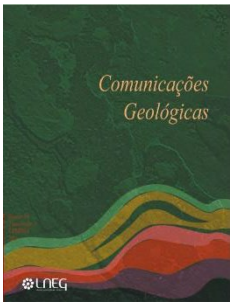
Comunicações Geológicas

Comunicações Geológicas (2026) 113, 1, 21-30
ISSN: 0873-948X; **e-ISSN:** 1647-581X

Mapping the Pan-African inventory of Critical Raw Material deposits and processing capacities



Mapeamento do inventário Pan-Africano de depósitos de Matérias-Primas Críticas e capacidades de processamento

C. Fortes[1*], D. P. S. de Oliveira[1,2], J. C. Guillaneau[3,4], C. Prazeres[1]

DOI: https://doi.org/10.34637/2xb7-qh87
Recebido em 12/01/2026 / Aceite em 9/6/2026
Publicado online em setembro de 2026

Original article
Artigo original

Abstract: The AfricaMaVal project (2022–2025) supported the European Union's objective of securing responsible and sustainable access to Extended Critical Raw Materials (ECRM) through strengthened cooperation with African countries. This study presents the development of two harmonised pan-African inventories: an ECRM mineral deposit database and a database of existing ore processing and refining capacities. Using the Minerals4EU data model within an INSPIRE compliant framework, heterogeneous datasets were integrated and validated through commercial and consortium sources. The resulting inventories document more than 20.000 mineral occurrences and 219 processing facilities, classified as plants, smelters, refineries and concentrators. The analysis reveals a strong geographical concentration, with South Africa and the Democratic Republic of Congo hosting over half of all facilities, and processing activities largely centred on copper and cobalt. These findings highlight regional disparities and priority areas for investment. Overall, the inventories provide a robust knowledge base to support a resilient EU raw materials strategy and guide future EU–Africa partnerships.

Keywords: Extended Critical Raw Materials, INSPIRE-compliant geodatabase, mineral deposits inventory, mineral processing capacities.

Resumo: O projeto AfricaMaVal (2022 – 2025) apoiou o objetivo da União Europeia de assegurar o acesso responsável e sustentável às Matérias-Primas Críticas Alargadas (MPCA), através do reforço da cooperação com países africanos. Este estudo apresenta o desenvolvimento de dois inventários pan-Africanos harmonizados: uma base de dados de depósitos minerais de MPCA e uma base de dados das capacidades existentes de processamento e refinaria de minério. Utilizando o modelo de dados Minerals4EU no âmbito de uma estrutura compatível com a diretiva INSPIRE, foram integrados e validados conjuntos de dados heterogéneos provenientes de fontes comerciais e do consórcio. Os inventários resultantes documentam mais de 20 000 ocorrências minerais e 219 instalações de processamento, classificadas como unidades industriais, fundições, refinarias e concentradores. A análise revela uma forte concentração geográfica, com a África do Sul e a República Democrática do Congo a acolherem mais de metade das instalações identificadas, e com atividades de processamento predominantemente centradas no cobre e no cobalto. Estes resultados evidenciam desigualdades regionais significativas e identificam áreas prioritárias para investimento. No seu conjunto, os inventários constituem uma base de conhecimento robusta que apoia o desenvolvimento de uma estratégia europeia mais resiliente em matéria de matérias-primas e orienta futuras parcerias entre a União Europeia e África.

Palavras-chave: Matérias-primas críticas alargadas, base de dados compatível com a INSPIRE, inventário de depósitos minerais, capacidades de processamento mineral.

[1] Laboratório Nacional de Energia e Geologia (LNEG), Mineral Resources and Geophysics Research Unit, Estrada da Portela, Bairro do Zambujal-Alfragide, Apartado 7586, 2610-999 Amadora, Portugal.
[2] EuroGeoSurveys, Mineral Resources Expert Group, Rue Joseph II, 36-38, 1000 Brussels, Belgium.
[3] Bureau de Recherches Géologiques et Minières (BRGM), 3 avenue Claude Guillemin, 45060 Orléans cedex 2, France.
[4] EuroGeoSurveys, International Cooperation and Development Task Force, Rue Joseph II, 36-38, 1000 Brussels, Belgium.

* Corresponding author / Autor correspondente: carla.fortes@lneg.pt

1. Introduction

Critical Raw Materials (CRM) are those raw materials considered economically and strategically essential for the European Union, but whose supply is subject to a high level of risk. To monitor these vulnerabilities, the European Commission performs a CRM criticality assessment approximately every three years, covering a broad range of non-energy and non-agricultural raw materials. The first assessment was published in 2011, with subsequent updates in 2014, 2017, 2020 and 2023 (EU Commission, 2011, 2014, 2017, 2020, 2023).

Global demand for CRM has intensified significantly in recent years due to the rapid expansion of green technologies, digitalisation and defence-related applications (EU Commission, 2021). These materials underpin many of the objectives set out in the European Green Deal (EU Commission, 2019), including the transition to renewable energy systems, electrification and advanced manufacturing. Consequently, securing stable, sustainable and diversified CRM supply chains has become a strategic priority for the EU.

Europe's rising demand creates both opportunities and substantial challenges. The EU currently relies heavily on imports from a small number of supplier countries, many located in geopolitically volatile regions. This dependency exposes European industries to supply chain disruptions, market instability and geopolitical pressures. Recent global crises and shifts in international relations have further highlighted the fragility of

current supply structures and reinforced the need to reduce external dependencies and enhance resilience.

In response, the EU has emphasised the development of domestic CRM resources, investment in advanced recycling technologies and the creation of strategic stockpiles (EU Commission, 2024). Nevertheless, Europe's geological constraints and strict environmental regulations limit its potential for full self-sufficiency. As a result, international partnerships remain essential for ensuring long term access to CRM.

Africa has emerged as a particularly important region in this context. With abundant mineral resources, rapidly developing infrastructure and increasing political engagement, several African nations offer promising opportunities for establishing responsible and mutually beneficial raw materials partnerships. As part of the EU Critical Raw Materials strategy, the European Union has recently concluded Strategic Partnership Agreements with Namibia (EU Commission, 2022), Zambia, Rwanda (EU Commission, 2023) and the Democratic Republic of Congo, with further agreements under negotiation.

In this context, the Building EU–Africa Partnerships on Sustainable Raw Materials Value Chains (AfricaMaVal) project (June 2022–November 2025) aimed to strengthen EU–Africa cooperation to ensure the responsible sourcing of mineral resources while simultaneously supporting sustainable industrial development within African partner countries. The project was grounded in the principles of high Environmental, Social and Governance (ESG) standards, promoting a stable long term investment environment for both European and African stakeholders.

A central objective of AfricaMaVal was to generate comprehensive and up-to-date knowledge on Critical Raw Materials in Africa, including an assessment of existing mining and mineral processing infrastructures. By providing this information to policymakers and industrial actors, the project supported efforts to diversify European supply chains. A key output was the development of a continental mineral deposit inventory which formed a baseline dataset for predictive analyses and evaluations of processing capacities, thereby contributing to more resilient and sustainable CRM supply strategies.

Given the scale and heterogeneity of the pan-African dataset generated, cartographic visualisation proved to be the most effective means of synthesising and communicating complex spatial information. By abstracting real-world complexity into clear and interpretable visual structures, maps facilitated robust analysis and informed decision making. This study therefore focused on assembling, harmonising and visualising the dataset to produce scientifically coherent maps that accurately represent current mineral resource and processing conditions across Africa.

