

Original Research

**DIAGNOSING CRITICAL RAW MATERIALS SECTOR READINESS IN
CANDIDATE COUNTRIES: A PESTLE-BASED ASSESSMENT OF NORTH
MACEDONIA**

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Abstract

The Critical Raw Materials Act (CRMA), adopted by the European Union in 2024, has reorganised the regulatory horizon facing suppliers of raw materials destined for European industrial value chains. Mineral-rich states located along the EU's enlargement frontier are now confronted with a dual obligation: aligning their domestic regulatory frameworks with the EU acquis as a precondition of accession, and demonstrating sufficient governance, environmental, and traceability performance to qualify as compliant upstream partners under the CRMA's strategic-supplier expectations. This paper offers a structured macro-environmental diagnostic of North Macedonia using the PESTLE framework as the analytical instrument. Results indicate that North Macedonia's mineral endowment and existing concentrate-export profile already articulate the country into European supply chains for lead, zinc, and copper, while ferro-nickel exports have undergone a contraction in recent periods. However, sectoral readiness for deeper integration is constrained by deficits in environmental enforcement capacity, by the absence of domestic intermediate processing capability, and by an extractive-waste inventory. The analysis identifies a feasible development trajectory built on two reinforcing pillars – ESG upgrading of operating concentrate streams, and pilot-scale secondary recovery integrated with mandated remediation at priority sites – while underlining that institutional credibility, rather than mineral prospectivity, is the rate-limiting determinant of progress.

Keywords: critical raw materials, PESTLE diagnostic, secondary raw materials, mining governance, North Macedonia.

INTRODUCTION

Three policy currents converge on the question of how candidate countries integrate into the European raw-materials economy. The first is the shift in industrial strategy that has accompanied the European Green Deal and the digital transition: meeting decarbonisation targets in transport, electricity generation, and energy storage requires materials whose supply is geographically concentrated and economically volatile [1]. The second is the consolidation of this strategic concern into binding regulation through the CRMA, Regulation (EU) 2024/1252, which lists 34 critical and 17 strategic raw materials and assigns 2030 benchmarks to the share of European demand to be satisfied by domestic extraction,

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processing, and recycling, while simultaneously capping single-source third-country dependency [1]. The third is the reactivation of EU enlargement in the Western Balkans (WB), where the acquis-alignment process now intersects with the same raw-materials agenda through a layered set of strategic partnerships, accession-conditioned reform, and access to financing instruments oriented towards green and circular industries.

For N. Macedonia, these currents arrive at a sector whose trajectory has been shaped by the long arc of Balkan mineral exploitation. Polymetallic veins at Sasa, Toranica, and Zletovo, porphyry copper-gold systems at Bučim and Borov Dol, the legacy ferro-nickel platform at Kavadarci, and a constellation of feasibility-stage projects (Ilovica-Štuka, Plavica and Crn Vrv, Kazandol, Kadiica) together constitute a base from which European-facing supply commitments could in principle be expanded [2–4]. Yet the same heritage has bequeathed an extensive footprint of unremediated tailings, slag heaps, and contaminated dumps, several of which have been the subject of recent geochemical re-examination as potential secondary sources of EU-listed materials [5–8]. These two faces of the country's mineral profile – prospectivity and liability – occupy the same physical and institutional space, and any credible CRM development trajectory must address them in parallel.

The literature on WB mining has matured considerably over the last decade. Region-wide assessments compiled under the RESEERVE project produced a WB Mineral Register documenting both primary and secondary deposits in compliance with INSPIRE specifications [3,9]. Geochemical and mineralogical studies have characterised tailings in Serbia and N. Macedonia in support of European secondary-supply strategies [7,8]. Strategic policy commentary from the Adria region has analysed CRMA implications for candidate jurisdictions [2,10]. Resource-efficiency assessments across Eastern and South-Eastern Europe have benchmarked N. Macedonia against comparator economies [11]. What remains thinner in the literature is a country-level synthesis that combines this scientific evidence with the institutional and regulatory dimensions captured in EU accession monitoring, and that assesses readiness against the specific CRMA performance benchmarks now in force.

