLNF) and licensed to Vital. The ore concentrate will be first sent to an operation being built by the Saskatchewan Resource Council (SRC), a Crown Corporation, where the uranium and thorium will be removed and a mixed rare earth carbonate produced for use in further downstream processing. The first such production has already been pre-sold to both American and European processing customers.

But the SRC has plans to construct not only a cracking, leaching, and radioactive recovery and storage system (Saskatchewan is Canada’s largest uranium mining and processing province, so the business there is well established and understood), but also a rare earths separation system in the form of a dedicated solvent extraction facility, the first of its kind in Canada.

Now we come to Appia Rare Earths & Uranium Corp., a Canadian company, originally exploring for uranium in Saskatchewan’s world-famous Athabasca Basin. About 5 years ago its then geologist discovered a dramatically high-grade sample of monazite on the company's Alces Lake Property in Saskatchewan. He soon found that the sample had come from an outcrop showing extensive monazite veining. He continued to explore the area and predicted that the monazite field was extensive. Analysis of samples he took showed that it was also the highest grade neodymium rich monazite ever found in North America.

I was a speaker that year at a Metal Events' Rare Earth Conference in Henderson, Nevada, and the Appia geologist, James Sykes, was an attendee. I had never met him, but we shared a cab to the airport, and he excitedly told me the Alces lake, monazite, story. I was intrigued, but I had reservations about the thorium and uranium that would be present in such a high-grade material. I thought of the highest grade rare earths deposit ever worked, Steencompskraal, in South Africa, which was actually worked as a thorium mine with no interest (in the 196os) in the rare earths contained. I didn't then know of the monazite project in China or CNC's role in it. I listened politely to Mr Sykes and wondered what anyone would do with this discovery if it were confirmed to be extensive enough to qualify as a NI 43-101 resource.

Did I mention that James Sykes also said that he believed the extended discovery to be near surface, so that a quarrying operation would obviate the need for underground operations?

It is now the Spring of 2022, and Appia has raised approximately $15.5 million in the last year. This funding is for a drilling program which is underway to prove a resource.

Energy Fuels is processing monazite, the Saskatchewan Resource Council has approved $31 million to acquire monazite, and other rare earth ore concentrates, and build a first of its kind in

Canada cracking and leaching and separation facility dedicated to rare earths, and Canada's Ucore Rare Metals Inc. (TSXV: UCU | OTCQX: UURAF) has begun construction of a Strategic Metals Center in Alaska for the central processing of critical metals, beginning with rare earth mixed carbonates from a variety of sources including Canadian and Australian monazites.

Appia's drilling results so far are very encouraging, and have been extensively reported.

I think we may see the highest grade neodymium-rich monazite in the America's flow from Alces lake before 2025. If so, It will certainly be in high demand.

Did I mention that the Appia monazite discovery contains 1% of xenotime, the hard rock mineral source of yttrium, dysprosium, and terbium? A one-stop-shop for magnet makers?

The stars and this planet are coming into alignment for this one. Monazite is back.

Disclosure: Jack Lifton is a member of Appia Rare Earths & Uranium Corp.'s Advisory Board and the Advisory Board for Energy Fuels Inc., and may hold securities or options in some of the companies mentioned in the above article.

Is American Rare Earths sitting on the largest rare

earth deposit in the USA?

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Commodities these days can be a bit of a fickle investment. They are definitely in demand for numerous reasons, including the world's move towards a lower carbon future. Putin's attack of Ukraine has placed further emphasis on security of supply, overall supply chains and the politics of commodities. However, we can't seem to align all the interested parties into coming up with a cohesive game plan to maximize the production of critical commodities, while optimizing their environmental and social impact.

What do I mean by this? In late February the White House ordered action across the US Federal Government to secure reliable and sustainable supplies of critical minerals and materials just before the first anniversary of Executive Order (EO) 14017, America's Supply Chains. However, a year after detailed reports of vulnerabilities in the critical mineral and material supply chains were produced by US federal agencies, detailing the over-reliance of the U.S. on foreign sources and adversarial nations for critical minerals and materials, posing national and economic security threats, the U.S. government isn't exactly walking the walk. In the last year, we've seen Rio Tinto's (NYSE: RIO) Resolution copper project in Arizona and Antofagasta's (LSE: ANTO) Twin Metals project (copper/nickel) in Minnesota both get the red light from the Biden Administration. It has also taken steps to slow down development of a lithium mine in Nevada from ioneer Ltd. (ASX: INR) to help preserve a rare flower. You could also include Northern Dynasty Minerals Ltd.'s (TSX: NDM | NYSE American: NAK) Pebble mine in Alaska in this list because there is a lot of copper as part of the resource, but to me, it's more of a gold mine so not necessarily critical.

I’m not saying that these actions to delay or cancel projects aren’t justified for environmental and social reasons. I’m simply pointing out that it’s easier said than done. Investors can’t simply pick all the companies pursuing critical minerals in the U.S. and think it’s going to be a slam dunk. Certainly, there is a renewed focus on addressing the critical minerals and materials supply chain, but it likely won’t come at the expense of the neighbors of these projects. That’s why one has to look a little deeper at any potential investments to ensure the project has a chance to see the light of day. You can’t just have a viable, economic resource, you need to tick a lot more boxes.