2. The AfricaMaVal Project

AfricaMaVal, coordinated by the Bureau de Recherches Géologiques et Minières (BRGM) and funded through the EU Horizon Europe programme, aimed to strengthen EU–Africa cooperation to ensure the responsible sourcing of Critical Raw Materials (CRM) required for Europe's green and digital transitions. The project involved 18 partner organisations from 11 European and African countries, including geological surveys, research entities, industry specialists and policy organisations.

The main objectives of AfricaMaVal included building an EU–Africa business and knowledge network across the CRM value chain and developing strategies to integrate African and European raw-material supply chains relevant to emerging energy and digital technologies. To advance these goals, AfricaMaVal conducted ten case studies in selected African countries and assessed approximately 100 potential investment opportunities. The project also incorporated the artisanal and small-scale mining (ASSM) sector, acknowledging its importance for local economies and raw-material supply (https://africamaval.eu).

The following section describes the methodological approach used to compile, harmonise and analyse the spatial data underpinning the AfricaMaVal ECRM deposit inventory.

2.1. Inventory of Known Critical Raw Materials Deposits

2.1.1. The concept of ECRM

Within the AfricaMaVal project, the term Extended Critical Raw Materials (ECRM) is used to describe an expanded group of materials that extends beyond the CRM list defined by the European Commission. The ECRM category encompasses all substances listed as CRM in the 2023 EU assessment but is intentionally broadened to include additional materials such as copper, nickel, tin and manganese which, although not classified as critical at the EU level, are considered strategically relevant for assessing Africa's mineral potential.

2.1.2. INSPIRE-compliant ECRM database

Since the publication of the Raw Materials Initiative in 2008 (EU Commission, 2008), the EU has prioritised the development of harmonised spatial information systems to support mineral resource policy. In this context, the INSPIRE Directive (Infrastructure for Spatial Information in the European Community) establishes the standards required for organising, sharing and ensuring the interoperability of geological and mineral resource data (INSPIRE, 2013). These principles have been implemented through major European initiatives, such as ProMine[1] (2009-2013), EuroGeoSource[2] (Fortes *et al.*, 2013) and, more recently, Minerals4EU[3] (Lopes *et al.*, 2018), which have progressively expanded and standardised mineral datasets at continental scale (*e.g.*, Cassard *et al.*, 2014a, 2014b; Vuollo *et al.*, 2014; Cassard *et al.*, 2015).

The ECRM inventory used in AfricaMaVal follows the Minerals4EU data model (Waardenburg *et al.*, 2014) and its associated codelists, which build on INSPIRE and integrate the EarthResourceML (ERML) and GeoSciML standards developed by the International Union of Geological Sciences – Commission for the Management and Application of Geoscience Information (IUGS/CGI). This framework ensures semantic consistency and interoperability across datasets.

Figure 1 presents a partial view of the Minerals4EU data model, illustrating how core entities, such as *MineralOccurrence*, *CommodityMeasure*, *OreMeasure*, *Resource* and *Reserve* are

[1] Nano-particle products from new mineral resources in Europe. https://arquivo.pt/wayback/20160421110251/http://promine.gtk.fi/

[2] EU Information and Policy Support System for Sustainable Supply of Europe with Energy and Mineral Resources

[3] Minerals Intelligence Network for Europe. https://arquivo.pt/wayback/20160110080714/http://www.minerals4eu.eu/

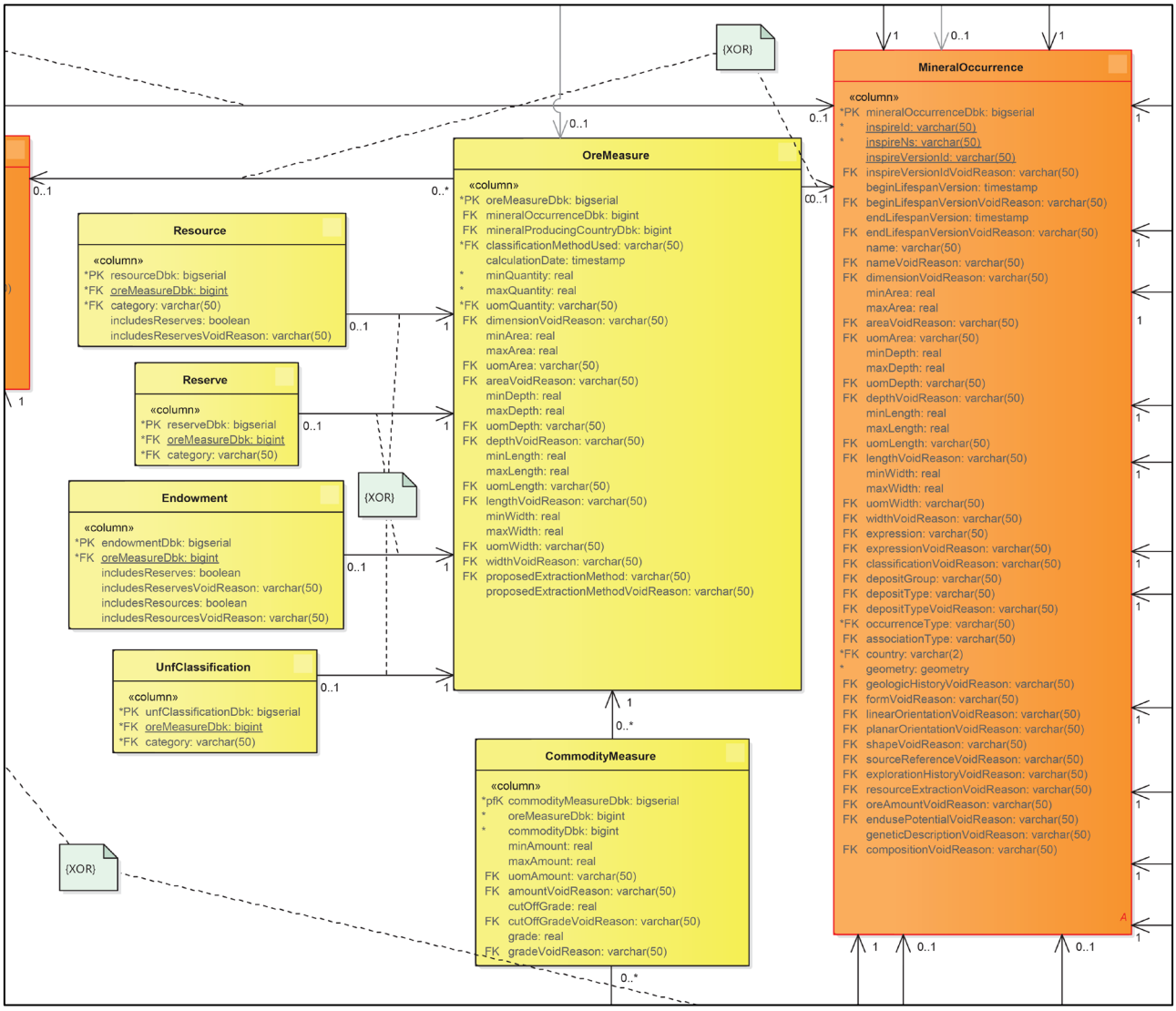


Figure 1. Partial visualisation of the Minerals4EU (Min4EU) data model.