This paper aims to contribute that country-level synthesis. First, it operationalises the PESTLE framework as a structured diagnostic for sectoral readiness, rather than as a generic environmental-scanning device. Second, it organises the available evidence on N. Macedonia along six analytical dimensions, each evaluated against an explicit EU-anchored benchmark. Third, it derives a parsimonious set of evidence-grounded policy levers calibrated to the CRMA's strategic-supplier expectations and to the country's accession trajectory.

MATERIALS AND METHODS

The CRMA codifies an interventionist response to documented vulnerabilities in European raw-materials supply. Its substantive innovations include the formal designation of strategic and critical materials lists, the establishment of share-of-demand benchmarks for domestic capacity by 2030, the introduction of fast-tracked permitting for projects designated as strategic, the creation of due-diligence obligations along industrial value chains, and explicit provisions for the recovery of critical materials from extractive waste [1,12].

The PESTLE technique was developed in the strategic-management literature as a tool for cataloguing macro-environmental influences on the success or failure of an organisation, an industry, or a market, by sorting those influences into political, economic, social, technological, legal, and environmental categories [13]. The framework's adaptability to sector-level analysis has been demonstrated across diverse contexts, including the construction industry [13], distributed energy infrastructure in Mozambique [14], and low-grade copper-mining viability in Zambia [15].

The diagnostic follows a four-step procedure. First, evidence is extracted from a curated source base and assigned to one of the six PESTLE dimensions. Second, each dimension is summarised against an EU-derived benchmark drawn from CRMA articles, accession monitoring criteria, or relevant directives. Third, dimension-level findings are aggregated into a cross-cutting analytical narrative that traces compounding interactions between dimensions – conditions in which a deficiency in one register amplifies constraints in another. Fourth, the findings are translated into an evidence-anchored set of policy levers, each tied to an institutional actor and a measurable indicator.

To ensure that the diagnostic rests on traceable evidence, only four categories of sources are admitted: (i) peer-reviewed journal articles and conference papers; (ii) official EU regulatory and monitoring documents; (iii) intergovernmental statistics from established providers; and (iv) sectoral analyses produced by recognised research institutions. Press materials and unverified secondary aggregations are excluded. Within these categories, recency was prioritised wherever the underlying conditions are subject to rapid change – particularly in the political, economic, and legal dimensions.

The geochemical evidence base draws on Steiner *et al.*'s tailings characterisations [7], the regional secondary-raw-materials assessment of Šajn *et al.* [6], the Veles slag-deposit study [8], the long-standing Lojane investigation by Alderton and co-authors [16], and the Jugohrom hexavalent-chromium contamination study by Mihailovski *et al.* [17]. The legal-regulatory evidence is anchored in Regulation (EU) 2024/1252 [1] and the European Commission's 2025 enlargement monitoring report on N. Macedonia [18]. Production and trade statistics are taken from the Reichl and Schatz World Mining Data compilation [19], the European Training Foundation (ETF) review on critical-raw-materials skills [20], and the WB Mineral Register [9]. WB context and policy framing rely on Borojević Šoštarić [2,10], Giannakopoulou *et al.* [11], Pličanič *et al.* [21], Kursunoglu [5], and Righetti *et al.* [12].

RESULTS AND DISCUSSION

The diagnostic findings are summarised in Table 1, which juxtaposes the principal evidence available for N. Macedonia in each PESTLE dimension against the corresponding EU benchmark. The narrative below elaborates the entries and links each to the underlying source.

Three patterns emerge from the dimension-level findings.

