MADITRACE

Final event report

Deliverable D5.7

Final Version

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Document information

Grant Agreement	n°101091502
Project Title	Material and digital traceability for the certification of critical raw materials
Project Acronym	MaDiTraCe
Project Coordinator	Daniel Monfort, BRGM
Project Duration	1 January 2023 – 30 June 2026 (42 months)
Related Work Package	WP5
Related Task(s)	T5.5
Lead Organisation	BRGM
Contributing Partner(s)	BRGM, ISMC, CEA, DMT, MUL, Spherity, AHK, GTK, ULEI, Funditec, UGENT, Metso
Due Date	M42
Submission Date	30/06/2026
Dissemination level	Public

History

Date	Version	Submitted by	Reviewed by	Comments
25/6/2026	1	D. Monfort (BRGM)	A. Garcia (ISMC)	
30/6/2026	Final	D. Monfort (BRGM)	A. Paul (LGI)	

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Summary

The final event of the MaDiTraCe project was held in Espoo at the headquarters of GTK and Metso. Around forty participants both on site and online were present. The event combined presentations of the main project results with invited keynote talks addressing key topics in critical raw material traceability.

The program also provided an overview of the current European regulatory framework for material traceability, as well as the project's key scientific and technological outcomes, such as material and artificial fingerprinting, digital product passports, supply chain mapping, and LCA integration. Developments within CERA4in1, communication activities, and the proposed "Mined in Europe" label and project roadmap were also presented.

In addition to the technical sessions, participants took part in laboratory visits and interactive demonstrations, and a poster session showcased research outputs from project partners over the course of the project.

Keywords

Material Traceability, Digital Product Passport (DPP), Critical Raw Materials (CRMs), responsible sourcing, responsible business conduct.

Abbreviations and acronyms

Acronym	Description
AFP	Artificial Fingerprint
CAHRA	Conflict-Affected and High-Risk Areas
CE	From French "Conformité Européenne"
CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
CENELEC	European Committee for Electrotechnical Standardization
CoC	Chain of Custody
CRM	Critical Raw Material
CRMA	Critical Raw Materials Act
CSDDD	Corporate Sustainability Due Diligence Directive
DPP	Digital Product Passport
EU	European Union
EUBR	EU Battery Regulation
FATF	Financial Action Task Force
G7	Grous of Seven countries: Canada, France, Germany, Italy, Japan, the United Kingdom and the United States; additionally, the European Union (EU) is a "non-enumerated member".

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GBA	Global Battery Alliance
ICT	Information & Communication Technology
IEA	International Energy Agency
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
MFP	Material Fingerprint
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
REE	Rare Earth Elements
SAE	Society of Automotive Engineers (USA)
TRL	Technology Readiness Level
UNECE	United Nations Economic Commission for Europe
UNTP	United Nations Transparency Protocol
VC	Verified Credential
WP	Work Package
XRF	X-ray fluorescence

1. Introduction, final event agenda

1.1 MaDiTraCe Context

MaDiTraCe project endeavours to expand and integrate a range of technological solutions for enhancing traceability and certification within responsible and sustainable supply chains of critical raw materials (CRMs). This initiative seeks to consolidate these solutions into a Digital Product Passport (DPP) compatible with the EU battery passport. By implementing comprehensive tracking mechanisms, MaDiTraCe aims to enhance the transparency, traceability, and sustainability of complex supply chains involving critical raw materials.

The project started in January 2023 and finalize in June 2026. The project final event was organised in Espoo (Finland) on 10th and 11th June 2026.

1.2 Event Dissemination and Promotion

With the aim of maximising the visibility of the MaDiTraCe final event and encouraging widespread participation, the ISMC, as the partner responsible for communication and dissemination activities (WP5), developed and implemented a comprehensive dissemination strategy with the support of all project partners. A combination of online and in-person communication channels was used to ensure that key stakeholders were kept informed and actively involved in the preparations leading up to the event.

Website

Detailed information about the final event, including the date, venue, programme, speakers and registration details, was published on the MaDiTraCe project website. The website served as the main information source, providing participants with up-to-date information and easy access to the registration process.

Social media

The event was actively promoted through the project's LinkedIn account using dedicated posts and relevant hashtags to increase visibility and reach a wider audience. The social media campaign highlighted the event objectives, key topics, speakers, and registration opportunities, encouraging interaction and engagement from stakeholders across the raw materials value chain.

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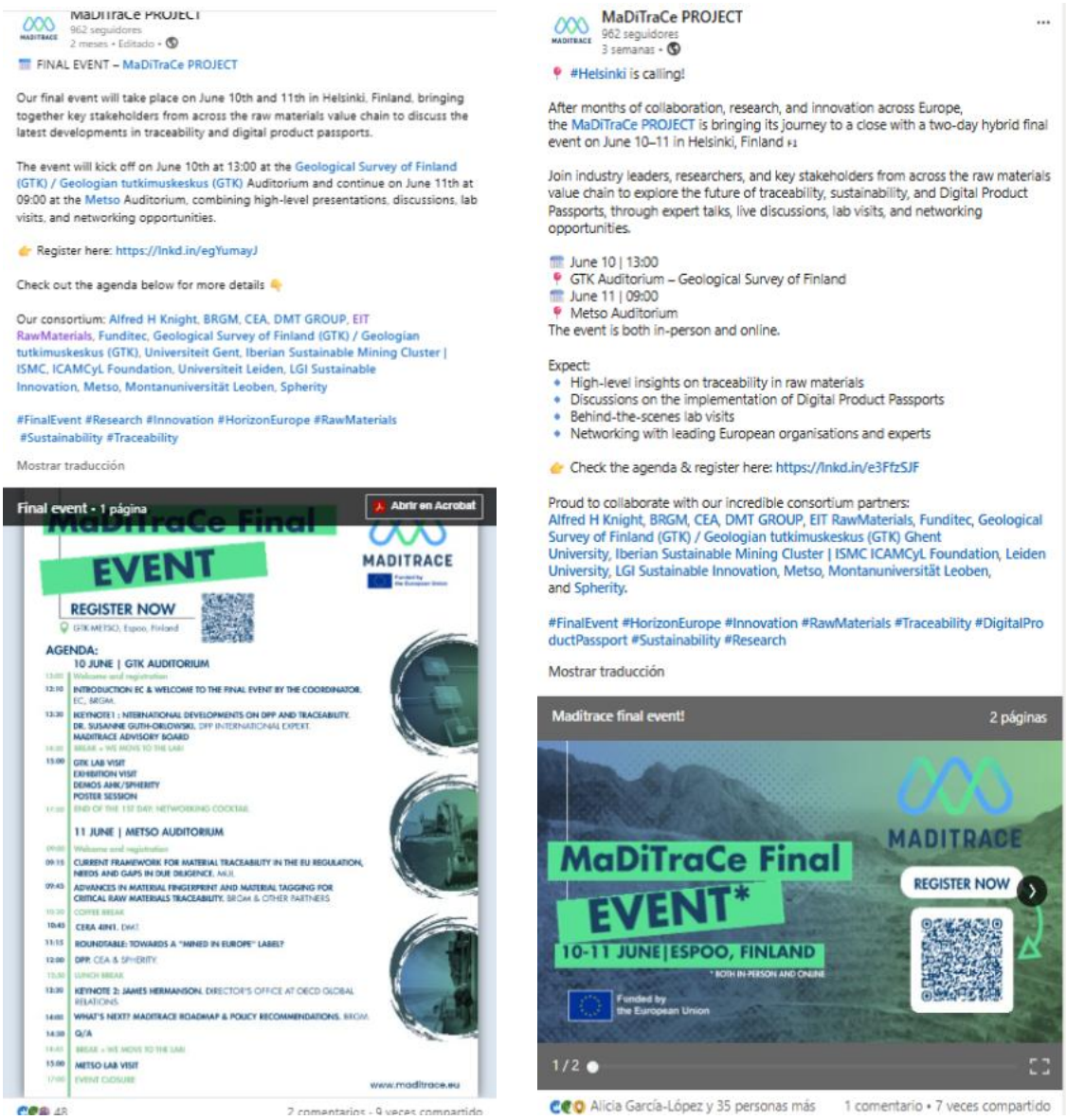

Figure 1: Dissemination of final event in LinkedIn

Newsletter

A dedicated newsletter announcing the Final Event was distributed on 15 May 2026 to MaDiTraCe subscribers, reaching a total of 101 recipients. The newsletter included key information about the event, the registration link, and an overview of the topics to be addressed during the sessions.

Join us in Helsinki for MaDiTraCe Final Event!

We are pleased to invite you to the **MaDiTraCe Project Final Event**, taking place on **10–11 June 2026** in Espoo city, part of the Helsinki urban area.

This two-day event will bring together key stakeholders from across the raw materials value chain to explore the latest developments in traceability systems and Digital Product Passports (DPPs), with a special focus on their implementation within the evolving EU policy and industrial landscape.

Day 1 – 10 June | Geological Survey of Finland (GTK)

Starting at 13:00

Presentation of the main MaDiTraCe project outcomes and international developments in traceability systems and Digital Product Passports (DPPs).

The programme will also include laboratory visits and networking opportunities.

Day 2 – 11 June | Metso Facilities

Starting at 09:00

Expert presentations on the EU framework for material traceability and the latest advances in material fingerprinting technologies.

The event will conclude with a roundtable discussion and a guided laboratory visit.

Participation of OECD and UN/CEFACT experts has been confirmed.

Registration is now open

For additional information and the latest agenda updates, please visit MaDiTraCe Website

Figure 2: Newsletter launched about the final event

Mailing Campaign

An email invitation template was prepared and circulated through the mailing lists of all project partners. In addition, the event was promoted through the networks and stakeholder communities of the MaDiTraCe consortium, ensuring that the invitation reached a broad audience, including representatives from industry, research organisations, public authorities, and other relevant actors in the raw materials sector.

Promotional materials

To support the dissemination campaign, several promotional materials were designed and produced, including flyers and banners highlighting the event objectives, key topics, and agenda. These materials were distributed both digitally through the project's

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communication channels and physically during the EIT RawMaterials Summit (19–21 May), where the MaDiTraCe project participated with a dedicated dissemination booth, further enhancing the visibility of the Final Event among relevant stakeholders.