Figura 1. Visualização parcial do modelo de dados Minerals4EU (Min4EU).

structured and interlinked through relational connections. Each coloured box represents a database table, while the connecting lines show how information flows between entities.

Given the limited timeframe of the AfricaMaVal project, developing a completely new geodatabase was not feasible. Instead, the team integrated existing datasets from Laboratório Nacional de Energia e Geologia (LNEG) and the Bureau de Recherches Géologiques et Minières (BRGM). However, the BRGM SigAfrique dataset was not fully INSPIRE compliant, requiring an extensive harmonisation process. The harmonisation workflow consisted of four main steps:

1) Identification of data sources and definition of objectives, including the required structure, content and standardisation needs, and specifying the elements of the dataset requiring transformation.
2) Integration of all information into a single INSPIRE compliant dataset, optimising time and resources. The merged dataset incorporates pre-existing information and is designed to be dynamically updated.
3) Ensuring database evolution through continuous data integration from independent reports and structured commercial datasets (*e.g.*, S&P Capital IQ, 2023). This phase involved mapping attributes across sources, performing necessary transformations, and conducting extensive data cleaning (error removal, correction of inconsistencies, unit standardisation and elimination of duplicates and outliers).
4) Validation of the harmonised dataset, verifying structural consistency, interoperability and compliance with INSPIRE and Minerals4EU requirements.

Table 1 provides an overview of the vocabulary used in the AfricaMaVal database, showing the INSPIRE Code Lists and their corresponding application within the Minerals4EU data model. The table presents the official INSPIRE code list names, their URIs, and the code lists adopted by AfricaMaVal version 1.0, enabling data providers to apply a standardised

Table 1. Overview of INSPIRE and AfricaMaVal code lists adopted in accordance with the Minerals4EU data model.

Tabela 1. Síntese das listas de códigos INSPIRE e AfricaMaVal adotadas de acordo com o modelo de dados Minerals4EU.

INSPIRE Code list name	INSPIRE_URI	AfricaMaVal Code list adopted	INSPIRE Code list name	INSPIRE_URI	AfricaMaVal Code list adopted
ClassificationMethodUsedValue	http://INSPIRE.ec.europa.eu/codelist/ClassificationMethodUsedValue	INSPIRE Code list adopted	ResourceCategoryValue	http://INSPIRE.ec.europa.eu/codelist/ResourceCategoryValue	INSPIRE Code list adopted
CommodityCodeValue	http://INSPIRE.ec.europa.eu/codelist/CommodityCodeValue	INSPIRE Code list adopted	LithologyValue	http://INSPIRE.ec.europa.eu/codelist/LithologyValue	LithologyValue SigAfrique_Type
ExplorationActivityTypeValue	http://INSPIRE.ec.europa.eu/codelist/ExplorationActivityTypeValue	INSPIRE Code list adopted	EarthResourceMaterialRole	http://resource.geosciml.org/classifier/cgi/earth-resource-material-role	INSPIRE Code list adopted
ImportanceValue	http://INSPIRE.ec.europa.eu/codelist/ImportanceValue	INSPIRE Code list adopted	EarthResourceFormValue	http://resource.geosciml.org/classifier/cgi/earth-resource-form/	INSPIRE Code list adopted
MineStatusValue	http://INSPIRE.ec.europa.eu/codelist/MineStatusValue	INSPIRE Code list adopted	EarthResourceShapeValue	http://resource.geosciml.org/classifier/cgi/earth-resource-shape/	EarthResourceShape SigAfrique_Type
MineralDepositGroupValue	http://INSPIRE.ec.europa.eu/codelist/MineralDepositGroupValue	INSPIRE Code list adopted	AlterationTypeTerm	http://resource.geosciml.org/classifierscheme/cgi/201012/alterationtype	INSPIRE Code list adopted
MineralDepositTypeValue	http://INSPIRE.ec.europa.eu/codelist/MineralDepositTypeValue	MineralDepositType SigAfrique_Type	MineralNameTerm	http://pubsites.uws.edu.au/ima-cnmnc/IMA_Master_List_(2014-07).pdf	INSPIRE Code list adopted
MineralOccurrenceTypeValue	http://INSPIRE.ec.europa.eu/codelist/MineralOccurrenceTypeValue	MineralOccurrence SigAfrique_Type	CountryCode	http://INSPIRE.ec.europa.eu/codelist/CountryCode	INSPIRE Code list adopted
MiningActivityTypeValue	http://INSPIRE.ec.europa.eu/codelist/MiningActivityTypeValue	MiningActivityType SigAfrique_Type	OreMeasureCategoryType (UNFC)	CGI	INSPIRE Code list adopted
ProcessingActivityTypeValue	http://INSPIRE.ec.europa.eu/codelist/ProcessingActivityTypeValue	INSPIRE Code list adopted	UomVolumeType	Min4EU-addition	INSPIRE Code list adopted
ReserveCategoryValue	http://INSPIRE.ec.europa.eu/codelist/ReserveCategoryValue	INSPIRE Code list adopted	UomWeightType	Min4EU-addition	INSPIRE Code list adopted

terminology consistent with European georesource data interoperability requirements.

A central issue in the harmonisation process is the inevitable loss of descriptive granularity that occurs when converting the highly detailed SigAfrique classifications into the more generalised INSPIRE code lists. SigAfrique distinguishes 313 deposit types, while INSPIRE recognises only 49, requiring that many nuanced geological descriptions be consolidated into broader categories. For example, a deposit described in SigAfrique as "carbonatite-hosted ore deposits: REE, Nb, Ti, Zr, U, Th (P, F, Cu, Ba, Sr, etc.)" must be simplified in INSPIRE to the general term "carbonatite". This illustrates the reduction in mineralogical and genetic detail inherent to the harmonisation process.

An equivalent simplification is required for the classification of Mineral Occurrence type and Mine Status. In SigAfrique (Fig. 2, Tab. A), both dimensions are combined within a single structure containing 72 fields. Under INSPIRE, these dimensions must be divided into two separate and standardised code lists: OccurrenceType (8 fields; Fig. 2, Tab. B) and MineStatus (14 fields; Fig. 2, Tab. C). This necessitates a systematic redistribution of each SigAfrique entry across the two INSPIRE-compliant categories, supported by explicit relational mappings between Tables A, B and C to ensure reliable and automated data transfer.

Although this process results in a reduction of descriptive detail, such simplification is necessary and deliberate: it reduces redundancy, enforces a common vocabulary and enables harmonisation and full interoperability across datasets originating from different sources, institutions and countries. Ultimately, these transformations allow AfricaMaVal to integrate heterogeneous data into a unified INSPIRE-compliant framework, ensuring consistency and comparability at continental scale.

At the current stage of development, the AfricaMaVal ECRM geodatabase contains over 20,000 documented mineral occurrences, each described through a harmonised set of attributes, including the occurrence or deposit name, occurrence type, deposit size and type, the ECRM, associated substances present, mine status and data provider. This number is expected to increase substantially as additional data sets are incorporated.

2.1.3. Mapping the results obtained

Clear and consistently structured cartographic elements are essential for effectively communicating spatial information. Fundamental components such as an informative title, legible labels, a coherent legend, a scale bar and a north arrow help users quickly understand the purpose, content and orientation of a map. The use of consistent colours, symbols and typography, together with the avoidance of visual clutter, enhances readability and directs attention to key spatial patterns. By abstracting complex datasets into simplified visual forms, maps become powerful tools for scientific analysis and public communication.

