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Not in my backyard? Prospects, problems and perceptions of lithium extraction in Austria

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Abstract

Background The European Green Deal has rekindled interest in the mining of critical raw materials within Europe's borders. The Weinebene lithium deposit, near Wolfsberg (Austria), deemed uneconomic as late as the 2000s, has attracted interest from developers because of the widespread demand for the metal for battery technology and in the electro-mobility sector. Based on a multi-scalar analysis, the main objective of this study is to investigate local citizens' and politicians' perceptions of potential environmental and socio-economic impacts of the Wolfsberg project. We deploy an interdisciplinary political geology approach that assesses its geological feasibility, social acceptability and the associated power relations, in the light of European debates around so-called 'green extractivism'.

Results The exploitation of the lithium deposit seems to be promising from a geological point of view: the Weinebene hard rock, vein-type spodumene deposit was assessed at 12.9 Mt grading 1% Li_2O, and the planned mine could provide 10,500 tpa LiOH/year for a period of 20 years, which would be around 4.5% of global production in 2021. However, the main results of the study show that conflicts are emerging around local environmental impacts, for example, the increase of traffic. Such environmental impacts resulting in greater CO_2 emissions contradict decarbonisation objectives and ecological transitions. Local youth and politicians have highlighted the possibility of local mineral production, job creation and economic development. Nevertheless, politicians have criticized the company's communication policy.

Conclusions The geological analysis suggests adequate lithium resources. Otherwise, the Wolfsberg project is undermined by the lack of an open public dialogue on its future. Local residents and politicians are barely involved in the planning and permitting stages. The company European Lithium is confident of starting extraction soon, but in reality this is still uncertain. More widely, our results point towards the need for a strong degrowth strategy to generally reduce mineral consumption in Europe while also stopping destructive mining projects in the Global South. Local public perceptions have to be taken more into account when it comes to the future of lithium extraction in Europe's 'backyard'. Mechanisms need to be developed to fully integrate local residents into decision making processes.

Keywords Wolfsberg lithium project, Austria, Political geology approach, Critical raw materials, Public perceptions, European Green Deal, Degrowth

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Background

The Wolfsberg Lithium project in southern Austria, led by the Australian company European Lithium, is firmly embedded within the European Green Deal discourse. The Green Deal is a set of proposals to make the European Union's (EU) climate, energy, transport and taxation policies align with its climate goals: to be climate neutral by 2050, compared to 1990 levels; to decouple economic growth from resource use; and to leave nobody and no place behind [1, 2]. To meet the commitments, EU member states need an increasing quantity of mineral resources. In their 2023 list of critical raw materials [3, 4], the European Commission registered 34 raw materials as being critical for the European economy, among them lithium. This soft and silvery metal has also been declared a critical raw material in the US, Japan and Australia [5]. The demand for increasing quantities of lithium comes mainly from the use of Li-ion battery cells to support the rise in e-mobility and the transition to a low-carbon future. Battery production is now set to return to Europe after more than a decade of reliance on the world market: there are 41 factories currently in the planning phase or under construction in the EU [6]. However, where will they source their raw materials? In general, the EU is struggling to respond to the rapidly increasing demand for critical raw materials (CRM) globally, in particular from China. Few major mining companies operate in EU countries and there is little primary resource extraction. As of 2025, there is no strong EU resource policy with concrete extraction projects programmed (e.g., [7]).

The EU is now, however, seeking to localize the extraction of CRM and the manufacture of inputs and components for the green transition. A higher degree of locally produced raw materials and processed components is expected to reduce the risk of supply-chain disruption and human rights concerns at production sites, as well as socio-political conflict and oligopolistic corporate behavior. In response to this, evolving EU policy has recognised earlier concerns about supply chains, and lithium exploration has been taking place in Europe for about 10–15 years. Several deposits have been identified that might supply Europe's industries with more of the metal in the future. Portugal is the only country in Europe that is currently producing lithium [8]. Among other lithium projects on the continent, the most advanced are the Wolfsberg project in Austria, the Jadar deposit in Serbia, Zinnwald and Vulcan in Germany, Emili in France, several further prospects in Portugal, and others in Spain. This article, therefore, aims to question the geological and socio-economic conditions for localizing (lithium) mining operations within EU member states by examining the Wolfsberg Lithium project as a case. What are the perspectives of local communities and politicians on this project? Can increasing demand for CRMs be met, or are other economic strategies, including demand reduction, necessary?

The Wolfsberg project relies on the Weinebene deposit, one of Europe's largest unexploited lithium deposits. The project is expected to start production in 2025 [9] and could produce as much as 8,800 tons per year of battery-grade lithium hydroxide monohydrate (LHM) over a 15-year lifetime [10].