Figure 3: Dissemination flyer at EIT Raw Material Summit 2026

Final Event Agenda

MaDiTraCe project final event was held in Espoo (Finland) in GTK (10th June 2026) and METSO (11th June 2026) facilities, both partners of the project.

The agenda (Figure 4) consisted of technical presentations of the project results, giving time to all WPs, with technical visits to laboratories or test rooms of GTK and METSO. In addition to it, there were two keynotes of externals to the project: Susanne Guth (4theRecord), consultant expert on product passport participating to UNTP and James Hermanson from OECD.

The event was held in hybrid mode, with 40 registered persons following it online.

Figure 4. Agenda of the final event of MaDiTraCe project hold in GTK and METSO facilities.

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2 Final event proceedings

2.1 Welcome and introduction

The final event started the 10th June with the welcoming speech of the Marja Lehtonen, the head of the Circular Economy Solutions unit, GTK (Figure 5).

Figure 5. Welcome speech of Marja Lehtonen, head of the Circular Economy Solutions unit, GTK.

Daniel Monfort (BRGM), the project coordinator, introduced the final event (Figure 6) giving a short overview of several main results of the project and contextualizing the importance of the project in 2026, with different international initiatives around traceability (OECD, IEA, G7, Europe, Australia, Canada, ISO, UN).

Figure 6. Introduction of the MaDiTraCe project by Daniel Monfort (BRGM).

2.2 Keynote 1. S. Guth-Orlowski: The Future of Supply Chain Transparency. Data, Identity & Trust in the Battery Ecosystem

Susanne Guth-Orlowski (4TheRecord) (Figure 7) gave a keynote on the first day about UN initiatives Transparency Protocol as she is an expert participating in this initiative.

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Figure 7. The keynote speaker Susanne Guth-Orlowski (4TheRecord).

S. Guth-Orlowski participated initially in the kick-off of MaDiTraCe project when she was in a former position in Spherity. After this, she has been consultant for EU Commission, UN, CENELEC and SAE.

She explained the governance of United National Transparency Protocol (UNTP) under the bureau of UN/CEFACT (Figure 8).

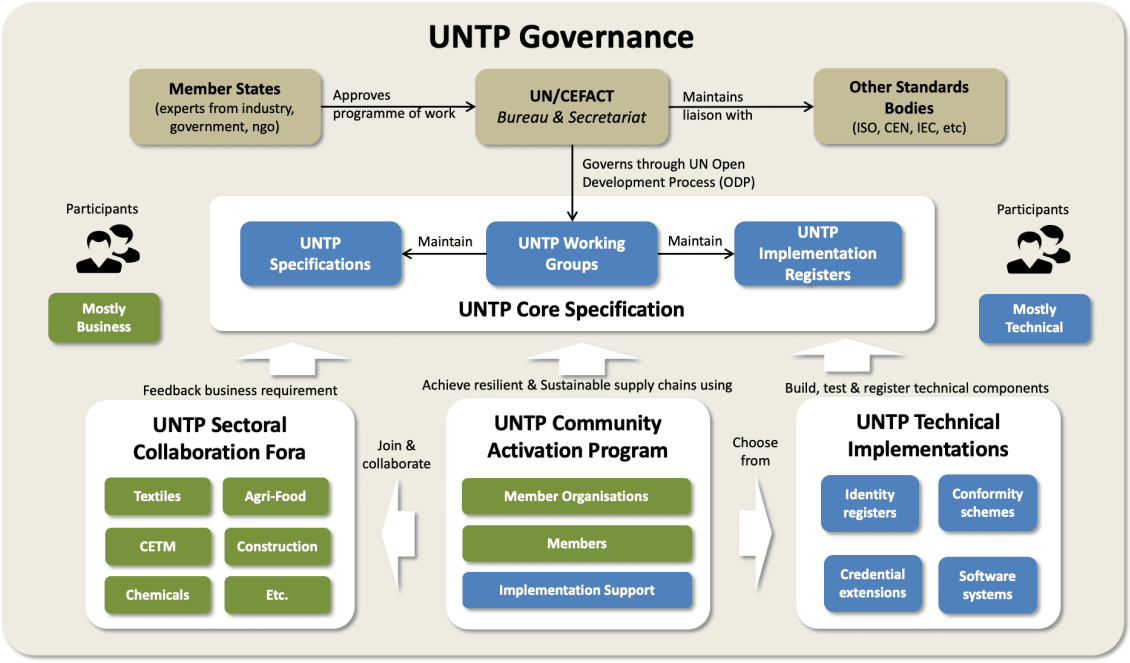

Figure 8: UNTP governance. Slide presented by S. Guth.

During the keynote she presented the recommendation No. 49 Transparency at scale – Fostering sustainable value chains (UNECE 2025) and she presented a schema (Figure 9) about how this recommendation could look like for a copper supply chain including MaDiTraCe MFP technique. In this schema are identified several Verified Credentials:

- Voluntary sustainable standards VC
- Material fingerprint VC
- CO2 emissions/footprint VC
- CE marking VC
- Human rights declaration VC

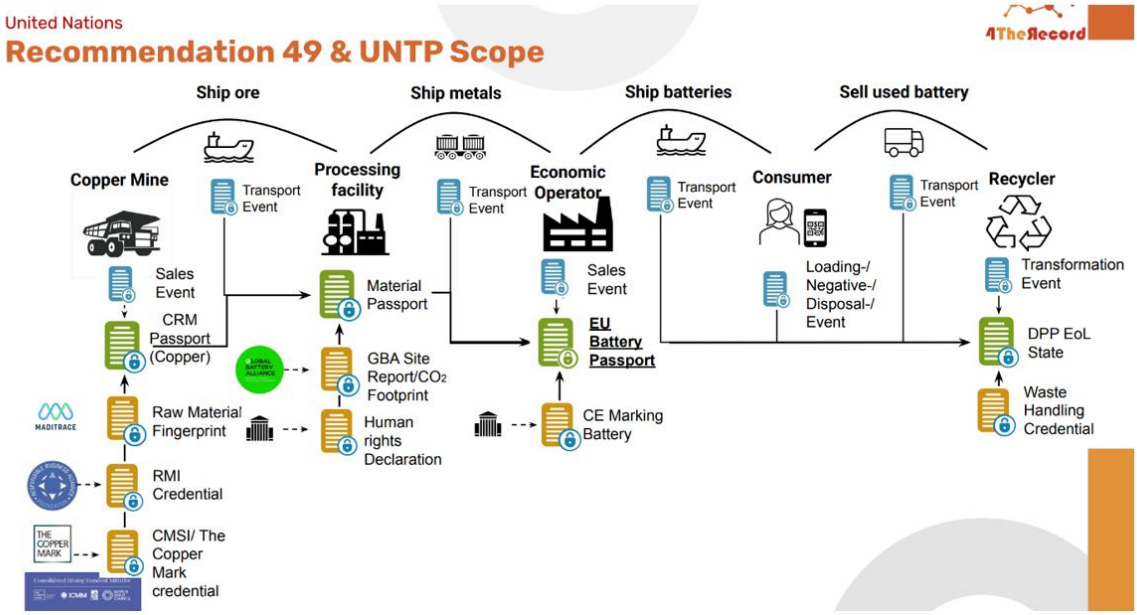

Figure 9: recommendation 49 adapted by S. Guth-Orlowski.

For a battery passport perspective, UNTP core element distinguishes between the battery passport data (contains organization data, facility data, technical product information), digital traceability event and digital conformity credential (like for example a credential for an entity giving a certification of sustainable practices) (Figure 10).

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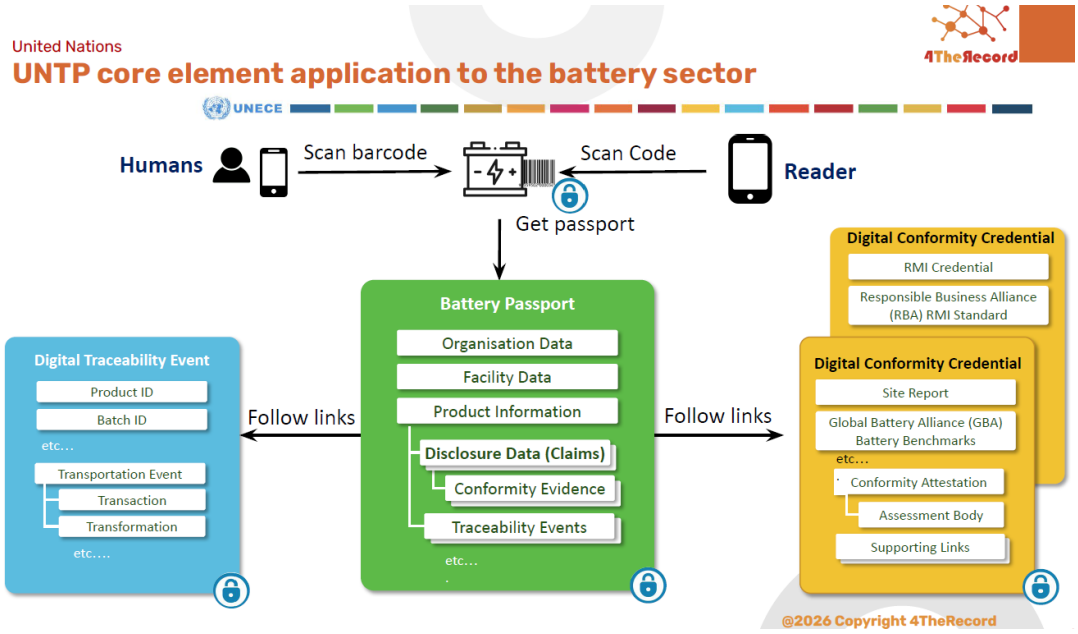

Figure 10: UNTP core element application to the battery sector. Slide presented by S. Guth (4TheRecord) in MaDiTraCe final event.

Finally during the keynote she presented the proposal for a European Business Wallet (EUBW)[1], which is a digital infrastructure that enables companies to securely manage, share, and verify organizational data using signed verifiable credentials (also called electronic attestation of attributes).