In accordance with the INSPIRE Directive and the Minerals4EU conceptual data model, and while respecting confidentiality constraints, the final ECRM geodatabase map has been published as a Web Map Service (WMS), accessible at:

https://sig.lneg.pt/server/services/Projects/AfricaMaVal/MapServer/WMSServer?

This map, produced following these cartographic and data model requirements, is presented in figure 3 to illustrate the spatial distribution of 20,000 ECRM across Africa.

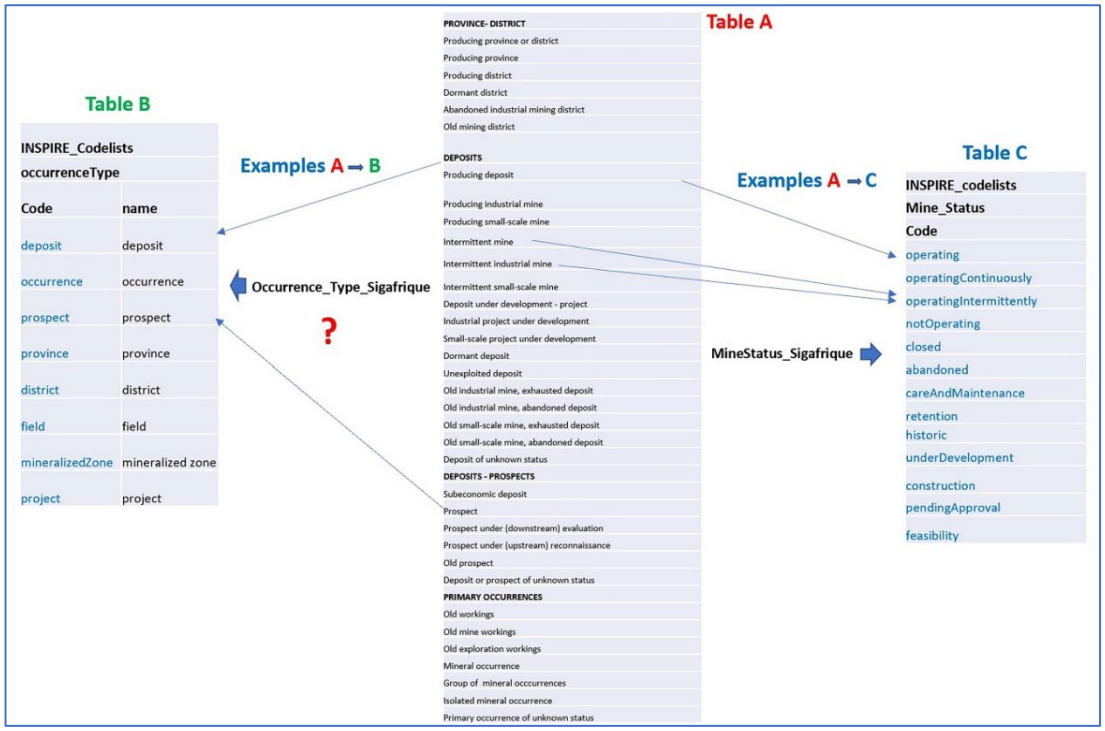


Figure 2. Diagram illustrating the reclassification of SigAfrique entries (Tab. A) into the INSPIRE OccurrenceType (Tab. B) and MineStatus (Tab. C) categories.
Figura 2. Diagrama que ilustra a reclassificação dos registos SigAfrique (Tab. A) nas categorias INSPIRE OccurrenceType (Tab. B) e MineStatus (Tab. C).

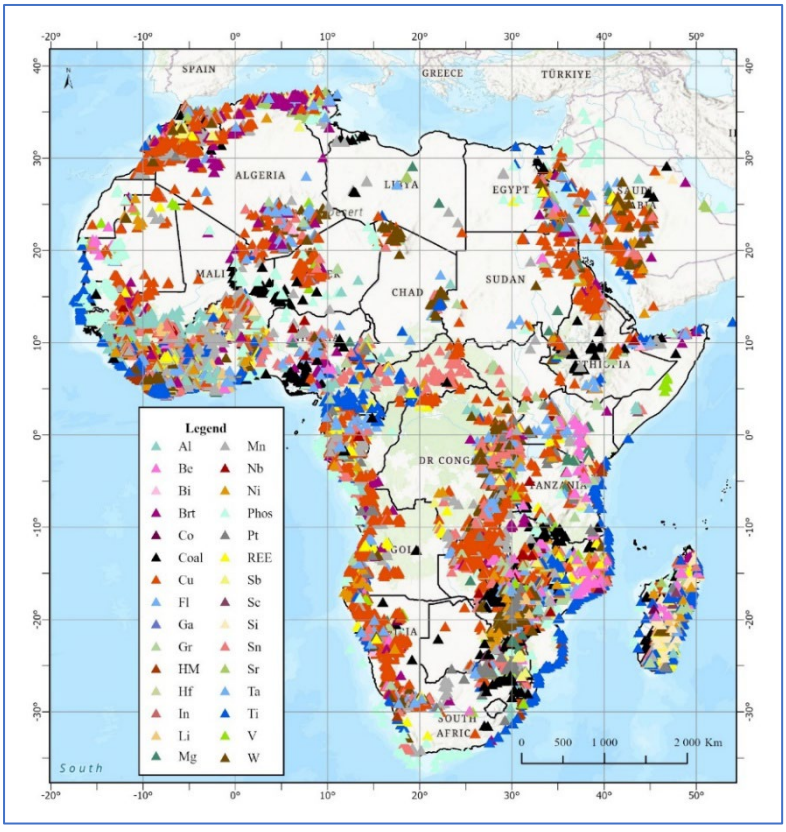


Figure 3. Overview of the AfricaMaVal geodatabase, illustrating the spatial distribution of ECRM across Africa.

Figura 3. Visão geral da geodatabase AfricaMaVal, ilustrando a distribuição espacial das ECRM em África.

2.2. Inventory of existing ore processing and refining capacities

2.2.1. Objectives

Assessing existing ore processing and refining capacities in Africa, defined here as concentrators, plants, refineries and smelters, is a critical step in understanding the current state of mineral beneficiation and identifying opportunities for cooperation, technological improvement and investment. This assessment enables the characterisation of existing infrastructure, levels of technological development and regulatory conditions, while also highlighting the challenges faced by African countries in strengthening their processing value chains.

2.2.2. Data sources, structure and resulting dataset

The processing facilities (PF) database was developed through the integration of multiple information sources, including publicly available datasets (*e.g.*, USGS, 2018; Padilla *et al.*, 2021, and others), data retrieved from mining company websites and proprietary datasets contributed by AfricaMaVal partners. Data verification and validation were supported by the S&P commercial database (S&P Capital IQ Pro, 2023). Additional expertise provided within the consortium contributed to improving data completeness and ensuring internal consistency.

The facilities included in the database are classified into four principal types:

Concentrators (n = 8; 4%)
Plants (n = 118; 54%)
Refineries (n = 45; 20%)
Smelters (n = 48; 22%)

These categories reflect the distinct roles performed within mineral and metallurgical processing chains. *Plants* function as general-purpose processing installations; *concentrators* upgrade the grade of valuable minerals through physical or chemical separation; *smelters* extract metals from ores through high-temperature processes; and *refineries* (in the context of metal beneficiation) further increase the purity and concentration of extracted metals.