That’s my long-winded intro to an Australian listed company with assets in the growing rare earths sector of the United States, looking to help the U.S. diversify away from China’s market dominance of the global rare earth market. American Rare Earths Limited’s (ASX: ARR | OTCQB: ARRNF) mission is to supply critical materials for renewable energy, green tech, EVs, National Security, and a Carbon-Reduced Future. The Company owns 100% of the world-class La Paz Rare-Earth Project, located 200 km northwest of Phoenix, Arizona and the Halleck Creek rare earth project in Wyoming, USA. La Paz is a large tonnage, bulk deposit, that is potentially the largest rare earth deposit in the USA and benefits from containing exceptionally low penalty elements such as radioactive thorium and uranium. The Company is currently drilling in the new Southwest Zone of the project where an exploration target of approximately 742 – 928 million tonnes could be added to the 170.6 million tonne JORC compliant (Australian equivalent of NI 43-101) resource.

The size and the grades at La Paz are impressive, as well as close to surface, but remember it’s not just about an economic resource. The reason I think American Rare Earths should be on an investor’s watchlist, if you have any interest in the rare earths space, is their attention to politics. On March 4th the Company announced it had welcomed a delegation of elected officials from all levels of government to its flagship La Paz project. Key members of the group of 25 federal, state and county officials and staff delivered enthusiastic and encouraging speeches about American Rare Earths and its work underway to help secure the United States' domestic critical minerals supply chain. Additionally, Company executive Marty Weems will speak to several dozen State Legislators about La Paz at an event held in collaboration with the Arizona Mining Association. That's the type of proactive effort required to get your project to the finish line in the world of today.

From a macro perspective, there are significant tailwinds for domestic rare earths production from both a market pull and a government push. Additionally, there are several near-term catalysts for American Rare Earths with an on-going drill program at both properties and applications have been filed for 36 additional drill sites at La Paz. The Company is well funded, finishing 2021 with over A$8 million plus having raised another A$1.4 million in the first two months of 2022. With a market cap of roughly A$161 million (US$ 117 million) it's not your typical junior mining stock, but then again, your typical junior mining stock isn't sitting on potentially the largest rare earth deposit in the USA.

One of the world's richest

rare earth deposits continues towards resolution of issues with Burundi partner

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Rainbow Rare Earths' production in Africa to be expanded through extraction from South African mine tailings.

When it comes to rare earths it is important to identify the most valuable ones. Rare Earth permanent magnet production accounted for 91% of the total monetary value of rare earth consumption in 2019, and neodymium and praseodymium (NdPr) are the two key rare earth elements used in permanent magnets, particularly neodymium. This explains why most rare earth miners target NdPr. They are simply the most in demand and are highly valuable.

Rainbow Rare Earths Limited (LON: RBW) ("Rainbow") is a rare earths miner targeting NdPr production at their two African rare earth projects. Rainbow's strategy is to become a globally significant producer of magnet rare earths. Rainbow has two African-sited projects, each of which has a special attribute leading to potentially lower cost mining. Rainbow also has exclusive rights, across the SADC region of Africa, to privately owned American specialty chemical engineering company's (K-Tech) rare earths continuous ion chromatography separation technology. The K-Tech process targets individual separation of rare earth from natural mixtures in fewer stages with more flexibility than traditionally used solvent extraction thereby saving on upfront CapEx and ongoing OpEx and potentially producing a higher end-value separated oxide rather than a carbonate. Testing is ongoing.

Rainbow's two rare earths projects are:

- The Phalaborwa Project in South Africa.
- The Gakara Project in Burundi, East Africa.

The Phalaborwa Project (70% earn-in agreement)

The Phalaborwa Project comprises an Inferred Mineral Resource estimate of 38.3Mt at 0.43% Total Rare Earth Oxides (TREO) contained within gypsum 'tailings' stacked in unconsolidated dumps derived from historic phosphate fertilizer hard rock mining. Being a tailings resource eliminates the need for hard rock mining, which is expected to lead to lower operational costs. The Resource has a high-value NdPr content representing 29.1% of the total contained rare earths, measured as oxides, with economic dysprosium and terbium, key rare earths for high temperature operation of permanent magnets, as valuable by-product credits. The Project has 5-10 times higher grade NdPr than a typical ionic clay style rare earth deposit (see table below). It also has low levels of radioactive elements which means easier processing and lower costs.

Being on the site of a past mining operation, the Phalaborwa Project has excellent infrastructure and transport logistics. The Project is largely permitted and positioned in an established mining region.

The Gakara Project (90% interest)

Rainbow states that “the Gakara Rare Earth Project is one of the world’s richest rare earth deposits.” Rainbow has a 90% interest in the Gakara Project with a non-dilutable 10% owned by the Burundi State. The mining permit covers a large area of over $39km^2$ and has a 25-year mining license that began in March 2015.

Gakara was placed on care and maintenance in June 2021 at the request of the Government of Burundi. Primary concerns of the Burundi Government are understood to relate to the pricing of the mineral concentrate currently sold under a long-term off-take agreement with a German company’s (ThyssenKrupp), trading arm. Rainbow states: “Rainbow continues to engage constructively with stakeholders to resolve the issue and allow trial mining to recommence as soon as possible.”

Closing remarks

Rainbow has two exciting African rare earth projects.

The Phalaborwa Project has several advantages including:

1. An ore tailings source, so no need for hard rock mining, crushing, or milling and hence lower production costs.
2. High-value Nd and Pr oxide content representing 29.1% of the total contained rare earth oxides, with low levels of radioactive elements, and
3. An existing mining site with great infrastructure and logistics available.

The Gakara Project has outstanding NdPr grades in visible “veins” and is amenable to simple physical separation of minerals from waste rock to produce a high value rare earth concentrate. This makes for a low OpEx project. The Project is currently on care and maintenance pending the expected resolution of certain legal issues with the government of Burundi.

Risks are typical of those for junior rare earths miners including funding risk and in this case, sovereign risk in Africa.

Rainbow Rare Earths Limited trades on a market cap of £ 78 million (~US$105 million). One to follow with great interest.