2.3 Keynote 2. J. Hermanson (OECD): Traceability for Resilient Critical Mineral Supply Chains

James Hermanson (Figure 11) presented some outputs of recent projects and works in OECD about critical minerals traceability. The objective of those works is to assess the uptake, drivers and limitations of traceability in critical mineral supply chains, drawing on an OECD-IEA survey of 90 leading companies, stakeholder interviews and site visits.

1 https://digital-strategy.ec.europa.eu/en/library/proposal-regulation-establishment-european-business-wallets

Figure 11. Keynote speaker James Hermanson (OECD).

The study has case studies on lithium in Chile and Argentina and nickel in Indonesia and the Philippines. A part of the study was already published in April 2026 by IEA and a second part of the study would be published in summer 2026.

For the short-term actions the OECD study proposes to promote Responsible Business Conducts based on OECD guideless, use existing trade data and harmonize smelter origin disclosure. One important priority is to encourage and calibrate traceability to actual risk. Half of the smelters and refiners still collect same information regardless of risks.

For the mid-term they distinguish actions with more engagement with midstream actors. Use expenditure-based incentives instead income-based tax holidays such as Chile's accelerated depreciation rules for capital intensive mining. They recommend as well verify physical evolution adding independent assay with split-sampling. SIMBARA[2] traceability initiative in Indonesia was cited as reference. Finally, a clarification about the beneficial ownership in supply chains is proposed, OECD is working on it.

For long-term actions, the emphasis is on data interoperability and expansions and harmonization of DPP practices. A traceability/CoC system with identity preservation would be reserved only for the most sensitive materials. Currently less than 30% of smelters consulted in OECD study use identity preservation due to cost. This CoC model must be used only in particular high-risk cases where other models are insufficient.

[2] https://www.iea.org/policies/25388-simbara-inter-ministryinstitutional-mineral-and-coal-information-system

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After the Q&A Hermanson identified R&D in traceability as an important aspect to consider.

2.4 Current framework for material traceability in Europe regulation

Paulina Fernandez from Montanuniversität Leoben (MUL, Austria) (Figure 12) presented the work done in the WP1 of the project, analyzing gaps in regulation and assessing the place for material traceability in frameworks (UN, OECD), laws and international instruments, activities and collaborations and Voluntary sustainable standards (VSS), mapping a total of 121 instruments covering the period 2010–2024 and highlighting that, despite the breadth of the landscape, a unified approach is still lacking.

Figure 12: Paulina Fernandez presenting during the final event.

Related to EU regulation, she mapped the place for traceability in 4 main EU regulations: CRMA, EBR, CSDDD and ESPR (Figure 13).

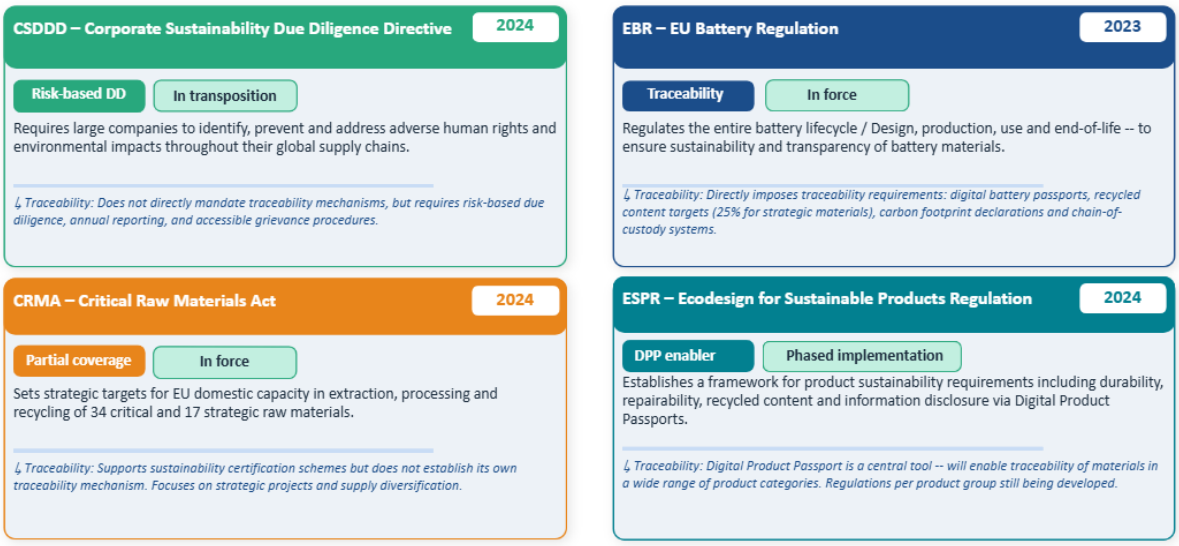

Figure 13: legal framework and key regulations for traceability in the EU (from Paulina Fernandez).

For VSS a comparison between several VSS was presented adapted to primary and secondary raw materials, in particular IRMA, RMI, CERA4in1 and The Copper Mark.

In addition, she presented the proposed conceptual framework for mineral traceability where traceability is a systemic process, not only a technical fix (Figure 14).

- Governance is the foundation -- defines accountability and data integrity rules
- Supply chain management translates governance into operational chain-of-custody procedures
- Social and environment impacts ensure people -- including ASM -- are not left behind
- Technology and analytics act as an enabler through tools such as blockchain, fingerprinting, digital product passports and chain-of-custody systems
- Evaluation keeps the system honest and adaptive as regulations evolve

Finally, she gave some recommendations for industry, policymakers and industry standard bodies (Figure 15).

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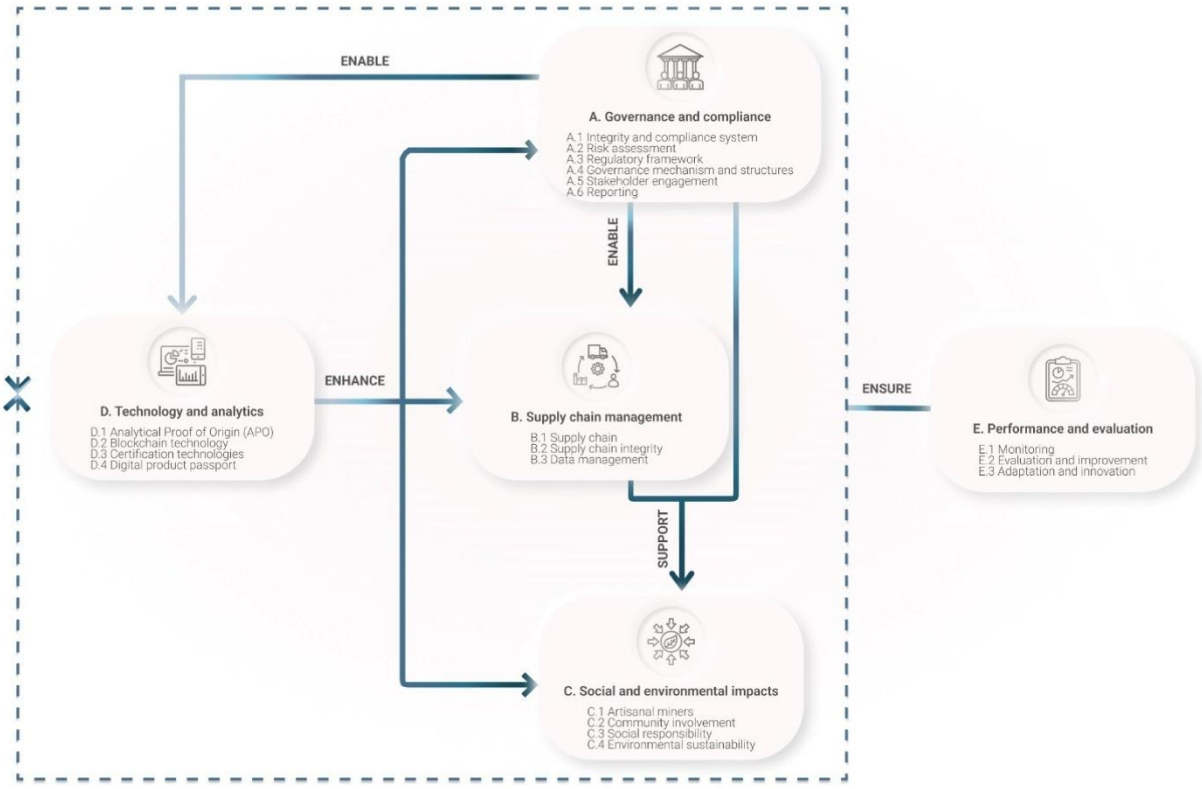

Figure 14: mineral traceability framework proposed by Fernandez et al (2026).

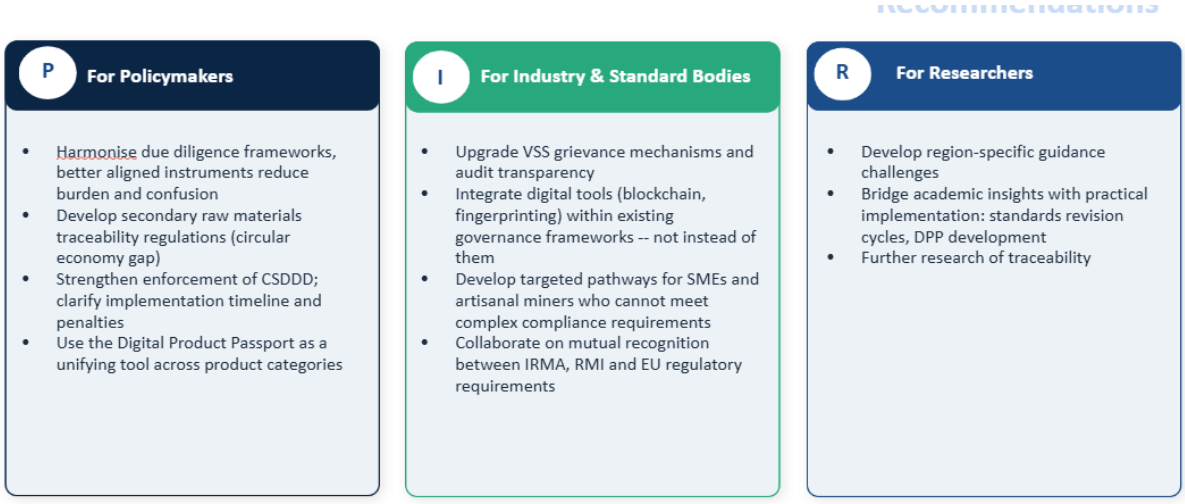

Figure 15: main recommendation from the perspective of regulatory and voluntary standard framework.