Figure 4 presents the attribute table of the AfricaMaVal Processing Facilities geodatabase, providing a concise overview of the harmonised fields used to characterise each installation.

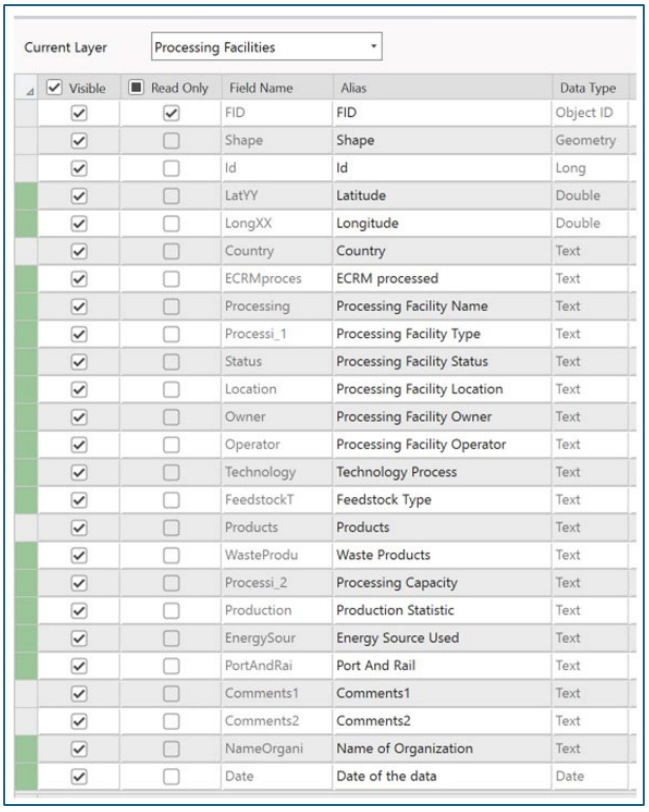
The table includes essential spatial attributes (Latitude, Longitude, Country, Location), facility descriptors (Processing Facility Type, PF Status, Owner, Operator, Processing Technology) and operational information (Products, Waste Products, Processing Capacity, Energy Source, Port and Rail). Metadata fields such as Comments, Name of Organization and Date of the data ensure traceability and support continuous updates. Each entry is linked to unique identifiers (FID, Id) and a geometry element (Shape), offering a consistent and interoperable structure for managing and analysing processing related data within the AfricaMaVal project.

The AfricaMaVal geodatabase comprises 219 documented processing facilities across the African continent. Mapping these entries provides a comprehensive spatial overview of processing activities and enables the identification of geographical patterns, clustering behaviour and regional inequalities in processing capacity (Fig. 5). The mapped facilities include plants, smelters, concentrators and refineries, each associated with one or more processed ECRM.

Figure 5 provides a spatial overview of these processing facilities and the specific ECRM they handle. The map shows high levels of clustering in southern and central Africa, particularly in South Africa, Zambia, Morocco and the Democratic Republic of Congo, where multiple critical raw materials, such as copper, cobalt, manganese and platinum group metals are processed. Conversely, other regions display sparse or isolated occurrences, highlighting strong geographical heterogeneity in processing capacity across the continent. The map thus serves as a basis for identifying processing hubs, gaps in infrastructure and potential areas for capacity development, while also highlighting the geographical concentration of specific raw materials.

To complement this spatial overview, a quantitative analysis of the facilities in the database provides further insight into the structure of processing capacity on the continent. At the country level, South Africa and the Democratic Republic of Congo emerge as the dominant hosts, with 59 and 53 facilities respectively, together accounting for more than half of all identified sites. A second group of countries, including Zambia, Morocco, Zimbabwe and Egypt, hosts more modest but still significant numbers of facilities, while most African nations contain only one to six installations, indicating a pronounced disparity in processing infrastructure. These country-level patterns are summarised in figure 6A.

A complementary analysis of the materials processed (Fig. 6B) shows an equally uneven distribution across ECRM types. Copper is by far the most represented material, processed in 80 facilities (37 % of the total), followed by phosphate rock and cobalt (each n = 27; 12 % of the total), manganese (n = 23; 11 % of the total) and



Current Layer: Processing Facilities

Visible	Read Only	Field Name	Alias	Data Type
☑	☑	FID	FID	Object ID
☑	☐	Shape	Shape	Geometry
☑	☐	Id	Id	Long
☑	☐	LatYY	Latitude	Double
☑	☐	LongXX	Longitude	Double
☑	☐	Country	Country	Text
☑	☐	ECRMproces	ECRM processed	Text
☑	☐	Processing	Processing Facility Name	Text
☑	☐	Processi_1	Processing Facility Type	Text
☑	☐	Status	Processing Facility Status	Text
☑	☐	Location	Processing Facility Location	Text
☑	☐	Owner	Processing Facility Owner	Text
☑	☐	Operator	Processing Facility Operator	Text
☑	☐	Technology	Technology Process	Text
☑	☐	FeedstockT	Feedstock Type	Text
☑	☐	Products	Products	Text
☑	☐	WasteProdu	Waste Products	Text
☑	☐	Processi_2	Processing Capacity	Text
☑	☐	Production	Production Statistic	Text
☑	☐	EnergySour	Energy Source Used	Text
☑	☐	PortAndRai	Port And Rail	Text
☑	☐	Comments1	Comments1	Text
☑	☐	Comments2	Comments2	Text
☑	☐	NameOrgani	Name of Organization	Text
☑	☐	Date	Date of the data	Date

Figure 4. Attribute structure of the AfricaMaVal Processing Facilities geodatabase.

Figura 4. Estrutura de atributos da geodatabase de Instalações de Processamento do AfricaMaVal.

