Bushveld Vametco on an expansion path

Vanadium producer Bushveld Vametco (Vametco), majority owned by AIM-listed Bushveld Minerals, is in the process of implementing a phased expansion strategy which could result in its production capacity increasing to approximately 5 000 t/a of vanadium within the next several years. ***Modern Mining's*** *Arthur Tassell was recently part of a media/investor group that visited the Vametco operation, located 8 km to the north-east of Brits in North West Province. It is one of only two active vanadium operations in South Africa, the other being Glencore's nearby Rhovan mine.*

Fortune Mojapelo, CEO of Bushveld Minerals, and Taff Williams, COO of Bushveld Vametco, pictured during the recent media visit to the mine.

Bushveld Minerals' decision in 2016 to acquire the Vametco operation, then owned by London-listed Evraz, transitioned it from being a junior explorer (whose main asset, at least in the vanadium field, was the 'greenfield' Mokopane project) to a fully fledged miner and producer responsible for a significant portion (currently about 3 %) of the world's vanadium output. Informing Bushveld's strategy was an assessment by its management that a structural deficit was developing in the vanadium market that would inevitably lead to a sustained increase in the vanadium price.

Although the acquisition process was launched in 2016 with the signing of an exclusivity agreement and largely completed in two transactions in 2017, it was only fully completed in September last year when Bushveld bought out its overseas partner to give it its present shareholding of 74 % (with the balance being held by its BEE partner). In all, Bushveld has invested approximately US$49 million for its controlling interest.

Talking to *Modern Mining* during the recent site visit, Bushveld's CEO, Fortune Mojapelo, said the company was very happy with its investment. "When we started negotiating the deal, the price of vanadium was around US$13,5/kg," he said. "Since then it has rocketed, peaking at almost US$130/kg in the fourth quarter of last year. It has since come off its highs but is still sitting at a very healthy US$80/kg. The result is that in 2017 Vametco generated more than R300 million in EBITDA with this rising to R1,4 billion in 2018." He adds that the 'hard' assets of Vametco – essentially the processing plant – were acquired at about a tenth of their replacement cost.

The vanadium prices quoted by Mojapelo refer to ferrovanadium. Vametco currently produces all its vanadium in the form of its trade-marked vanadium carbon nitride (VCN) product, Nitrovan™ , which is similarly priced and which is sold to steel mills across the

world. The company's biggest market is the US, which takes approximately 60 % of Vametco's production. According to Vametco, Nitrovan™ strengthens steel more efficiently than ferrovanadium, allowing steelmakers to use less vanadium in high-strength low alloy steels and reduce vanadium costs by as much as 40 %.

The assets that constitute Vametco – which passed into the hands of Evraz in 2007 – are in good shape, considering that the operation is several decades old having started its life in 1967 (when it was known as UCAR Minerals,

Aerial view of the Bushveld Vametco operation near Brits (photo: Bushveld Minerals).

The open pit at Vametco (photo: Bushveld Minerals).

The rotary kiln, a key part of the Vametco plant.

which was owned by US company Union Carbide). "Given the low vanadium price in recent years, the previous owners prioritised maintenance over expansion," Mojapelo told *Modern Mining*. "We've, in fact, kept most of the previous management in place. Collectively, they have 100 years of combined vanadium mining and processing experience in South Africa."

Heading the operation is Lyndon 'Taff' Williams as Chief Operations Officer, a qualified metallurgical engineer who has over 35 years of experience in the vanadium industry, including a range of roles within Highveld Steel & Vanadium (HSV) during the years when it was owned by Evraz. He is supported by Vametco Works Manager William Steinberg, who has a Masters degree in Metallurgical Engineering and who, prior to his current appointment in 2012, was Manager for Iron Plant 2 at HSV, and Chief Financial officer Tania Mostert, also with a background at HSV.

Vametco is both a mining and a processing operation, with the mining – due to its relatively straightforward nature – being by far the easier part of the operation to manage. The orebody is mined by standard open-pit, bench-mining methods using medium-sized excavators and articulated dumps trucks along a 3,5 km strike running west to east and dipping between 14 and 20 deg in a northerly direction.

Vametco's total resource is estimated (to JORC standards) to be 142 Mt and includes ore reserves of 26 Mt which have been shown to have some of the highest in-magnetite vanadium pentoxide (V_2O_5) grades in the world, averaging 1,96 % V_2O_5 in magnetite. Three magnetite seams, the Upper, Intermediate and Lower, are mined, with the Lower Seam being the main ore seam.

While the resource is sufficient for decades of mining at present rates, Bushveld Minerals is planning to bring a neighbouring deposit into production. Known as the Brits vanadium project, it represents an outcropping strike extension of the Vametco mine. Bushveld Minerals controls the project with its interest in the asset ranging from 51 % to 74 % through three different companies. A second phase of drilling has recently been completed and a maiden mineral resource estimate for the deposit is currently being prepared.

"The rationale for bringing Brits into production is that it will lower our mining costs – because we can start mining ore from near-surface – and also give us optionality surrounding selective mining," said Mojapelo. He added that the ore could be processed at Vametco or at other facilities in the area. "We are constantly looking for additional 'brownfield' infrastructure," he told *Modern Mining*.

The ore from the Vametco mining operation undergoes multiple stages of treatment in the plant, which is located within a kilometre or two of the mining operation. The facility utilises the well-established salt roast processing method to produce the refined vanadium

in – as mentioned – the form of Nitrovan™.

The first step is three stages of crushing and milling followed by low-intensity magnetic separation to produce a magnetite concentrate product with an average grade of approximately 2,0 % V_2O_5. This concentrate is then roasted with sodium salts in a rotary kiln to form water-soluble sodium vanadates. Solids exiting the rotary kiln are discharged directly into a rotary cooler that cools the solids sufficiently to allow them to be conveyed to the leaching circuit.