2.5 Material fingerprinting and artificial fingerprinting

The following presentations focused on the four critical raw materials (Li, Co, natural C and Nd) investigated within MaDiTraCe. Each partner (BRGM, GTK, MUL, UGent) presented the main results obtained for the commodity under their responsibility (Figure 16), including the analytical methods evaluated, the statistical approaches applied and the key advances achieved in traceability (Figure 17). The presentation also featured the developments in Artificial Fingerprinting presented by GTK and AHK.

Figure 16. Presenters of the results for the material fingerprint and artificial fingerprint.

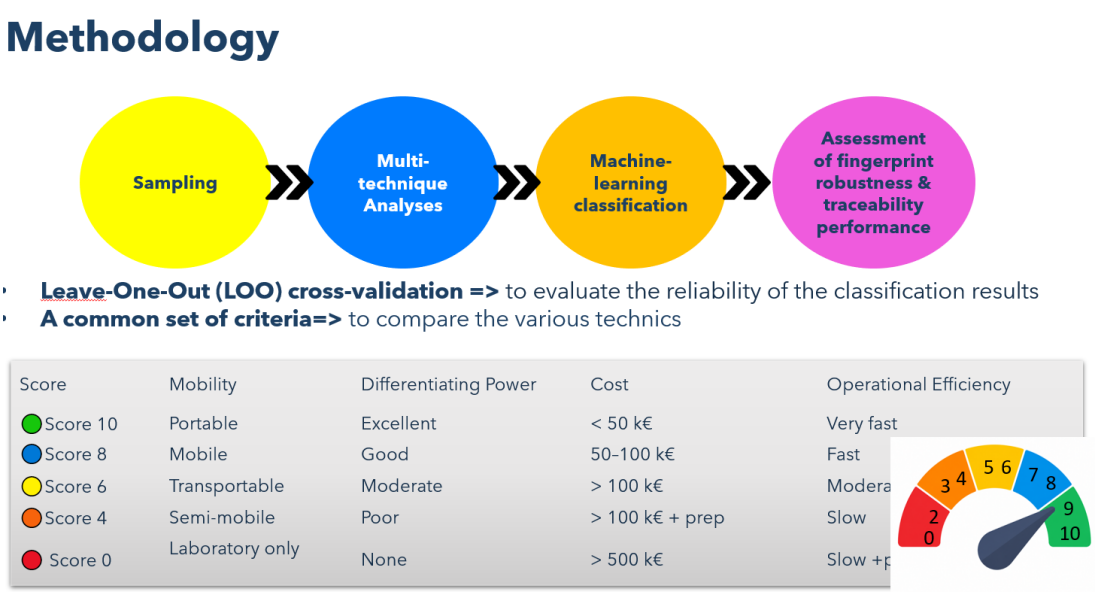

Figure 17. General workflow applied for material fingerprint evaluation, from sampling and multi-technique analyses to machine-learning classification and assessment of traceability performance. A common scoring framework was used to compare analytical techniques according to mobility, differentiating power, cost and operational efficiency.

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Lithium. Analytical fingerprinting results regarding lithium were presented by Anne-Marie Desaulty (BRGM). After introducing the challenges associated with tracing lithium through increasingly complex battery supply chains, she presented a comprehensive multi-fingerprint approach covering the entire value chain, from ore deposits to battery products. Several analytical techniques were evaluated, including lithium isotopes, elemental geochemistry (bulk composition and elemental mapping) and luminescence properties. Statistical and machine-learning approaches, including clustering, linear discriminant analysis and cross-validation procedures, were applied to assess the reliability and traceability performance of the different fingerprints. The results demonstrated that multiple fingerprints can successfully discriminate lithium resources at the upstream stage, with portable and mobile XRF emerging as particularly promising tools for operational traceability. While most elemental signatures are lost during refining due to the high purity of lithium salts, lithium isotopes remain largely preserved through refining, cathode active material production and battery manufacturing. The presentation concluded that lithium isotopes constitute one of the most robust tracers for lithium provenance assessment across the value chain, although isotopic fractionation may occur during battery cycling.

Cobalt. Analytical fingerprinting results regarding cobalt were presented by Yuan Shang (GTK). Following an overview of the cobalt supply chain and its traceability challenges, she presented a material fingerprinting workflow combining mineralogical, elemental and isotopic approaches to track cobalt from magmatic sulphide ores to battery materials. The study focused on sulphur isotopes, trace elements and mineralogical characteristics measured along the Ni-Co processing route. The results showed that sulphur isotopic compositions provide valuable information for distinguishing different ore sources and remain largely preserved during mineral processing, although some modifications occur during pyrometallurgical and hydrometallurgical stages. Combining isotopic and elemental datasets with advanced statistical and machine-learning approaches significantly improved source discrimination. The presentation concluded that multi-fingerprint approaches based on isotopes and trace elements offer a powerful solution for cobalt traceability and that additional isotope systems, such as Pb and Ni isotopes, show strong potential for future supply-chain verification.

Natural graphite. Analytical fingerprinting results regarding natural graphite were presented by Róbert Arató (Technical University of Leoben) on behalf of all participating colleagues from the Technical University of Leoben and the Geological Survey of Finland. After presenting the broader context of this commodity, he showed the analytical and data analysis approach for natural graphite. The presentation highlighted the most promising and also some less applicable methods for graphite traceability. The presentation also included snapshots from the most promising results obtained on mineral impurities separated from graphite concentrates. The talk concluded that graphite traceability is possible with various analytical methods throughout various stages of processing. The key in applying all analytical methods lies in the fact that mineral impurities remain in the graphite products even at the highest purity stages. This provides a solid basis for applying analytical methods on bulk graphite products or specifically focussing on the type and composition of mineral impurities for traceability purposes.

Neodymium. Analytical fingerprinting results regarding neodymium were presented by Delphine Losno (UGent and BRGM). After introducing the strategic importance of rare earth elements and the challenges associated with tracing neodymium through the permanent magnet value chain, she presented analytical approaches based on rare earth element patterns and neodymium isotopic compositions. The study investigated geological samples, mining concentrates, alloys and magnets from different origins. The results revealed distinct elemental and isotopic signatures between rare earth deposits and concentrates, demonstrating the potential of these fingerprints for provenance assessment. Importantly, the Nd isotopic composition and rare earth element patterns were shown to be preserved throughout the industrial manufacturing process of permanent magnets, with no significant fractionation observed. The presentation concluded that neodymium traceability and origin certification appear feasible using a combination of REE patterns and Nd isotopic signatures, providing a promising framework for verifying the origin of Nd in magnet products.

Artificial Fingerprinting. These developments were presented by Ian Corfe (GTK) and Omar Amri (AHK). After reviewing the challenges associated with maintaining traceability when intrinsic material fingerprints are altered or lost during industrial processing, they presented the development of Artificial Taggant Particles (ATPs) specifically designed for critical raw material supply chains. The work explored the design, manufacture and testing of tracer particles tailored in terms of shape, composition, detectability and data encoding. Several prototype particles were produced using 3D printing technologies and evaluated through laboratory and field tests assessing their detectability, distribution and survivability. The results demonstrated that the particles could be detected at very low concentrations that may be economically feasible. The presentation concluded that artificial fingerprinting represents a promising complementary solution to material fingerprinting, particularly at processing stages where natural geochemical signatures are partially or completely modified, and highlighted the need for future pilot-scale validation and industrial deployment.

The principal conclusions emerging from the assessment of material and artificial fingerprinting approaches are summarized in Figure 18.

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Conclusions

- No single fingerprint is sufficient for all materials and all stages.
- Multi-fingerprint approaches combining elemental, isotopic and mineralogical information provide the highest traceability performance.
- Processing and refining stages represent the main challenge, as some geochemical information can be partially or completely lost.
- Artificial fingerprinting offers a promising complementary solution when intrinsic signatures are altered during processing.

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Figure 18. Key conclusions and recommendations for critical raw material traceability.

2.6 Digital product passport, supply chain mapping and LCA

Starting with an overview of the word developed regarding the supply chain mapping, Sónia Cunha (ULEI) started by giving an overview of the work performed. She then introduced a proposed evaluation of high-risk areas based on the CAHRAs[3] and FATF[4] lists that was applied for the assessment of the European imported flows of materials, like cobalt, lithium, and rare earth minerals originating from areas where there is a higher risk of human rights infringement, or financing of armed conflicts. In the case shown (Figure 19), the DRC, as a country classified on the grey list by FATF and with regions present in the CAHRA list, is classified as a high-risk country (red in Figure 11a), meaning other countries importing cobalt directly from the DRC are also exposed to this high risk, thus becoming risk level 1 (orange in Figure 11a). Countries without direct commercial flows with high-risk countries are less exposed.

Cunha then shared the worked done regarding the availability of life cycle inventory data (necessary for life cycle assessment (LCA) of the extracted minerals. The data showed that for a large number of identified mining projects there is not sufficient data available.

[3] https://www.cahraslist.net/
[4] https://www.fatf-gafi.org/en/countries/black-and-grey-lists.html

The presentation finalized with establishing links between very complex value chains associated with different levels of risk, clear key ports of entry of raw materials in Europe as essential leverage geographical points, and a lack of data regarding the operations of a significant number of mining projects with the need for DPPs, Material Fingerprinting, and certification.