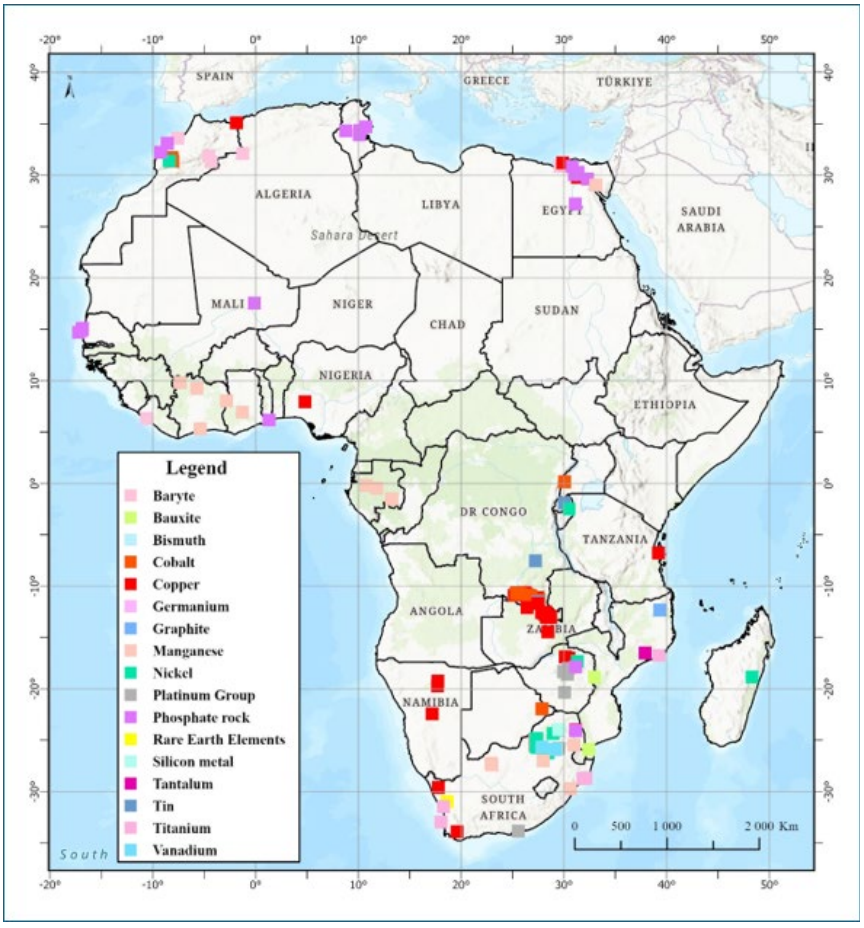


Figure 5. Spatial distribution of ECRM processing facilities across Africa. WMS accessible at: https://sig.lneg.pt/server/services/Projects/AfricaMaVal/MapServer/WMSServer?

Figura 5. Distribuição espacial das instalações de processamento de ECRM em África. WMS acessível via: https://sig.lneg.pt/server/services/Projects/AfricaMaVal/MapServer/WMSServer?

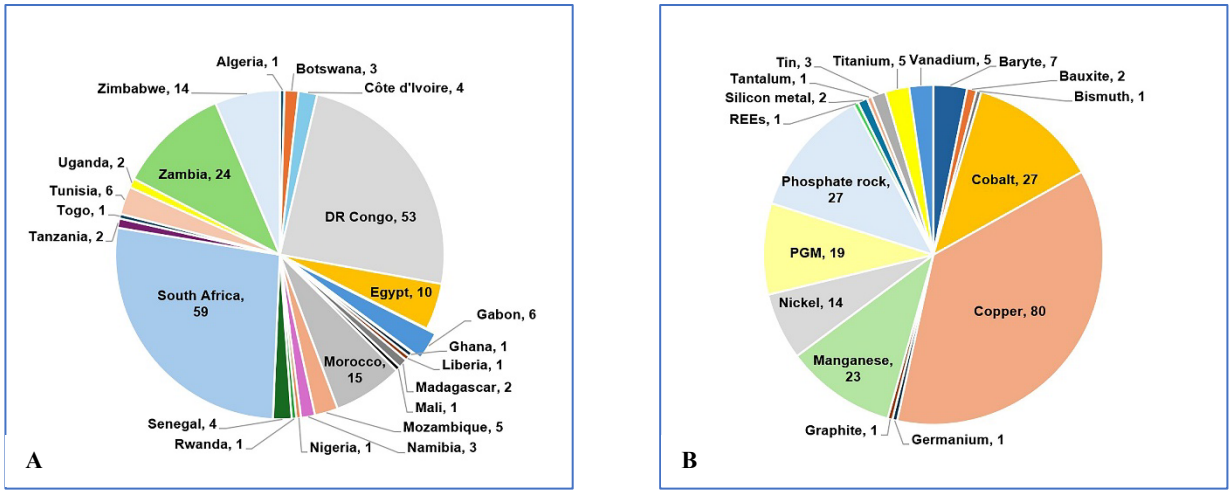


Figure 6. A) Number of processing facilities identified in each African country; B) number of processing facilities by ECRM type.

Figura 6. A) Número de instalações de processamento identificadas em cada país africano; B) número de instalações de processamento por tipo de ECRM.

platinum-group metals (n = 19; 8% of the total). Many other ECRM occur in only a handful of facilities, and several, including germanium, graphite, rare earth elements, tantalum, bismuth and silicon metal are processed in only one facility each. This pattern reflects Africa's strong focus on well-established mining and metallurgical sectors such as copper, cobalt and manganese, while processing activities for technologically strategic but less abundant materials remain limited.

Figure 7 shows the proportion of processing facility types such as plants, concentrators, smelters and refineries hosted by different African countries. The charts reveal that processing capacity is highly unevenly distributed across the continent: plants are widespread but dominated by the Democratic Republic of Congo and South Africa, while concentrators, smelters and refineries are strongly concentrated in only a few countries, with South Africa emerging as the major hub across most facility types.