In the leaching circuit, the cooled calcine is fed to a wet ball mill which grinds the agglomerated material for improved leaching and also acts as the first stage of leaching. The mill discharge slurry is pumped to belt filters to separate the vanadium-rich solution and calcine tailings. The vanadium-rich solution is then pumped to thickeners where desilication and concentration of the vanadium-bearing leach liquor takes place.

Ammonium sulphate is added to the vanadium-bearing leach liquor which allows for the precipitation of vanadium in the form of ammonium metavanadate (AMV). The AMV filter cake is dried in a rotary dryer and thereafter transferred to the MVO rotary calciners to produce Modified Vanadium Oxide (MVO). Finally, this is mixed with carbon and a binder which is briquetted and fed into an induction shaft furnace under a nitrogen atmosphere to produce Nitrovan™ (which contains between 76 and 81 % vanadium metal).

While the treatment route is well understood, it is nevertheless complicated compared to what is required in most other mining and processing operations in the Bushveld Complex. “If you have a chrome or platinum mine, you mine, crush, mill and concentrate,” said Mojapelo. “Compare this with our flowsheet, which has five distinct stages of processing after the concentrate stage.”

Interestingly, when Evraz controlled both Vametco and HSV, ore from the pit was

“We are constantly looking for additional ‘brownfield’ infrastructure.”

Another view of the open-pit operation. The orebody is mined by standard open-pit, bench-mining methods.

supplemented with high-grade vanadium slag from HSV, raising the overall grade of the material treated in the plant. Obviously, Vametco no longer has this option open to it but the current management is confident that the operation can be profitably run – even at a much lower vanadium price than at present – based purely on ore derived from the pit.

Since taking over the Vametco operation, Bushveld has increased the capacity of the plant in two phases, with Phase 2 – the addition of a new milling circuit – having been completed in June last year to bring the operational capacity up to 3 750 t/a. In practice, Vametco has experienced difficulties in ramping up to this nameplate capacity. As a result, a diagnostic review was recently undertaken (with the assistance of an external consultant). This identified a strategy – which is currently being implemented through a 'Transformation Programme' – which will allow a sustainable production of 3 400 t/a to be achieved, representing 90 % of the nameplate capacity.

None of the measures recommended requires any capex. They relate to operational practices and include increasing the vanadium grade in crushed ore through improved mine scheduling and increasing the vanadium grade in the kiln feed through improved silica liberation.

Looking beyond Phase 2, Vametco is planning a Phase 3 expansion, which will see additional targeted investment in the kiln and the leaching and crushing circuits to bring capacity up to 5 000 t/a (the limit of what can probably be achieved with present kiln). The company says detailed design work and capital estimation will commence with a view to construction starting in 2020, which would probably see Phase 3 starting its ramp up in 2021.

Over the course of FY-2018 (Vametco's financial year coincides with the calendar year), Vametco produced 2 560 tonnes, which was below guidance and actually a slight decrease on the 2017 figure (although revenue in 2018 was 143 % higher than in the previous year due to the better vanadium price). A major contributing factor to this under-performance was unprotected strike action and community unrest which impacted on operations. The slow ramp-up of the Phase 2 expansion, as well as an unplanned maintenance and repairs programme in the final quarter at the refractory and cooler girth sections of the plant, also affected production.

Mojapelo told *Modern Mining* that he was confident that 2019 would see a much improved performance by Vametco. "We have not yet set guidance but will do so when we issue our Q1-2019 report. Obviously, we will be hoping to better the production achieved in 2018 – and better it quite substantially. Medium-term, we see the vanadium market staying in deficit. Phase 3 of our expansion will allow us to make the most of this favourable operating environment and lift our share of the global market to roughly 5 %," he concluded.

Photos by Arthur Tassell (unless otherwise credited)

Vametco currently produces all its vanadium in the form of its trade-marked vanadium-nitrogen (VCN) product, Nitrovan™.

Huge potential for vanadium in energy storage

Bushveld Minerals has stated that one of its visions is to become one of the world's most significant, lower cost and most vertically integrated vanadium producers.

To assist it in achieving the goal of vertical integration, it launched a company in 2016 known as Bushveld Energy, which is focused on developing and promoting the role of vanadium in the growing global energy storage market through application in Vanadium Redox Flow Battery (VRFB) systems, which utilise a vanadium electrolyte.

VRFB technology is growing at a fast pace and is set to have a huge impact on the vanadium market, with Bushveld's analysis of trends suggesting that it will account for as much as 44 % of global vanadium demand (as opposed to 2 to 3 % currently) within a decade.

Bushveld Energy's strategy is to install several VRFB systems as part of its longer term vision to become a significant electricity storage provider in Africa, meeting the demand for utility-scale energy by leveraging South African-mined and beneficiated vanadium.

The company – which was co-founded by Mikhail Nikomarov, who is CEO of Bushveld Energy – has recently, in collaboration with the IDC, commissioned a VRFB system with a peak power of 120 kW and a peak energy of 450 kWh at Eskom's Research and Testing Facility at Rosherville in Johannesburg (which *Modern Mining* was recently able to view on a visit to the site).

This is reportedly the first utility-scale VRFB to be deployed in South Africa and will, among other things, allow Eskom to assess the performance of VRFB technology under local conditions.

In addition, and again in collaboration with the IDC, Bushveld Energy is investigating the establishment of a plant – which would probably be located within the East London Industrial Development Zone in the Eastern Cape – to manufacture vanadium electrolyte in South Africa. ■