AVANTIS – SUSTAINABLE, DECARBONISED VANADIUM, TITANIUM AND IRON EXTRACTION FROM EUROPE'S LOW-GRADE VANADIUM-BEARING TITANOMAGNETITE DEPOSITS

by

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INTRODUCTION

The European Commission´s Critical Raw Materials Act (CRMA) sets multiple benchmarks for reducing Europe's dependency on a few third countries for strategic/critical raw materials. Vanadium (V) and titanium (Ti) have received less attention than other CRMs such as the battery raw materials, or the light/heavy rare-earth elements that have been central to many previously funded projects. However, the situation for vanadium and titanium is no different to that of the popular CRMs: there is no domestic vanadium or (refined) titanium metal production in the EU, making the EU critically dependent on imports.

The EU is 100% import reliant for Ti metal, with a strong dependency on China and Russia. For V, this import reliance could not be calculated by the European Commission, although it is clearly also very high as once more, China and Russia are the dominant players. There is no primary vanadium extraction in the EU at present, although there are plans in Finland to recover V from steelmaking slags from 2026. It is estimated that for 2016–2021 the EU imported 1.5 Mt/y titanium (including TiO_2 pigment, Ti metal) and 12.7 kt/y vanadium. The good news is that, based on known domestic resources, the EU can supply its growing needs for V and Ti.

At present the only large-scale primary extraction of Ti-bearing minerals in geographical Europe is happening in Rogaland province in Norway, where AVANTIS partner Titania AS operates the Tellnes mine, a high-grade ilmenite mine of the magmatic type (grading 18 wt% TiO_2, as present in ilmenite, $FeTiO_3$) (USGS 2017). The high-grade Tellnes ilmenite mine where ilmenite is the main ore mineral and is easy to extract is not representative of the other Ti deposits in Europe, or even the rest of the world.

The global reserves of Ti-rich oxide minerals such as ilmenite ($FeTiO_3$) and rutile (TiO_2) are about 62 and 880 million tonnes, respectively, while the global reserves of vanadiferous/ V-bearing titanomagnetite deposits are 58 billion tonnes: i.e., far more than the reserves of the deposits where Ti is extracted from Ti-rich oxides, ilmenite and rutile. However, at present there is no commercial co-valorising of V and Ti from V-bearing titanomagnetite [Ti-V-Fe-(P)] deposits.

