Nano Particle Coating Technology:

Tailings Service Offering

Business Offering 2020

BUSINESS CASE STUDY

NANO PARTCILE COATING TECHNOLOGY TAILINGS HANDLING, PROCESSING

Report No. T075043

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EXECUTIVE SUMMARY

The objective of this business case is **NOT** to:

- Proclaim or sell the technology as the answer to all tailings/waste problems;
- To replace existing / current tailings deposition and re-mining methods;

The **CTS** on the table are:

- The technology can treat hazardous material (Tailings: cyanide, acid forming elements; radiation, carcinogenic forming elements e.g. Chrome (VI) into an inert (non-hazardous) material (mineral filler);

- The technology and process can reclassify the material from a toxic/hazardous rating to an inert rating – resulting in substantial cost savings and environmental improvements;
- The technology can dewater the tailings material to the required engineered specifications
- (from dry (0% moisture content) to a wet slurry) and therefore conserve water;
- The technology is well suited for dry and remote areas where water supply is a scare and expense resource (e.g.: Northern Cape to the desert conditions in south America);
- The technology can beneficiate (extract) locked-up assets within the material creating revenue streams for the client / owner (Whether the 'asset' being gold, chrome, uranium or silica for the building industry);
- The technology will greatly reduce or remove the negative and costly legacy element of the tailings body after the mine has achieved its objectives;
- The technology will surpass the health, safety and environmental requirements on a global scale due to the transformation process of the technology. Placing highly in that space.

Therefore, the objective of this business case **IS** to:

- Create awareness of the technologies capabilities *(listed above)* and how it could be used within our market ;
- Access the financial and market benefits of such a technology in real (financial) terms via the application of case-in-point studies/comparisons;
- Access and understand the impact that this technology possess within our market should it be available to the general market;
- This technology has the potential to generate a market and work stream for the Tailings, Bulk material and Mineral Processing sub-divisions;
- This technology has been 'tried and tested' within the tailings market.

Two fundamental service offerings / opportunities reside within this Nano Particle Coating Technology (NPCT) process, namely:

1) ***A proven [i] technology service offering that transforms hazardous material into an environmentally inert and stable material upon which it can be officially re/declassified (treatment).***
2) ***Specialized chemical treatment, unlocking the relative chemical bonds to release the targeted mineral for extraction purposes (recovery).***

The above statements have the potential to unlock entirely new service offerings to marginally tight and competitive industry. This business case compares the feasibility (financial and operational/engineering aspects) of the new technology directly with current market practice. Three scenarios are considered that cover all eventualities, namely:

1. *'Apples with Apples' Scenario:*
   Examining an existing opportunity (done in design / feasibility phase) and subjecting it to the new technology.
   A fundamental point to this scenario is that the engineering specifications/requirements are not significantly altered requiring a fundamental shift in design (delaying the design/construct/operate requirements); instead adding value **to the operation** by reducing overall costs, improving safety and environmental areas and reducing the long-term legacy impact of such facilities.

2. *'Brown Fields' Scenario:* Examining an operational facility and combining the new technology with the existing technology or transforming the existing technology/operation with the new technology. ***(e.g. Brakpan TSF).***

3. *'Green Fields' Scenario*: Examining a new opportunity using the new technology.

The findings from the study indicate significant cost savings. Conservative estimates indicate savings to conventional methods in the order of ***35% and 60%*** for the 'Apples' and 'Green Field' operations respectively. Savings for 'Brownfield' operations are also significant.

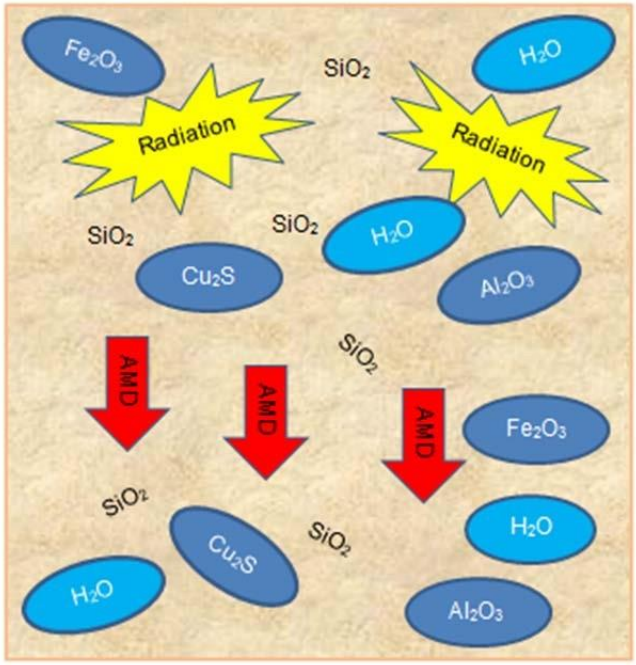
Further to that, the legacy benefits are difficult to virtually impossible to commercially quantify as the treated material can either be left dormant with little to no aftercare requirements or sold-off as a mineral filler commodity.