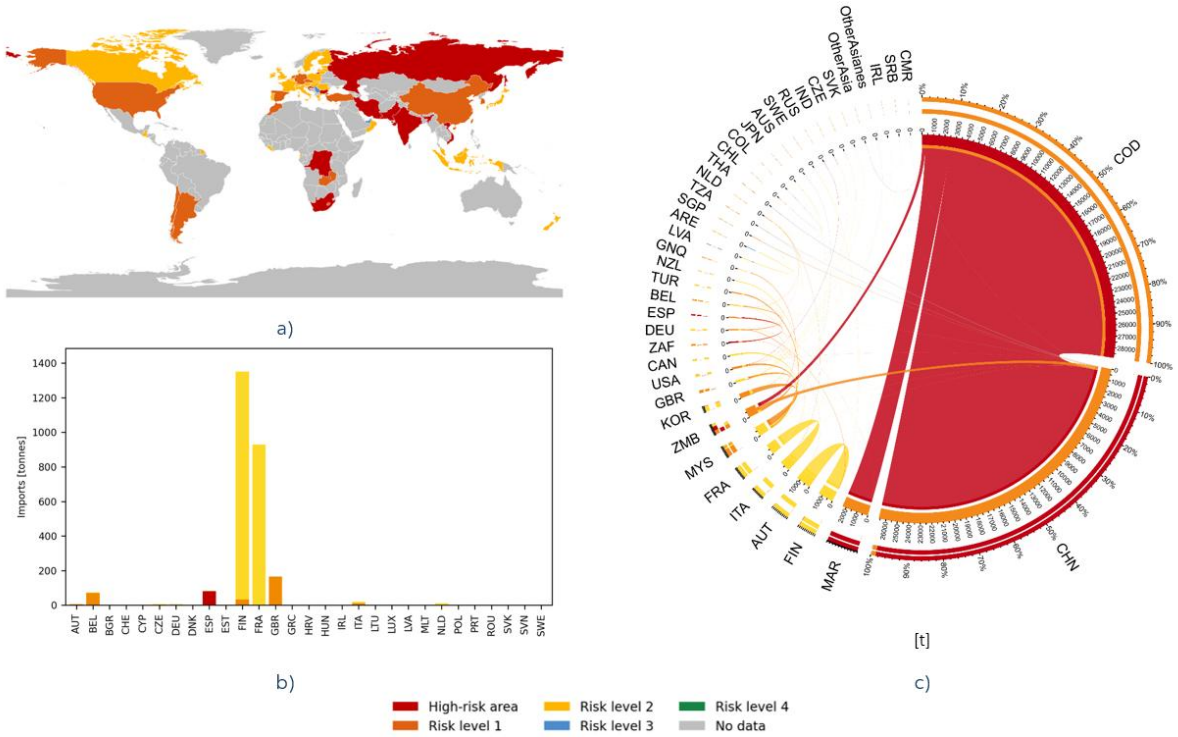

Figure 19: Risk of human rights infringement, or financing of armed conflicts or terrorism linked to the extraction and trade of cobalt ore, based on the supply chain data for 2022, with countries coloured according to the proposed risk level classification. a) Global exporters of cobalt ore. b) Imports of cobalt ore into Europe .c) Trade flows between countries.

Doruk Şahinel (Spherity) presented the work carried out on the Digital Product / Material Passport architecture and its implementation for critical raw materials. He started by summarizing the main highlights and achievements, including the D3.6 deliverable, conference presentations at DPP4EU and ISM 2025, raw material DPP examples, and the proof-of-concept linking material fingerprinting and certification with verifiable credentials. He then introduced raw material passport examples showing how DIDs, QR codes, machine-readable JSON data, and credential verification can support trusted access to product-specific information.

The presentation then moved into the core DPP architecture and its supporting components, explaining how material fingerprinting results and certificates can be represented as verifiable credentials to support origin claims, including cases where a red flag is raised against the declared origin. Doruk also summarized the D3.6 proof-of-concept use cases, covering demonstrated use cases such as material fingerprinting and origin verification, linked DPP data sharing, as well as MaDiTraCe roadmap related use cases such

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as automated dataspace onboarding and decentralized red flag governance. Finally, the European Blockchain Services Infrastructure (EBSI) Trusted Accreditation Organisation (TAO) approach (EBSI, 2025) was presented as a way to make material fingerprinting results trustworthy DPP evidence by embedding them in a recognized trust chain. This model enables market actors to scan the Raw Material DPP and verify whether provenance, certification, and traceability claims come from an accredited and identifiable issuer. Applied to MaDiTraCe, the approach connects material fingerprinting, raw material passports, and verifiable credentials with an EBSI-style trust framework, where the model defines who is allowed to issue which credentials and allow verifiers to check the accreditation chain behind the evidence, as depicted in Figure 12.

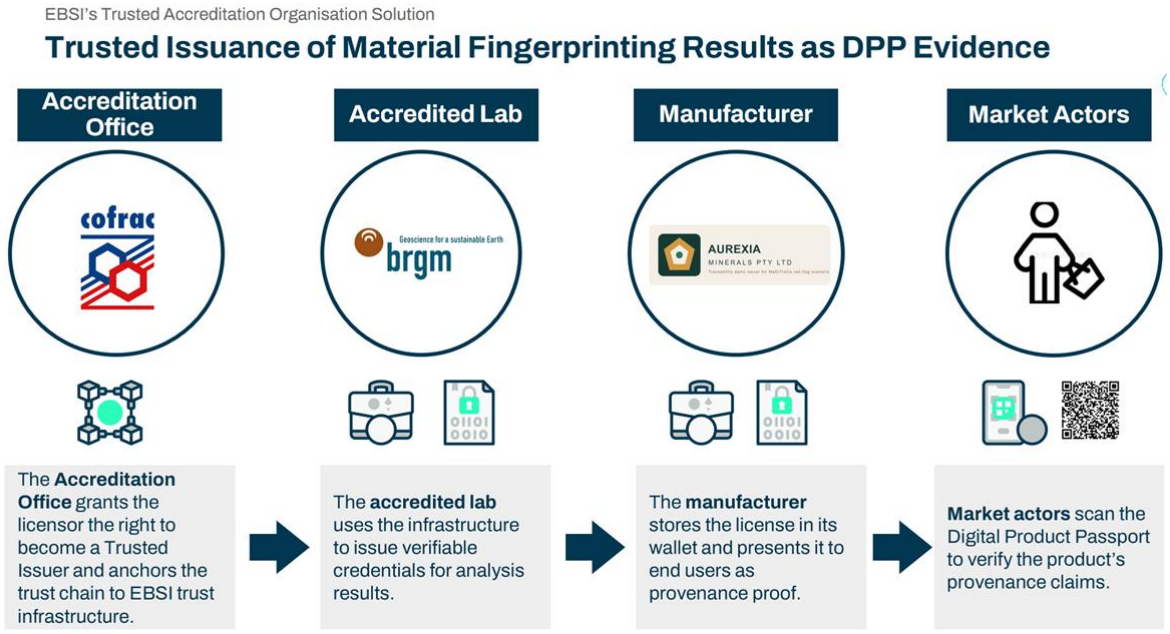

Figure 12: EBSI Trusted Accreditation Organisation (TAO) approach for issuing material fingerprinting results as verifiable DPP evidence, linking accreditation offices, accredited labs, manufacturers, and market actors in a trusted credential chain.

Rouwaida Abdallah (CEA) presented two complementary uses of blockchain within the proposed Digital Product Passport (DPP) framework. The first focuses on establishing trust and integrity through the notarization of analytical evidence, while the second leverages tokenization to enable fine-grained lifecycle traceability and material genealogy across complex supply chains.

Notarization of analytical evidence: The first use of blockchain in the project concerns the notarization of analytical evidence associated with Digital Product Passports (DPPs). In this approach, the blockchain is not used to store analytical data directly but to create a tamper-evident and verifiable proof of their existence and integrity. The analytical results, together with information about the analysis process (e.g., methodologies, measurement conditions, and validation procedures), are cryptographically hashed and anchored on the blockchain. This mechanism provides an immutable timestamp and allows any stakeholder

to verify that the analytical evidence and its associated metadata have not been altered since their issuance, thereby strengthening trust, auditability, and provenance verification within the DPP ecosystem.

Tokenization for fine-grained lifecycle traceability: The second use of blockchain addresses the tokenization of materials and products throughout their lifecycle. In this approach, materials, intermediate products, and final products are represented as tokenized assets, enabling the explicit modelling of lifecycle operations such as splitting, aggregation, transformation, composition, and ownership transfer. Tokenization creates a verifiable lifecycle graph that preserves material genealogy and mass-balance continuity across supply chain transformations. By maintaining traceable relationships between upstream and downstream entities, this mechanism supports fine-grained traceability, facilitates the propagation of non-conformity information across related products, and provides a richer representation of complex circular supply chains and Digital Product Passports.

Óscar Ansótegui (FUNDITEC) presented the cross-cutting work on security, confidentiality and accountability, covering the non-functional requirements that govern the secure operation of the Digital Product Passport at both design-time and run-time. He framed these as three interdependent pillars that together turn traceability data into real market trust: security protects the architecture against threats and data manipulation, confidentiality keeps sensitive commercial data private while sharing only what compliance requires, and accountability guarantees an immutable, verifiable record of every actor and transaction. He then summarized the scope of the work along three lines: threat intelligence and risk governance, trust and integrity guidelines for decentralized notarization, and accountability and privacy by design. This work is consolidated in deliverable D3.7, which provides the guidelines and recommendations for security, confidentiality and privacy across the DPP lifecycle.

2.7 CERA4in1 Development

As part of the MaDiTraCe Closing Event held in Espoo, Finland, Samuel Olmos (DMT) delivered the presentation "Certification Schemes Development – Overview of the CERA 4in1 Standards." The presentation introduced the certification framework developed within the project, including the CERA 4in1 Readiness Standard (CRS), Performance Standards (CPS-II), Chain of Custody Standard (CCS), and the Claims and Labelling Standard (CFS). It provided attendees with an overview of the project's key outcomes and demonstrated how the developed standards can support ESG performance, traceability, and regulatory compliance across mineral raw material value chains.

A key focus of the presentation was the CAMD (Commitment–Assessment–Monitoring–Disclosure) methodology and its integration with the Bowtie risk management approach, which forms the foundation of the CRS, CPS, and CCS standards. The methodology enables organizations to identify ESG and traceability risks, define preventive and mitigation barriers, monitor their effectiveness, and communicate performance improvements

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through a structured risk management framework. A practical example related to human rights risks in supply chains was presented to illustrate how causes, events, consequences, and barriers are connected, supporting organizations in integrating ESG considerations into their broader risk management and decision-making processes.