The first concerns the relationship between political and legal conditions on the one hand and economic outcomes on the other. The country's existing concentrate exports demonstrate that European supply chains can absorb upstream output produced under current conditions:

the buyer side has accommodated, through pricing and contracting, the risks attaching to the WB as a sourcing region. What it has not absorbed – and is unlikely to absorb in the CRMA era – is investment exposure to the regulatory, environmental, and litigation risks that accompany upstream expansion or processing investment. The Kazandol arbitration and the Ilovica-Štuka procedural history both illustrate the cost of misaligned environmental and concession governance for project economics. CRMA due-diligence expectations will sharpen this distinction further. The credibility deficit identified in the political dimension therefore translates not into a failure of current trade flows but into a constraint on the deepening of those flows toward higher-value processing stages.

Table 1 Macro-environmental diagnostic of the N. Macedonia's CRM sector against EU benchmarks

Dimension	Evidence (North Macedonia)	EU benchmark	Diagnostic verdict
Political	Closer alignment with EU accession trajectory; persistent rule-of-law and anti-corruption concerns flagged in 2025 monitoring [18]; institutional reorganisation through a dedicated Ministry of Energy, Mining and Mineral Resources	Trusted-supplier governance under CRMA Article 8; rule-of-law conditionality under enlargement	Material gap in enforcement credibility
Economic	Lead, zinc, and copper concentrates exported at scale; mining and quarrying contributes a modest share of GDP; ferro-nickel exports show a sharp contraction in 2024 reporting [20]	CRMA 2030 benchmarks for extraction, processing, recycling; single-source cap [1]	Upstream participation present; intermediate processing absent
Social	Documented community opposition and concession termination at Kazandol (2018); pollution incident at Toranica (2025) with parliamentary scrutiny [18]; weak public participation in environmental decision-making	Acquis on public participation in EIA/SEA; CRMA ESG and community-consent expectations	Elevated social-licence risk
Technological	Active flotation and SX/EW capacity at Bučim; underground operations at Sasa with paste-backfill modernisation; characterised tailings inventory of approximately 175 megatonnes [7]; no domestic intermediate refining	CRMA recycling benchmark; BAT compliance for extractive industries	Secondary-resource potential not yet operationalised
Legal	2025 Mineral Resources Act introducing strategic-project designation and concession-fee revisions; EIA and SEA frameworks not fully aligned with the EU acquis [18]	EIA and SEA Directives; Environmental Liability Directive; CRMA due-diligence obligations	Partial alignment; environmental-law gaps require closure
Environmental	Hexavalent chromium concentrations at Jugohrom reported at 132.98 mg/L against a 0.01 mg/L maximum allowable level [17]; arsenic and antimony concentrations exceeding 10,000 ppm at Lojane [7,16]; structural shortfalls in inspection capacity [18]	Water Framework Directive; Mining Waste Directive; Habitats Directive; NATURA 2000	Documented non-compliance at legacy sites

The second pattern concerns the joint geochemical and environmental signature of the legacy tailings inventory. Sites characterised in the published literature as environmental hotspots – Lojane, Veles, Probištip, the broader Sasa complex – are the same sites characterised as containing materially relevant concentrations of CRM-listed or prospectively listed elements [6–8,16]. This co-location offers an opportunity to design integrated remediation–recovery interventions whose financial logic differs from greenfield primary mining. The capital intensity of secondary-resource recovery is in general lower than that of new mine development; the social-licence risk profile is different (the underlying sites are not pristine and remediation has independent public-interest justification); and the alignment with CRMA recycling and circularity provisions is direct. Whether this opportunity becomes operational depends on the establishment of three preconditions: a national inventory of secondary resources with risk-ranked prioritisation; environmental-monitoring capacity sufficient to ensure that recovery activities do not exacerbate existing contamination; and contracting structures – with downstream EU processors – through which the recovered material can be priced and traded under CRMA-compatible due-diligence regimes.