Where to next? … as stated earlier, in order to capitalize on such an opportunity two (2) specific tasks need to be undertaken; namely 3rd party reporting by a professional specialist (CSIR) followed by an on-site "Scaled Operation".

NPCT Solutions

BACKGROUND

What is NPCT



1 ***Existing In-Situ State:***

Generally speaking, mined ore passes through a jaw crusher, followed by a milling process (ball mill) and finally some kind of separation process (e.g. Flotation).

At this point the mine has recovered what they technically were able to achieve at that point in time. During the floatation stage, chemical additives are added for the extraction process.

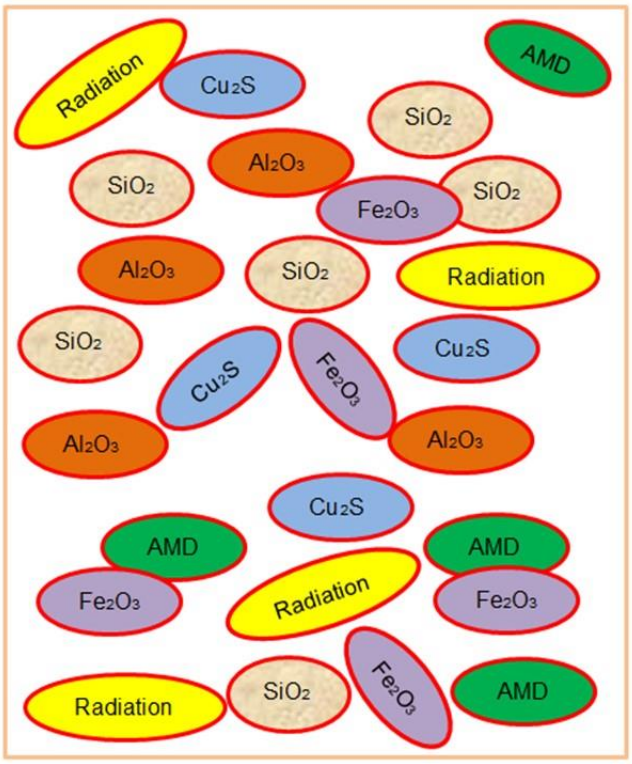
The balance of the material, termed **'waste'** is then deposited in a slurry form to a TSF:

Good: SiO_2 (Silicone Dioxide (sand)), Cu_2S (Copper Sulphate), Al_2O_3 Aluminium Oxide

Bad: AMD (Acid Mine Drainage);

Ugly: Radiation (U, Pt...)

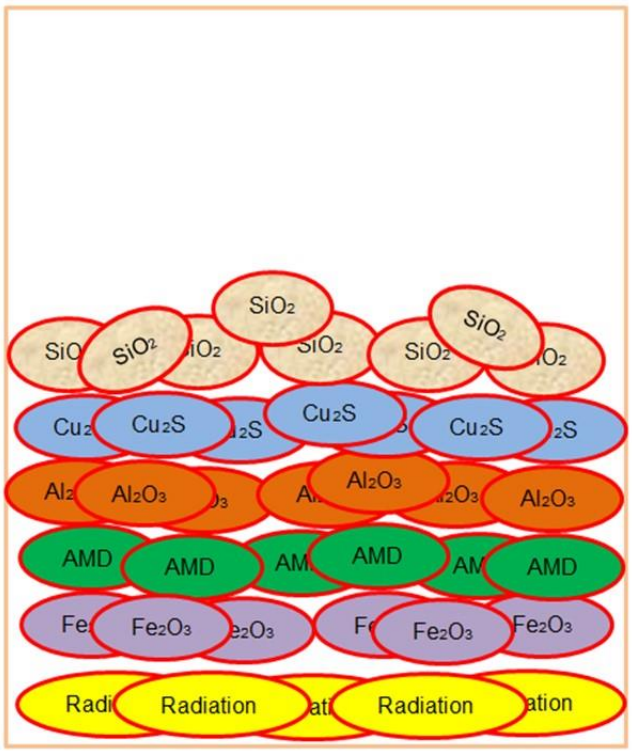
Figure 1 – Illustrative in-situ tailings composition



2A ***NPCT™ TREATMENT:***

- Each element or compound is encapsulated within a 'jacket'; fundamentally sealing-off the element/compound from the outside world.
- A once highly ***hazardous, toxic or radioactive*** element/compound is now physically ***inert*** in its new state.
- Water via an exothermic treatment reaction can be captured and returned to the plant for further use. This water is inherently 'cleaner' that it's prior state as the majority of the suspended solids have been removed.