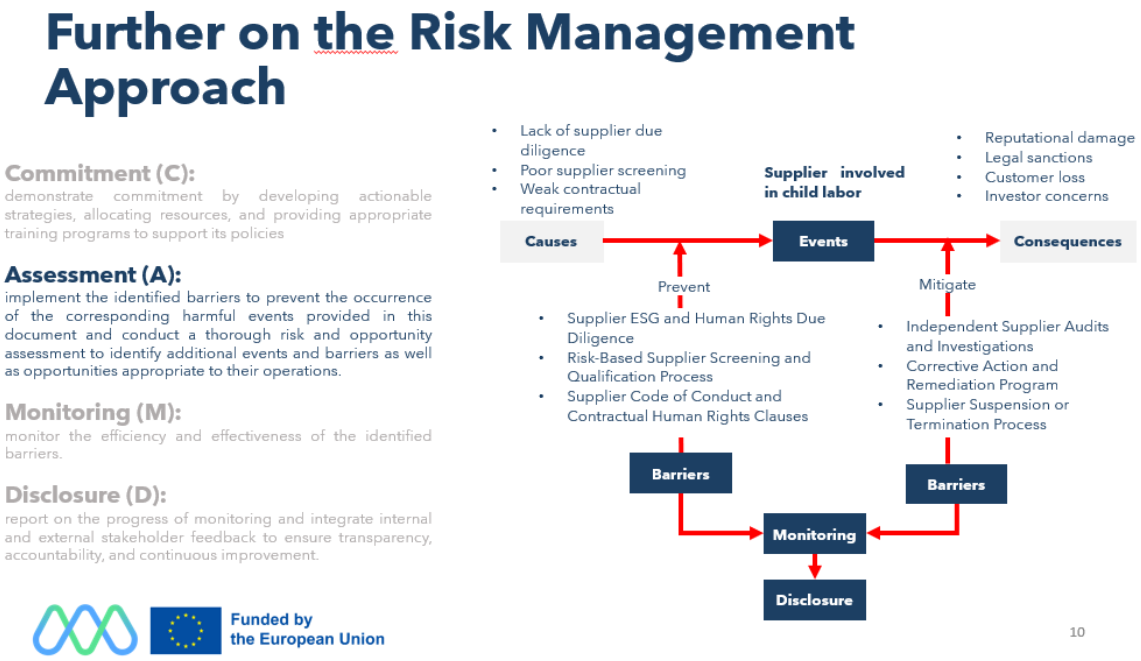

Figure 11. CAMD-Bowtie risk management methodology presented during the MaDiTraCe Closing Event.

The presentation also covered the individual components of the CERA 4in1 certification system. The Performance Standard (CPS) was presented as an ESG certification framework designed to assess and improve the environmental, social, and governance performance of organizations operating across the mineral value chain. The CPS-II, which focuses on downstream manufacturing facilities and covers topics such as climate change, responsible sourcing, circular economy, pollution prevention, biodiversity, occupational health and safety, labour conditions, and corporate governance. The standard applies a risk-based approach and combines management system principles with emerging ESG requirements to support continuous improvement and independent third-party verification.

The Chain of Custody Standard (CCS) was presented as the traceability component of the certification system. The CCS establishes requirements for the tracking, handling, transfer, and verification of certified materials throughout complex mineral supply chains. The presentation explained how different Chain of Custody models, including Identity Preserved, Segregation, Controlled Blending, Mass Balance, and Book and Claim, can be applied. The CCS combines traceability requirements with ESG-related requirements to support credible sourcing claims and increased transparency across the value chain.

The presentation also covered the Final Product Standard (CFS), which was developed to provide clear rules and requirements for the communication of certification-related claims. Rather than functioning as a separate ESG certification standard, the CFS establishes guidance for responsible communication, claim approval, labelling, and the use of

certification marks (which needs further development). The standard was designed to support transparency, prevent misleading sustainability claims, and align with emerging regulatory expectations related to green claims and product transparency.

The final part of the presentation focused on the pilot validation activities carried out during the MaDiTraCe project. The pilot implementation of the CPS-II and CCS standards demonstrated that the requirements, audit methodology, and conformity assessment processes were practical and auditable in a real-world manufacturing company. The pilot also provided insights regarding ESG maturity, responsible sourcing practices, traceability systems, and evidence requirements. Feedback collected during the pilot contributed to the refinement of standard requirements, audit criteria, key performance indicators, and verification procedures, strengthening the applicability of the certification framework.

Figure 12. Samuel Olmos presenting the CERA 4in1 certification framework and project outcomes during the MaDiTraCe Closing Event in Espoo, Finland.

2.8 MaDiTraCe communication resources

During the final event, María Fernández & Alicia García (Figure 20) from Iberian Sustainable Mining Cluster presented the communication and dissemination resources developed throughout the implementation of the MaDiTraCe project, highlighting the wide range of materials created to engage stakeholders and ensure the long-term impact of the project's results. The main communication and dissemination resources presented are summarised below:

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MaDiTraCe Website
The project website design by LGI served as the main communication platform, providing comprehensive information about the project's objectives, activities, results, news, and events.

Social Media
The project's LinkedIn channel was actively used to disseminate project updates, share key achievements, promote events, and engage with the wider community interested in sustainable and traceable mineral supply chains.

Scientific Publications
A dedicated MaDiTraCe community was established on Zenodo, where all public deliverables and scientific publications generated within the project are openly available, ensuring broad access to the project's knowledge and results.

Audiovisual Materials
Several audiovisual resources were produced during the project, including a series of video pills and webinars addressing key topics related to traceability and responsible sourcing:

- Sustainable Sourcing: The MaDiTraCe Solution
- The Future of Traceability: The MaDiTraCe Two-Tier Approach Solution
- From Source to Supplier: Due Diligence Matters in Responsible Sourcing
- Graphite for the Greener Future
- Digital Passport for Minerals
- Digital Product Passport & Raw Materials | MaDiTraCe 1st Webinar
- Transparency in Mineral Supply Chains | MaDiTraCe 2nd Webinar

All audiovisual materials are publicly available through the project's YouTube channel.

MaDiTraCe Talks Podcast
A series of podcasts entitled MaDiTraCe Talks was launched, focusing on the main topics addressed by the project. The episodes featured the participation of MaDiTraCe partners and were moderated by Eric Pirard from the University of Liège, fostering discussion and knowledge exchange on sustainable mineral supply chains and traceability. The podcasts are available on YouTube and Spotify.

MaDiTraCe e-Training Course
An e-learning course was also presented during the event. Andrea Martínez from EIT RawMaterials introduced a demo of the course, which has been developed by EIT RawMaterials in collaboration with BRGM.

Figure 20: Alicia García presenting the communication results during the final event in Metso

2.9 Towards a "Mined in Europe" label?

Countries such as Canada and Australia have recently published initiatives about "proof of origin" and verified credentials for mined materials in their countries. These initiatives resonate with the EU project for an Industrial Accelerator Act (IAA) and the "Made in EU" initiative, but this initiative is not explicit about a "Mined in Europe" criterion. Australia and Canada are mostly upstream countries, whereas Europe is an end-consumer with an OEM industry.

The discussion, led by Jana Plananska (Advisor Critical Raw Materials and Clean Mobility) and Capucine Nouvel Zurcher (Political Science Researcher, BRGM), explored what could be the interests for EU upstream and downstream industry in a "Mined in Europe" label and how the downstream industry could benefit.

The main questions raised during the short debate were:

- A full value-chain approach is essential. "Mined in Europe" alone will not strengthen Europe's critical raw material ecosystem. A comprehensive value-chain approach is needed, with measures supporting not only upstream, but also midstream, downstream and recycling activities to build competitive European CRM value chains.
- The label must provide clear added value. For a "Mined in Europe" label to be effective, it should offer tangible benefits for producers, such as improved market access, advantages in public procurement, or preferential access to financing mechanisms.
- Clear definitions, robust verification and a credible issuing authority are crucial It must be clearly defined what the label "Made in EU" or "Mined in Europe" certifies (e.g. materials, sectors, geographical scope, ESG criteria, etc.). These criteria should be independently verified through reliable traceability and verification mechanisms.

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Ideally, the issuing body should be a widely recognised European institution, providing credibility and broad acceptance across industry.

- In any case, "Mined in Europe" or "Made in EU" will still use raw materials from elsewhere. So, other regulations such as Corporate Sustainable Due Diligence, Battery Regulation and CRM Act apply. There is a global objective, and ESG practices must be at the centre, in Europe and elsewhere.

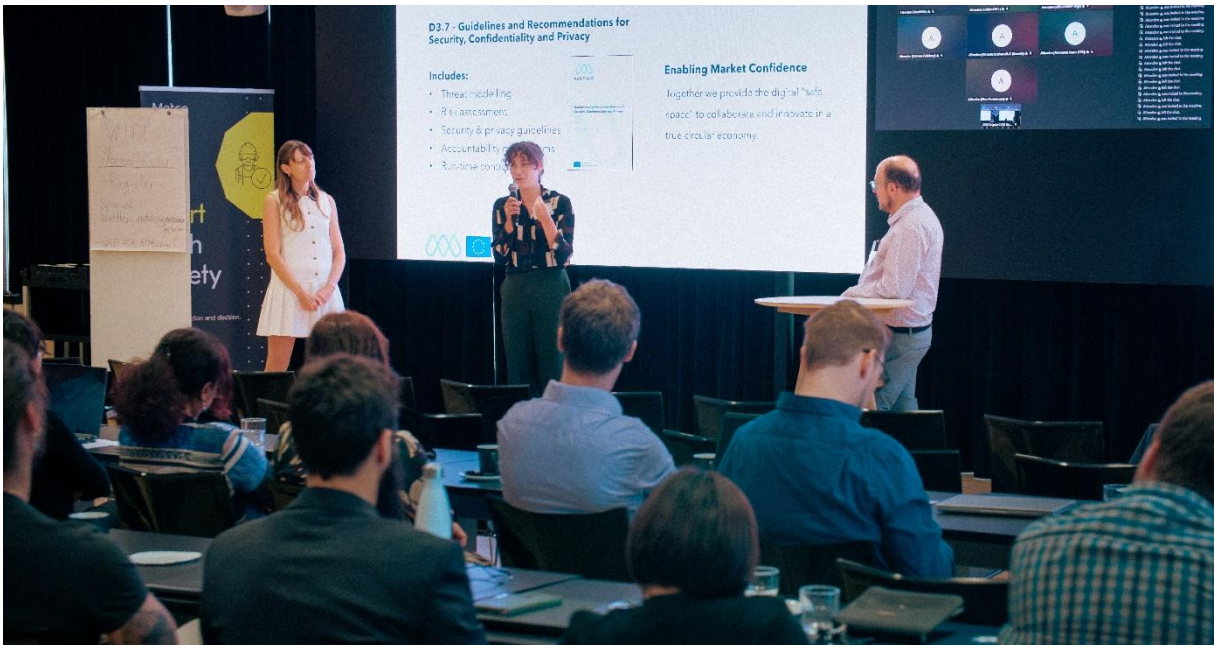

Figure 21. The discussion lead by Jana Plananska (Advisor Business Development Critical Raw Materials and Clean Mobility) and Capucine Nouvel Zurcher (Political scientist in BRGM).