The third pattern concerns the function of EU accession as a meta-driver. Accession conditionality, the CRMA, the Reform and Growth Facility, the WB CRM cooperation track, the ETF's CRM-skills agenda, and the broader strategic-autonomy literature all push in the same direction with respect to the institutional reforms that the diagnostic identifies as constraining [18,20]. The historically novel feature of the present moment is the alignment of these external drivers with the commercial incentives of EU-side processors and battery-supply-chain participants seeking near-shore, traceable raw-materials inputs. This alignment is unlikely to persist indefinitely. The CRMA's 2030 benchmarks will catalyse capacity investment elsewhere – in Serbia, in the Iberian Peninsula, in Scandinavia, and outside Europe under strategic-partnership agreements – and the windows of opportunity for any specific candidate jurisdiction to be designated as a priority partner are correspondingly time-bound.

Two further observations should be recorded. First, the analysis here is conducted at a level of aggregation that may obscure differences across deposits and operators. Site-level techno-economic studies remain necessary for the design of any specific intervention, particularly at Lojane, where geochemical hazards constrain the operational envelope, and at Veles, where urban proximity raises additional planning and consent considerations. Second, the diagnostic does not address the wider regional political economy in which competition among WB jurisdictions for European preference operates: a comparative assessment across Serbia, Bosnia and Herzegovina, Albania, Montenegro, and Kosovo would supplement the country-level findings reported here.

CONCLUSION

This paper has presented a structured PESTLE diagnostic of the readiness of North Macedonia's critical raw materials sector for deeper integration into European supply architectures shaped by the CRMA. The diagnostic indicates that geological prospectivity and existing concentrate-export flows are not the rate-limiting determinants. The decisive factors are the credibility of environmental enforcement, the alignment of EIA and SEA frameworks

with the EU acquis, the transparency of concession governance, and the operational integrity of tailings-safety regimes – conditions whose present performance falls materially short of CRMA strategic-supplier expectations.

Six policy levers follow from the analysis, presented here without ranking and with explicit linkages to the diagnostic evidence.

First, a national strategy on critical and secondary raw materials, mapped explicitly to the CRMA's strategic and critical materials lists and to the 2030 benchmarks. Such a strategy should incorporate a standardised inventory and risk-ranking of tailings and extractive waste, building on the geochemical work of Steiner *et al.* [7] and Šajn *et al.* [6,8] and prioritising sites where commodity recovery is co-located with documented environmental hazard.

Second, comprehensive EIA and SEA acquis alignment, in line with the European Commission's 2025 recommendations [18]. This is the legal reform with the largest single effect on investment risk reduction and on the eligibility of any subsequent strategic-project designations under the Mineral Resources Act.

Third, an extractives-transparency standard covering concession agreements, beneficial ownership, environmental permits, inspection outcomes, and revenue flows, published as open and machine-readable datasets. Such transparency is a precondition both for CRMA due-diligence compliance and for the credibility of the anti-corruption agenda that EU monitoring identifies as unresolved [18].

Fourth, mandatory tailings-safety audits and emergency-response protocols across operating and inactive facilities, with independent monitoring and public reporting. The Toranica incident demonstrates that present arrangements are inadequate even at active mines [18], while the geochemical signatures at Lojane document the urgency of pre-emptive action at legacy sites [7,16].

Fifth, pilot-scale secondary-recovery initiatives at high-priority sites – Lojane, Probištip, Sasa, and the Veles slag landfill – designed in tandem with mandated remediation, governed by strict water and emissions controls, and conditional on community consent. Pilot results should be reported against CRMA recycling-benchmark progress and feed the national strategy referenced above.

Sixth, sustained investment in human capital and applied-research infrastructure, with priority on hydrometallurgy, geometallurgy, and environmental monitoring. Coordinated programming with the ETF's CRM skills agenda [20] and with regional research groups conducting Western Balkans tailings-geochemistry work [6,7] would shorten the lead time required to operationalise the recommendations above.

The shared feature of these levers is that they precede, rather than accompany, large-scale primary-mining expansion. The position taken here is that an upstream investment-led trajectory in advance of governance reform would compound rather than resolve the dimensions of risk identified by the diagnostic. The sequence matters: institutional credibility is the threshold condition under which both the CRMA's strategic-supplier expectations and the broader objectives of the EU accession process can be jointly met.

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