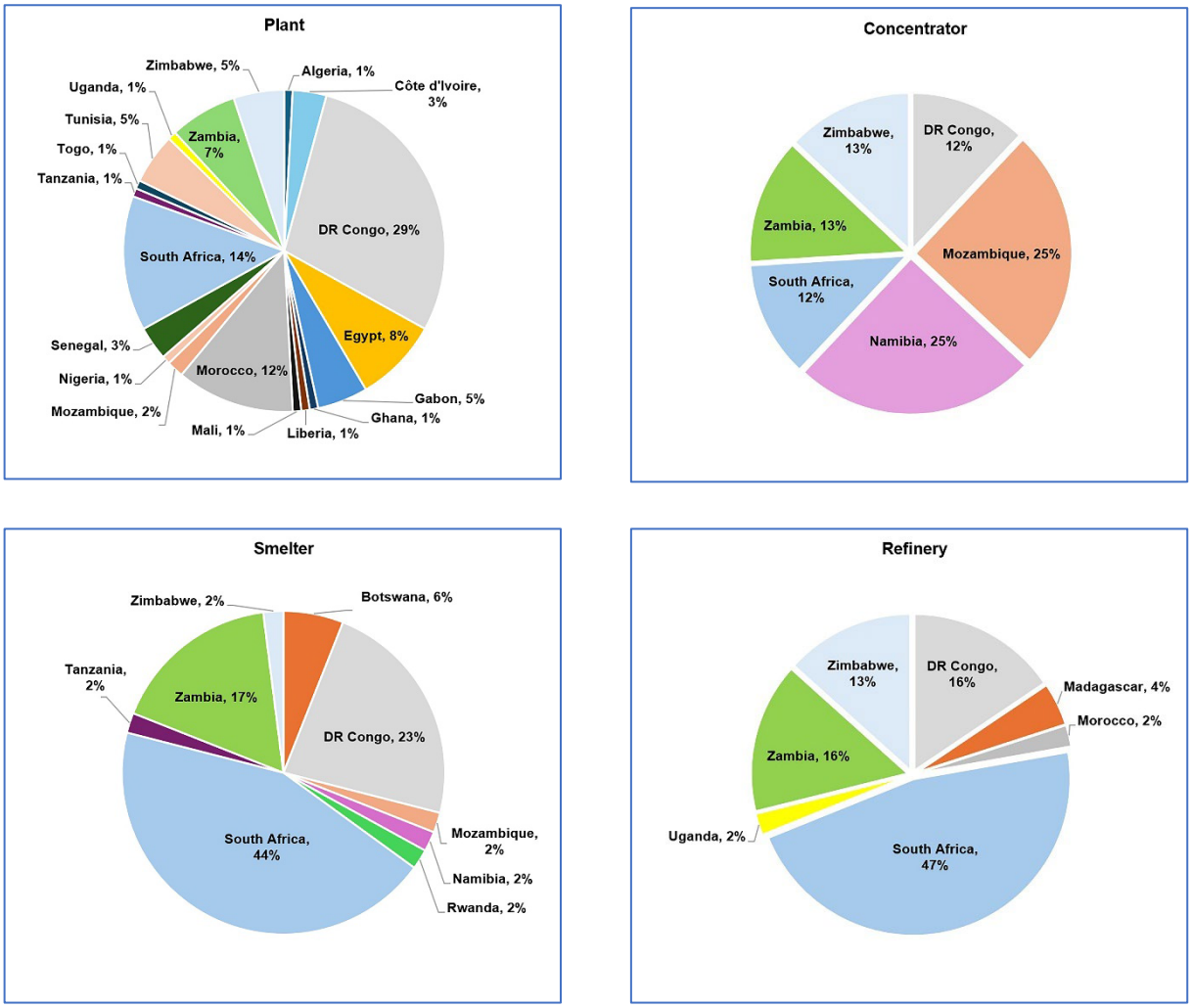


Figure 7. Proportion of processing facility types (plants, concentrators, smelters and refineries) by country across Africa.

Figura 7. Proporção dos tipos de instalações de processamento (instalações de tratamento, concentradores, fundições e refinarias) por país em África.

Figures 8 and 9 compare South Africa and the Democratic Republic of Congo in terms of the processing facility types they host and the ECRM processed within each country. South Africa shows a balanced distribution of smelters, refineries and plants together with a diversified ECRM portfolio, whereas the Democratic Republic of Congo is dominated by plant-type facilities and processes mainly copper and cobalt.

The AfricaMaVal project offers a consolidated and interoperable foundation for understanding Africa's Extended Critical Raw Materials (ECRM) landscape and its associated processing capacities. Beyond compiling two harmonised pan-African inventories, the project demonstrated the value of integrating heterogeneous data into a common compliant framework, enabling cross-country comparability and supporting evidence-based decision-making. The harmonisation of legacy datasets, particularly the transformation of the more detailed SigAfrique classifications into INSPIRE-compatible structures, illustrated the feasibility of aligning diverse data sources while maintaining analytical usefulness, even though the process inevitably reduces geological specificity.

The cartographic representations developed from these inventories significantly enhance the usability of the data, allowing rapid visual assessment of spatial patterns, processing hubs and infrastructural gaps. These visual tools provide a practical basis for identifying regions with strong potential for value chain development as well as areas where targeted investment could expand local processing capacity or diversify the portfolio of materials handled.

The insights generated through AfricaMaVal point towards concrete opportunities for strengthening EU-Africa cooperation in mineral resource development. The inventories can support national and regional planning, guide industrial actors in assessing investment prospects, and help policymakers design strategies aimed at increasing processing capabilities for a broader range of ECRM.

By providing transparent, up-to-date and interoperable information, the project created favorable conditions for long-term partnerships that promote sustainable resource management and contribute to more resilient and diversified raw material supply chains for both Africa and the European Union.

Acknowledgements

The authors express their sincere gratitude to Carol Zammit for her valuable support and dedication in coordinating the initial stages of the project. AfricaMaVal is financed under Horizon Europe with Grant Agreement number 101057832.

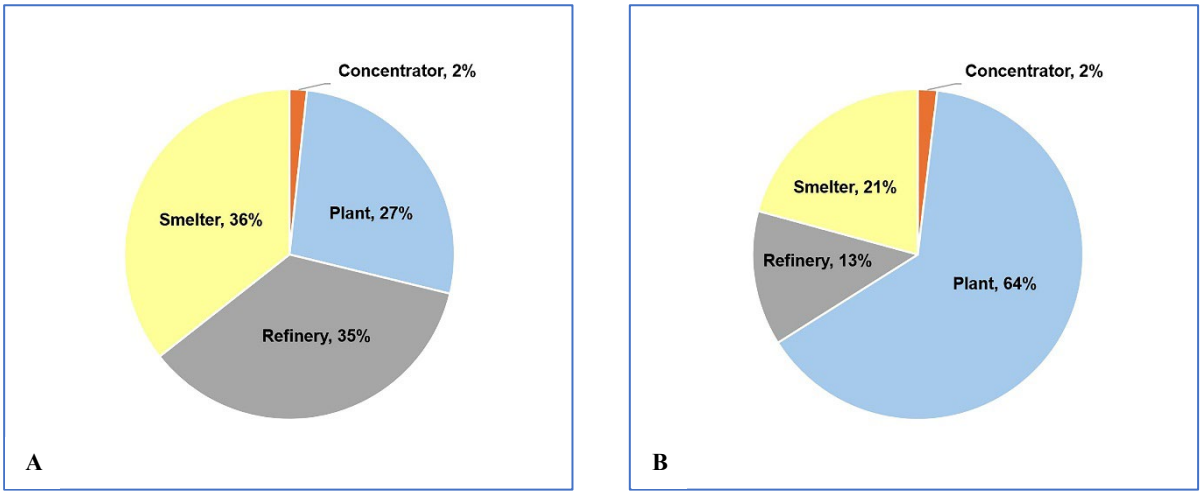


Figure 8. A) Proportion of processing facility types hosted in South Africa (A) and in the Democratic Republic of Congo (B).

Figura 8. A) Proporção dos tipos de instalações de processamento existentes na África do Sul; B) Proporção dos tipos de instalações na República Democrática do Congo.

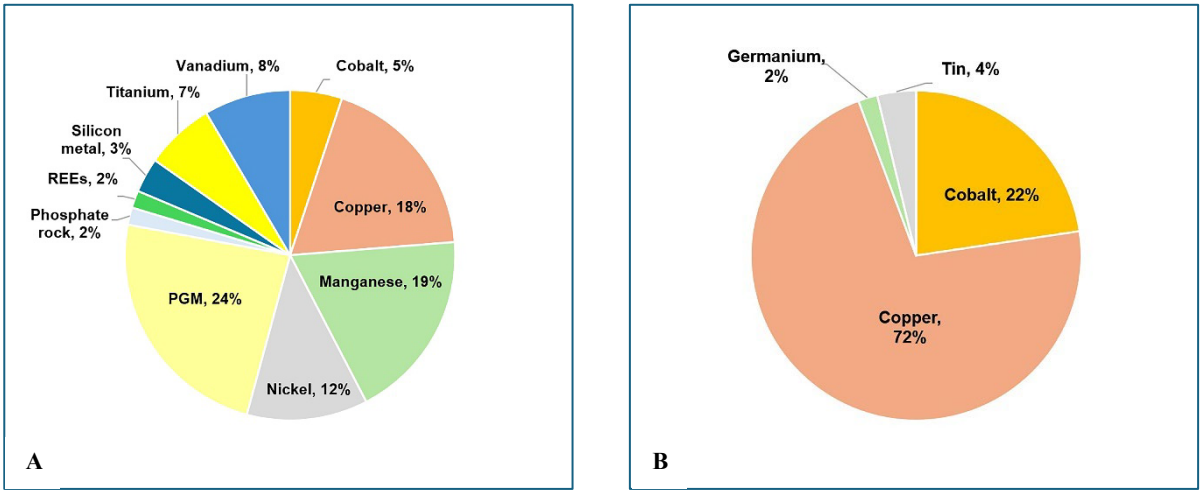


Figure 9. A) Proportion of ECRM processed within South African (A) and Democratic Republic of Congo (B) processing facilities.