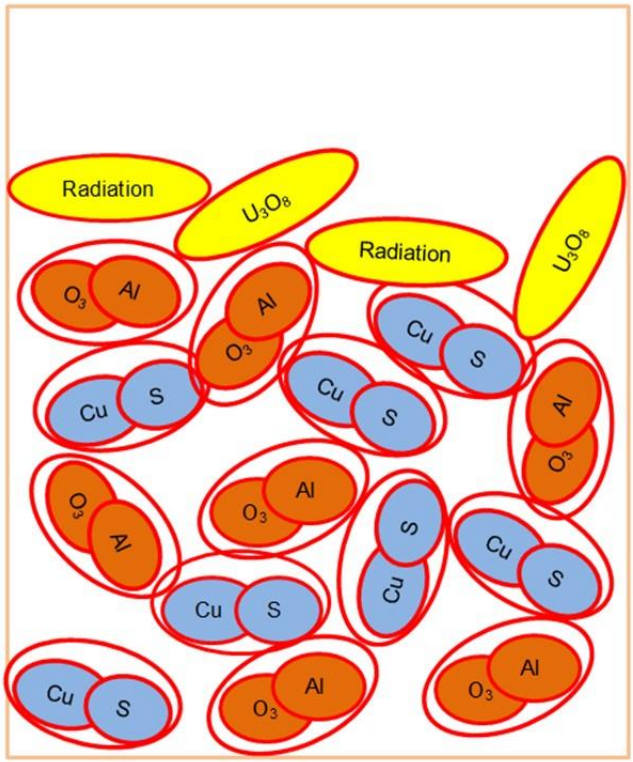
Figure 2 – NPCT Treatment Process



2B ***NPCT™ TREATMENT:***

- A mineral/compound separation step in the deposition phase allows one to separate the minerals/compounds for the mine to treat as potential ***resource streams***.
- Resource streams have other legal and commercial implications in comparison to a 'waste' site.
- The ***'Nano Particle Coating Technology'*** can be reversed.

Figure 3 – NPCT Separation Process



3 ***NPCT™ RECOVERY:***

- More often the element that we are looking for is found within a chemical compound; in turn will have to be separated by further chemical processes. For example, copper in Cu_2S or aluminium in Al_2O_3.
- Should ***"Recovery"*** be the agenda for the mine (as per many of FA's re-mining operations) then during the 'Treatment' phase a chemical additive is included within the process.
- These chemicals react with the compound within the "jacket". The compound in hand is then separated, the 'jacket' technology reversed and the elements extracted.
- The technology reportedly encapsulates the radioactive elements (becomes inert) and then unlocks the Uranium element for recovery purposes.
- The value ($) in uranium recovery outweighs the value in gold recovery; a case in point would be the current FAT / Sibanye study.
- The ***NPCT™*** technology recovery process reportedly is able to recover a higher grade of Uranium (Grade [ii] Vs Grade [5]) making the technology that more attractive.

Figure 4 – NPCT Recovery Process

The patented technology coats or 'encapsulates' each particle and/or compound (e.g. AuCr) on a mineralogical (nano) level/scale and depending on the clients requirements can completely separate the (hazardous) material within the 'jacket' from the outside world. This implies that there is zero concern of harmful leaching into the environment (i.e. Acid Mine Drainage (AMD)) – negating the need (or greatly reducing) expensive lining systems, drainage networks and earth layer works.

A second attribute to this technology is the ability to separate the waste yield via the nano-particle separation process into homogeneous ('the same mineral or compound) waste streams. These waste streams in turn become 'resource' streams as one can harvest the resource directly without conventional chemical processes. A term that is used in the resource sector is 'Mineral Filler'. These 'waste' streams in essence can be classified as 'Mineral Filler'.

In summary, this patented technology has 2 broad fields of service offering for , namely:

1. ***Treatment*** – transforms waste/tailings into an inert material (fully reversible process), 2. ***Recovery*** – able to separate by ***'design'*** 'all' minerals / compounds of value compared to ***'selective'*** recovery of conventional recovery operations.

KNOWN NPCT PARAMETERS

In order for a product or a service to be attractive in the tailings ***deposition/handling/re-mining*** market, 3 fundamental questions need to be qualified, namely:

1. Does the technology and resulting deliverables technically meet the minimum requirements from an operational and design perspective? (Section 3 and 4)
2. Provided the technology is technically sound (item 1 above), is it financially feasible compared to other technologies and techniques that result in equivalent outcomes? (Section 8)
3. Is the technology legally compliant in terms of safety, health and environmental legislation? (Section 13 and Appendix B)

In terms of qualifying the technologies' 'known' parameters:

Technical Knowns

The waste generated within the tailings waste industry (mine tailings) in comparison to the industrial waste sector can generally be classified as a homogenous mix of crushed/processed rock with

chemical additives. This is in contrast to the heterogeneous material of the industrial/general waste market consisting of both organics and inorganics.