2.10 MaDiTraCe Roadmap

Daniel Monfort (BRGM), as the coordinator of the project, presented the elements that would be in the main last deliverable of the project, D4.5 MaDiTraCe roadmap.

He insisted in the fact that raw materials traceability has become a buzzword and a research topic in recent years (Figure 22), with the publication of academia works but as well many institutional reports (IEA, OECD, EU Commission, G7, Australia) and standardization agencies as well (ISO, SAE).

Figure 22: Overview of several recent documents about raw materials traceability.

During this session were presented some examples of how MaDiTraCe project results could work in a "Made in Europe" system that includes extraction in Europe "proof of origin":

- Possibility for a "Made in Europe" or even "Mined in Europe", inspired by Australian and Canadian documents/plans
- Verified credentials system for companies operating in the EU
- Neutral public entity (s) settling EU raw materials MFP database and delivering "proof of origin"
- A network of accredited laboratories for MFP must exist
- Develop AFP technologies and create business on it
- Associate "Made in Europe" with certifications, connect it with certification schemes from CRM Act
- Continuation of EU battery passport movement
- Global vision, alignment with UN CEFACT, G7 traceability roadmap and other global initiatives
- Integrate traceability for non-European materials

Made in Europe was not the only example of implementation. Also, some examples about fraud situations in supply chains and how MaDiTraCe project results could prevent and report "red flag" were presented.

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Beyond Made in Europe possibilities, were presented the main elements for a traceability roadmap that are shown in Figure 23. Those 5 levels are directly and inspiration of other traceability roadmaps such as Australian one.

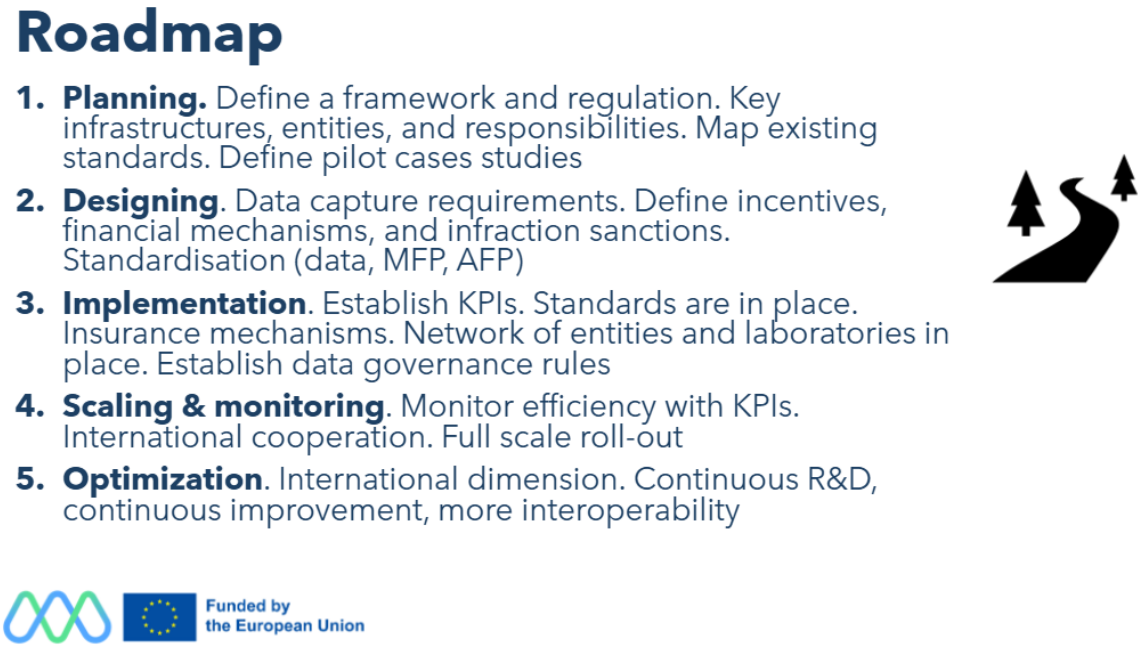

Figure 23: MaDiTraCe roadmap in 5 levels.

Some policy and general recommendations were made as well.

- Interoperability with other countries' initiatives under the umbrella of **UN CEFACT/UNTP and other international initiatives**
- MaDiTraCe experience and case studies could be the basis for first pilot cases in G7 roadmap
- Put responsible sourcing and **ESG in the middle of the action**
- Launch of **ISO** working groups and other standardization works for laboratory techniques
- Alignment with ISO traceability norms
- Assess data quality content of **first battery passports put on the market** in Europe in 2027
- International dimension of MFP, work with main raw materials producers, assess CAHRA countries, **international cooperation**
- R&D is a continuous process, go beyond project snapshot. Build multi partnerships

G7 DECLARATION ON SECURING SUPPLY CHAINS FOR CRITICAL MINERALS

One week after MaDiTraCe project final event, G7 countries published the joint declaration on securing supply chains for critical minerals, with a particular attention on traceability, transparency and standard-based market. This declaration is very important for MaDiTraCe project as several points are directly related to the project achievements:

- Harmonized, **interoperable mechanisms** aligned with G7 interests that ensure **traceability and transparency** regarding the origin of critical minerals
- 2 pilot critical minerals – **lithium** and nickel – and intention to extend to 5 new ones, with particular attention to **REEs**
- Aim to avoid undermining competitiveness or imposing excessive cost burdens.
- Align practices with internationally recognized labour standards and encourage coordinated action to address systemic risks of forced labour
- Publication of "G7 Toolkit for Standards-Based Criteria to Identify Risks of Forced Labour in the Extraction of Critical Minerals"
- Development of policies and mechanisms that would be necessary to **ensure supply chain resilience and diversification** that may include, as appropriate, resilience criteria, **standards-based approaches**, transparency and traceability mechanisms.
- Trade-related instruments such as quotas and price floors.

3 Demos and laboratory visits

During the two-day event, participants had the opportunity to visit the laboratories of GTK and Metso (Figure 24), gaining valuable insights into their facilities and analytical capabilities. The program also included several interactive demonstrations, such as the E-learning Support Demo, the Artificial Tagging Demo, and the MaDiTraCe Material Passport Demo. In addition, posters produced by project participants over the past three years were displayed throughout the event.

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Figure 24. Visit of the Innovation centre at Metso.

3.1 E-learning support demo

During the final event were released and presented the 2 modules of e-learning about traceability developed in the project. One module is general about the topic of critical raw materials traceability, and the second module is oriented to MFP and analytical methods.

The e-learning supports are accessible in "BRGM formation" website.

https://formation.brgm.fr/contactez-nous-70.html?mtm_campaign=Inscription-CRMs_Elearning (register form in French)

https://form.typeform.com/to/t77t1ZoP (register form in English)

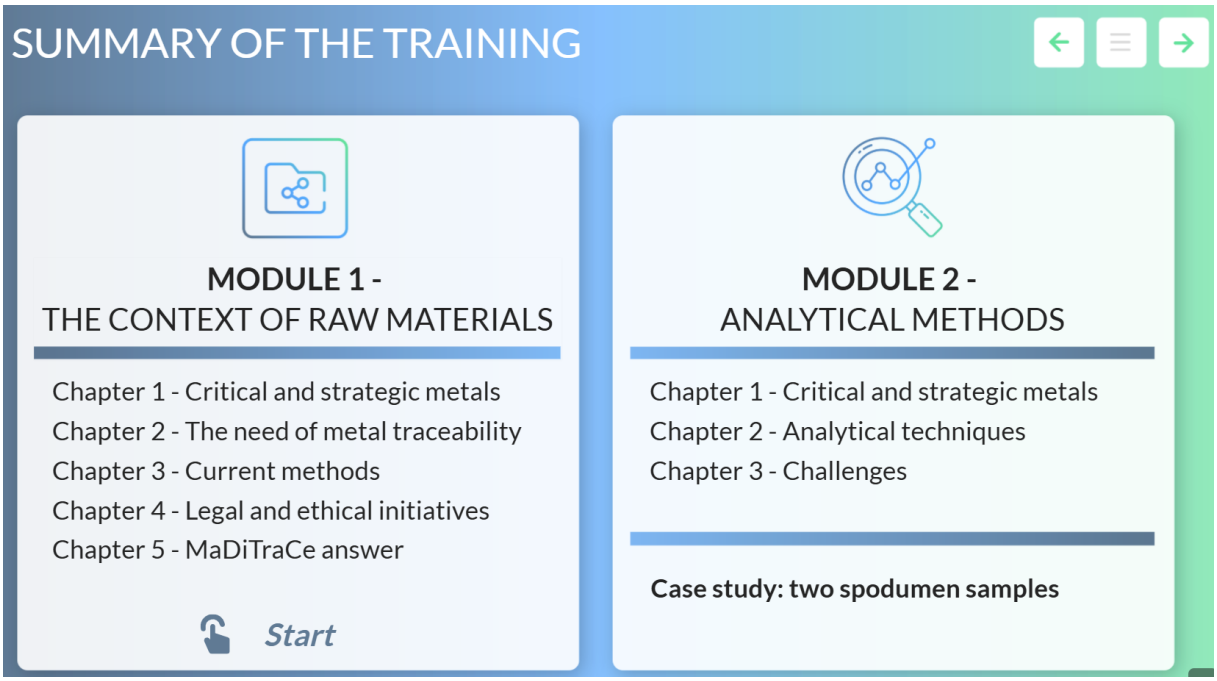

Figure 25. MaDiTraCe e-learning consists of two modules.