Figura 9. A) Proporção das ECRM processadas nas instalações da África do Sul; B) Proporção das ECRM processadas nas instalações da República Democrática do Congo.

References

Cassard, D., Tertre, F., Bertrand, G., Tellez-Arenas, A., Schjøth, F., Tulstrup, J., Heijboer, T., Vuollo, J., Cápová, D., Šinigoj, J., Gruijters, S., Tomas, R., Schubert, C., 2014a. The Minerals4EU Knowledge Data Platform for managing Web-based mineral resources information in Europe. *Minerals in Circular Economy Conference (MINCE)*. Espoo, Finland, 26-27 November 2014.

Cassard, D., Tertre, F., Tulstrup, J., Vuollo, J., Tomas, R., Capova, D., Sinigoj, J., Delfini, C., Burlet, C., 2014b. The Minerals4EU Knowledge Data Platform: implementing INSPIRE data models in the first pan-european raw materials knowledge base. *INSPIRE Conference 2014*. Aalborg, Denmark, 16-20 June 2014.

Cassard, D., Tertre, F., Bertrand, G., Tellez-Arenas, A., Schjøth, F., Tulstrup J., Heijboer, T., Vuollo, J., Čápová, D., Šinigoj, J., Požar, M., Gruijters, S., Bogaard, P., Waardenburg, F., Tomas, R. and Schubert, C., 2015. Minerals4EU – INSPIRE in Action: Pan-European Raw Materials Knowledge Base Data Platform. *INSPIRE Conference 2015*. Lisbon, Portugal, 25-29 May 2015.

Chris Schubert (EC-JRC), Jouni Vuollo (GTK), Robert Tomas (EC-JRC), Daniel Cassard (BRGM), and WP5 Partners. Minerals4EU, 2014. Minerals Intelligence Network for Europe – Minerals4EU. *WP5: Common terminology for Minerals4EU – Version 1.0*, 330.

de Oliveira, D. P. S, Fortes, C., Patinha, P, Le Gleuher, M., Cornelissen, H., Christou, N., Vasters, J., Schütte, P., 2023. D1.3 – Pan-African inventory of existing ore processing and refining capacities. *WP1-Task 1.3. AfricaMaVal - EU-Africa Partnership on Raw Material Value chains*. September 2023.

European Commission, COM/2008/699 final, 2008. Communication From the Commission to the European Parliament and the Council: The Raw Materials Initiative – Meeting Our Critical Needs for Growth and Jobs in Europe.

European Commission, COM/2011/0025 final, 2011. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions: Tackling the Challenges in Commodity Markets and on Raw Materials.

European Commission, COM/2014/0297 final, 2014. Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: On the Review of the List of Critical Raw Materials for the EU and the Implementation of the Raw Materials Initiative.

European Commission, COM/2017/0490 final, 2017. Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions: On the 2017 list of Critical Raw Materials for the EU.

European Commission, COM/2019/640 final, 2019. Communication from the Commission to the European Parliament, The European Council, The Council, The European Economic and Social Committee and the Committee of the Regions: The European Green Deal.

European Commission, COM/2020/474 final, 2020. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions: Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.

European Commission, 2021. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, 2021. 3rd Raw Materials Scoreboard – European innovation partnership on raw materials, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2873/567799.

European Commission, 2023. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Grohol, M. and Veeh, C., 2023. Study on the critical raw materials for the EU 2023 – Final report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2873/725585.

European Commission. Press Release, 2023. Global Gateway: EU and Namibia agree on next steps of strategic partnership on sustainable raw materials and green hydrogen. https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_23_5263/IP_23_5263_EN.pdf.

European Commission, 2024. Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020.

European Commission. Press Release, 2024. EU and Rwanda sign a Memorandum of Understanding on Sustainable Raw Materials ValueChains. https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_24_822/IP_24_822_EN.pdf.

FRAME Project, 2018. Forecasting and Assessing Europe's Strategic Raw Materials needs. *Deriverable: D3.1: Producing a report describing the methodology used for the identification and selection process of the CRM to be included in the metallogenetic map*. http://www.frame.lneg.pt

Fortes, C., Viegas, H., de Oliveira, D. P. S, Filipe, A., Almeida, P., Gruijters, S., 2013. EUROGEOSOURCE – The new generation of EU mineral and energetic resources Web GIS Systems using cloud computing". *Geonovas*, **26**: 03-10.

Fortes, C., de Oliveira, D. P. S., Prazeres, C., 2023. D1.1 – INSPIRE compliant data set of Pan-African inventory of the known CRM deposits. *WP1-Task 1.1. AfricaMaVal - EU-Africa Partnership on Raw Material Value chains*. February 2023

INSPIRE, 2014. D2.8.III.21 Data Specification on Mineral Resources – Technical Guidelines. https://inspire-mif.github.io/technical-guidelines/data/mr/dataspecification_mr.pdf.

Laxton, J. L., 2016. Geological map fusion: OneGeology-Europe and INSPIRE". *Geological Society, London, Special Publications*, **408**: 147-160. https://doi.org/10.1144/SP408.16.

Lopes, C., Quental, L., de Oliveira, D.P.S., Filipe, A., Pereira, A., 2018. INSPIRE data harmonisation of mineral resources: contribution of MINERALS4EU Project. *Mapping*, **27**(187): 56-63, enero-febrero 2018. ISSN: 1131-9100

Pantaloni, M., Campo, V., Congi, M. P., Monti, G. M., Primerano, P., Ventura, R., 2021. The INSPIRE harmonisation: the Geological Map of Italy at 1:100,000 scale", *Proc. Int. Cartogr. Assoc.*, **4**: 85.

Pereira, A., Luís, G., Cabral, P., 2013. INSPIRE Geology Data Model Implementation in Digital. Geological Map Production in Portugal: A Preliminary Approach. International *Journal of Spatial Data Infrastructures Research*, **8**: 128-143. https://doi.org/10.2902/1725-0463.2013.08.art6 .

Padilla, A. J., Otarod, D., Deloach-Overton, S. W., Kemna, R. F., Freeman, P.A., Wolfe, E. R., Bird, L. R., Gulley, A. L., Trippi, M. H., Dicken, C. L., Hammarstrom, J. M., Brioche, A. S., 2021. Supporting Data for USGS data release entitled: "Compilation of Geospatial Data (GIS) for the Mineral Industries and Related Infrastructure of Africa". https://doi.org/10.5066/P97EQWXP.

S&P-Capital IQ Pro Database, 2023. *S&P Global Market Intelligence, a division of S&P Global Inc*. S&P Global Market Intelligence, 55 Water Street, New York, NY 10041.

Vuollo, J., Eloranta, T., Cassard, D., Tomas, R., Schubert, C., 2014. Geoscience Data Transfers Standards: EarthResourceML and GeoSciML, tools to deliver mineral resources data in EU and globally. The EU-MKDP example. *Minerals in Circular Economy Conference (MINCE)*. Espoo, Finland, 26-27 November (2014).

Waardenburg, Frank D. E., Heijboer, Tjerk C., Pen, Simon, Schjøth, Frands and WP5 Team, 2014. Minerals4EU, WP5. The Enterprise Architect UML and model for Min4EU Database.