The point in question is that the heterogeneous waste is more complex by nature in terms of its chemical composition and the required treatment process. None-the-less, a successful track record of treated heterogeneous waste projects is proven.

Financial Knowns

The financial analysis and comparisons of the NPCT technology to existing/conventional operations. The largest financial gains are:

- Savings on conventional capex costs in the form of synthetic liner systems, extensive drainage systems and other leachate containment systems;
- Limited to zero legacy costs. The transformation of environmentally hazardous material into an inert material negates the need for long-term (future) costs. In turn, the legal obligation and responsibilities (risk) that the state imposes on the mine is reduced.

- The tailings will be transformed into a classified material, legally documented as 'mineral filler'. This implies that the mineral filler can now be sold off as a commodity, generating a further revenue stream for the client.
- Water recovery/conservancy. As the treated waste results in dry, inert, mineral filler. The water can be captured and sent back to the plant directly. Treated water can also be sold off to a willing buyer.

Legal Knowns

The environmental legal compliance aligns to the stringent waste sector in which the mining sector now needs to abide by.

UNKNOWN NPCT PARAMETERS

For most conventional projects an upfront planning and design phase is required. It is during this process that the relative unknowns are recorded and analysed to access the impact on the project. To the best of the author's knowledge, the only unknowns reside within the engineering parameters from a structural and geotechnical perspective.

Such parameters include and not limited to:

I. Load bearing limits of treated material (can it fracture under pressure / compaction);
II. UV stabilization;
III. Drainage properties as a collective;
IV. Internal angle of friction (slope analysis);
V. Time test of material
VI. Destructive tests (gauging the 'product/materials' limits).

The above properties and more can be tested in certified soils laboratories. Comparisons can be made against other 'synthetic' products in the industry to gauge competitive performance from a technical perspective.

During the project study phase between client, consultant and technical provider; the relative parameters will be quantified in order for the design consultant to specify/qualify the design. The same principles are applied here as for geosynthetic products within the tailings, geotechnical and broader engineering markets.

Initially it is anticipated that these findings will be recorded and a knowledge base generated from a project to project basis (this knowledge of data will primarily be collated by the technical partner but so too with the client themselves).

Should the technology be accepted more generally then it would be advised that a more prescriptive approach be taken (i.e. material property classification and grading, destructive test work) similar to the geosynthetic market / road building market etc. The primary reason is that the design engineers can then include such NPCT material within their concept design from the start having documented and certified information on the product/technology in hand.

SWOT Analysis

The breakdown below is a high level analysis:

Strength:

i. Proven technology in the waste market;
ii. Transforms materials from hazardous to inert and allows one to declassify the material;
iii. Can extract locked-up assets within the tailings material;
iv. Environmentally aligns to best practice requirements;
v. Social/health: inert and non-toxic;
vi. Financially competitive to current/existing methods/technologies

TAILINGS / MINING MARKET

The tailings/mining market for the purpose of this exercise is 's current existing footprint. In general terms the market will be any mining, industrial or waste site.

NPCT COMPETITION

Currently there is no competition to the NPCT service offering capabilities. As far as the author is aware; based on discussions with the technology and patent holder, together with internet research, there is no other company/person that can commercially offer this technology.

In turn and highly likely, there could be a large drive by the traditional waste operational companies to make inroads to the tailings 'waste' market. The biggest driver being their knowledge and experience base on the environmental legislative side. Now that the laws have changed (are changing); the playing fields of the former mining and waste markets are now level and open to other players.

The NPCT offering is a 'Blue Ocean' solution to the market. That implies a market that our competition cannot enter or compete as long as they don't have the technology or similar offering. Provided that has exclusive access to this technology (or at least first to market) then has the ability to control and manage its market base and competitors.

FINANCIAL ANALYSIS

Overview

The qualification and quantification of the financial models is at the heart of most profit driven companies. It is therefore critical to understand the source/baseline data and verify it's composition as true and correct.

In turn one needs to understand the variations and intricacies of the financial composition; this is gained more so by understanding the operational side of the business – *in this case, tailings deposition and re-mining*.

In Summary

- The technology can treat hazardous material (Tailings: cyanide, acid forming elements; radiation, carcinogenic forming elements e.g. Chrome (VI) into an inert (non-hazardous) material (mineral filler);
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