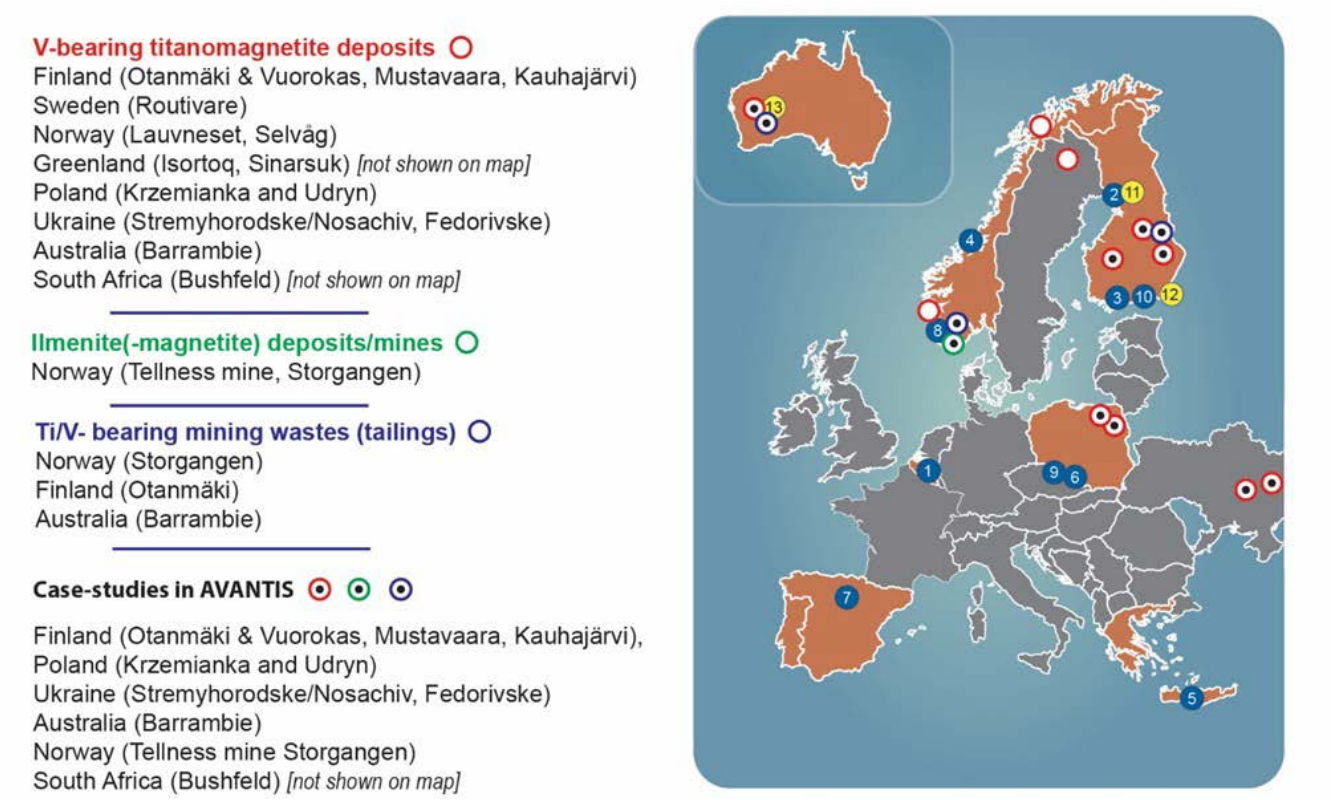

Fig 1. AVANTIS case studies.

To help achieve the benchmark of 10% domestic extraction in the EU's CRMA, the project AVANTIS will develop a low-carbon, multi-metal extraction approach for Europe's low-grade under/unexploited, vanadium-bearing titanomagnetite (Ti-V-Fe-(P)) deposits and mining wastes in Finland, Sweden, Norway, Poland and Ukraine. This novel "responsible mining" approach will extract two key CRMs V and Ti as pre-concentrates, which can be further processed by the relevant downstream industries to high-purity materials, e.g., all-V redox-flow battery (VRFB), Ti-V alloy. AVANTIS will also impact on the co-extraction of light rare earths and phosphorus from the rare-earth containing apatite concentrate.

AVANTIS APPROACH

Europe has a multitude of unexploited, low-grade V-bearing titanomagnetite deposits in Finland, Sweden, Greenland, Norway, Poland and Ukraine. However, these deposits have a complex "spiderweb-like" mineral assemblage (Fig. 2). Without selective blasting, selective fragmentation and pre-concentration technologies to separate the Ti-rich ilmenite grains from the V-bearing magnetite, these deposits are not economically viable.