3.2 Artificial tagging demo in GTK laboratory

The artificial tagging demo comprised a physical presentation of 3D printing technology and products, and showed how different AFP technologies can be incorporated into solid products and in upstream CRMs, such as spodumene concentrate and nickel concentrate. Additionally, 3D printed tracer particles were shown using a digital microscope.

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Figure 26. Artificial tagging demo in GTK laboratory.

Figure 27: Drawings of the visit to GTK laboratory and artificial tagging demo by Capucine Nouvel.

3.3 Poster session

Several MaDiTraCe projects presented in scientific conferences during those 3 years were in the hall of GTK building.

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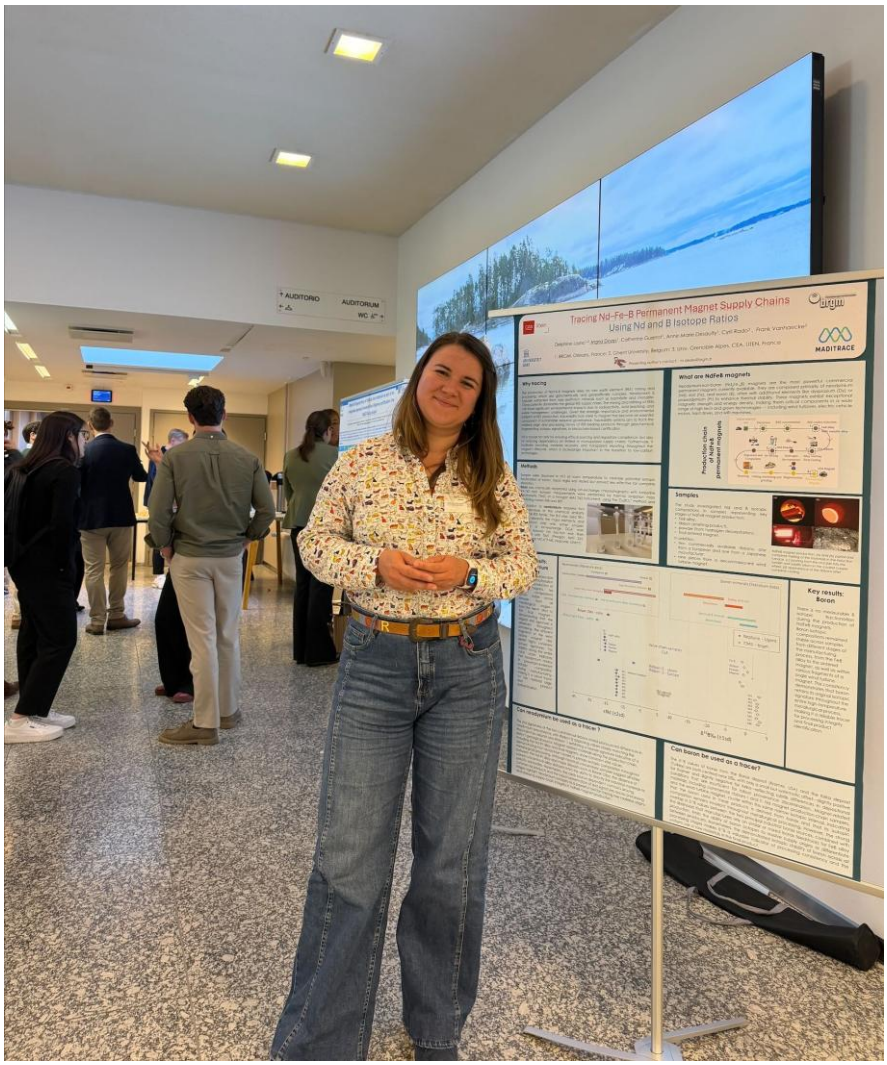

Figure 28. Poster session, Maria Dezes from BRGM with a poster presented in Goldschmidt conference.

4 Main conclusions

- One of the main conclusions of the OECD presentation is that chain of custody (CoC) models with identity preservation must be only for supply chains with a high risk. CoC and associated traceability must be adapted to each context.
- MaDiTraCe project was funded by the EU Horizon Europe programme, highlighting the importance of EU R&D programmes. It is important to continue the research on this topic and TRL ride.
- Policy momentum at EU level and globally is appropriate for more traceability. However, plans such as "Made in Europe" are still under discussions and the integration of domestic raw materials supply is unclear. G7 roadmap could be also an interesting initiative with a strong resonance for MaDiTraCe project results.
- MaDiTraCe project results must be accessible in UNTP.
- More interoperability between DPP systems and standards is the key.

- Continuation of certain works in standardization bodies such as ISO. Important to standardize laboratory methods for MFP.
- Evaluation of costs induced by traceability initiative. The estimation (cost per ton of tagged material) made for Artificial Fingerprint should be a basis for further works.
- As stated by Fernandez et al (2026), traceability is not the final objective but a tool for risk management and ESG performance monitoring.

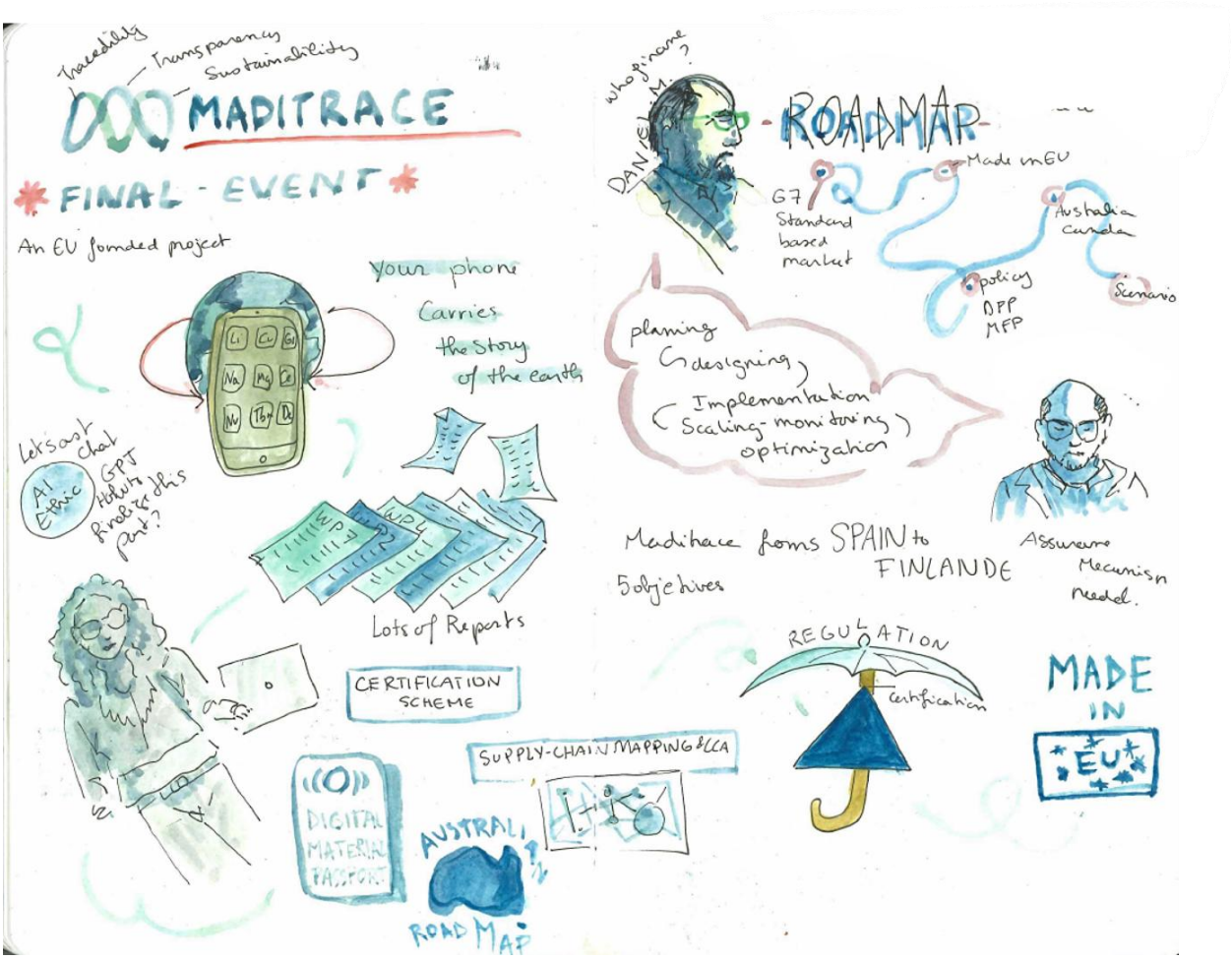

Figure 29: Graphical synthesis of the final event by Capucine Nouvel.

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References

UNECE (2025). Transparency at Scale. Fostering sustainable value chains. Recommendation No. 49. https://unece.org/trade/documents/2026/04/recommendation-ndeg-49-transparency-scale-fostering-sustainable-value

IEA (2026). Critical Mineral Traceability for Energy and Economic Security. https://www.iea.org/reports/critical-mineral-traceability-for-energy-and-economic-security

FrontierSI (2024). Strengthening critical minerals provenance and traceability. https://www.nrmmrrd.qld.gov.au/mining-exploration/initiatives/critical-minerals-provenance-traceability

EBSI (2025). Build Trusted Accreditation Organisation solutions. https://hub.ebsi.eu/get-started/build/tao