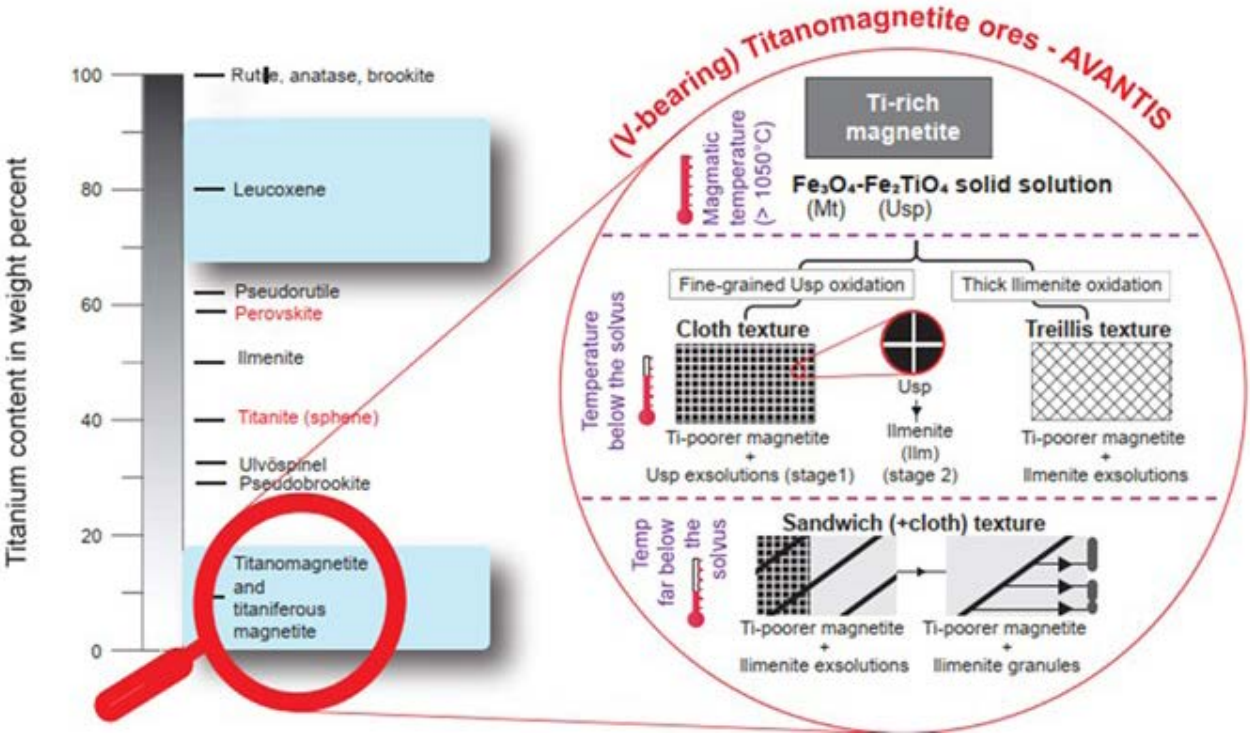

Fig 2. Complex mineral assemblage in vanadium-bearing titanomagnetite ores.

Supported by a bespoke forensic geometallurgy, AVANTIS develops a novel selective blasting approach that allows for rock excavation in view of increased mineral liberation at the blasting stage, and reduced energy demand in the crushing and grinding stages. In addition, AVANTIS designs tailored, water-free and water-lean pre-concentration technologies that can produce two distinct pre-concentrates: (1) ilmenite-rich, Ti-pre-concentrate and (2) ilmenite-free, V-pre-concentrate. The water-lean method is also tailored to process V/Ti-bearing mining wastes from historical/on-going operations. It is expected that the resulting flowsheets have a low net water consumption and reduced GHG intensity of extraction. AVANTIS strengthens the "responsible mining in Europe"-paradigm, increasing society's trust in domestic CRM production.

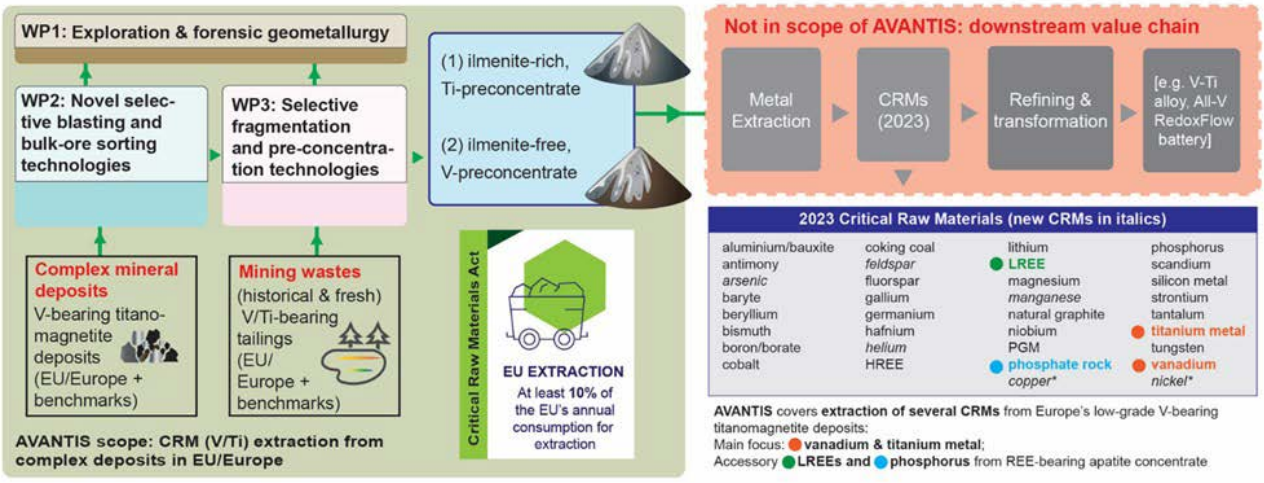

Fig 3. AVANTIS concept.

AVANTIS OBJECTIVES

- To develop and implement a forensic geometallurgy protocol for the extraction of Ti & V from V-bearing titanomagnetite deposits and V/Ti-bearing mining wastes, based on cutting-edge orebody knowledge.
- To advance towards a definition of optimum blasting parameters for rock excavation in V-bearing titanomagnetite ore that means (1) an increase in mineral liberation at the blasting stage; (2) a lower energy demand for the crushing and grinding stages
- To develop water-lean and/or water-free, advanced selective fragmentation and pre-concentration technologies that allow the separation of ilmenite and magnetite from V-bearing titanomagnetite ores and mining wastes, thereby producing two discrete pre-concentrates: ilmenite-rich, Ti-pre-concentrate and ilmenite-free, V-pre-concentrate.
- To develop an integrated environmental, health & safety, public-acceptance and techno-economic assessment for the tailored extraction routes of low-grade, EU-based vanadiferous titanomagnetite deposits and historical/fresh mine tailings.

REFERENCES

USGS 2017. Titanium, Critical Mineral Resources of the United States Economic and Environmental Geology and Prospects for Future Supply.