This article is based on an interdisciplinary, 'multi-scalar' analysis (cf. [11]) that includes international, national and local perspectives relating to the European Green Deal and CRM extraction. Our author team is drawn from different scientific disciplines, including geology, human geography, geographical education, and social anthropology. Based on theoretical foundations and empirical studies, we reflect on the attitudes of local municipalities, citizens, and school students to lithium extraction in the region around the Wolfsberg Lithium project (henceforth, the Wolfsberg project). The article is structured as follows. After the background section, we outline our methodology, employing semi-structured interviews and social surveys. We use a social and political geology approach (cf. [12, 13]) and discuss key concepts related to green extractivism, green colonialism and the social acceptability of mining. After a short presentation of EU resource policy, the industrial uses of lithium, and an overview of other European lithium projects, we then provide a geological analysis, and present the perceptions of local youth and politicians of the Wolfsberg project. In the discussion section, we consider to what extent the project might (or might not) contribute to the green transition, and to what extent it is feasible or critically important from a geological and social perspective.

Political geology, resistance, and the social acceptability of mining for the green transition

Ciaran O'Faircheallaigh ([14] p. 3) highlights a major contradiction inherent in mining aspirations for the green transition. If consumer societies stick to economic growth while at the same time aiming to move away from a carbon-intensive economy: "[M]ost of the amenities, comforts, and securities of modern life rely directly or indirectly on the extraction of minerals, including energy minerals [raw materials] such as oil and gas. In my view we do not, on a global scale, have a choice not to mine. This reality will not change as the world moves away from a carbon economy […]. The relevant questions relate to where mining should occur and should not occur, and the conditions under which it should occur."

Political geology (cf. [12, 13]) teases out the fundamental issues raised by O'Faircheallaigh. The extraction of raw materials for the green transition is not a politically neutral technical operation. The scale and the techniques used in mining, and who profits from it, are integral to the geosciences, which need to look 'beyond the mine' as part of contemporary sustainability debates [12, 15]. There are obvious geopolitical influences on many mining operations, particularly for strategic minerals [13, 16–20], and non-Western earth knowledges are less understood by the geosciences [21]. Geological deposits are nested in scaled and uneven power relations [22, 23]. These forces are often layered on centuries of exploitation, and almost always result in a failure to invest profits in the communities most affected by mining operations [24, 25]. Mining activities are influenced by external forces at different scales.

At the European scale, the rush to mine local lithium is already fueling uncertainty about the feasibility of 'green' and 'just' transitions, based on concerns around how the required resources will be sourced, transported, and processed [26]. In other places, 'extractivism' describes the economic prioritisation of resource extraction (primarily for export to wealthier countries for processing and consumption), and is associated with authoritarian modes of wealth accumulation, and colonial and neocolonial policies of appropriation [27–30].

The low-carbon transition is, therefore, increasingly being dubbed 'green extractivism' [31] or 'green colonialism' [32]. Both terms, 'green extractivism' and 'green colonialism' have been used in relation to mining for energy and mobility transition globally, including lithium mining [33, 34]. 'Green colonialism' is used in the European context (targeted at the EU itself and national governments), referring to threats posed to Indigenous livelihoods and culture from the development of renewable energy projects, such as large-scale wind farms in Sápmi (the homeland of the Indigenous Sámi people in northern Europe) [35, 36].

The EU has spent decades sourcing raw materials primarily from nations endowed with rich mineral reserves, many of which are located in the Global South, and/or from Indigenous peoples' territories in countries including Canada, Papua New Guinea and DR Congo, resulting in forms of extractive colonialism. Progressive deglobalisation [37] poses the question whether critical minerals should increasingly be extracted in countries of the Global North and emerging nations which are their prime consumers. Extraction carried out closer to densely populated areas, and less intensively on lands traditionally used by Indigenous peoples and other rural communities with resource-dependent livelihoods, could reduce some land-use challenges as well as addressing spatial injustices. Thus, to satisfy the (growing) needs of (European) industries and consumers, the question arises: why not mine in Europe's backyard? The social acceptability of mining [38, 39] will certainly be challenged in those continental locations, where consumers have been accustomed to an absence of large-scale mining for almost a generation, with metals and minerals largely sourced from elsewhere. The 'social licence to operate' (SLO), linked to business responsibilities [40, 41], also involves local communities, and wider social, governmental, and power relations at different scales [29, 42].

Based on a literature review relating to social non-acceptance of mining in the EU, Badera [43] suggests that local opposition to mining often embodies NIMBYism (Not In My Backyard). Local acceptance of a mining project is invariably influenced by national and international scales [39, 42]. Moffat ([39], p. 32) outline four 'critical relational variables' of social acceptance:

a) quality of citizen engagement,
b) benefit distribution,
c) procedural fairness (including flow of information),
d) citizen confidence in governance arrangements.

For the purposes of our article, variables (a), (b) and (c) are particularly relevant. Social acceptance is not the same as public acceptance [44], and seeks wider approval than the local 'communities of the affected' alone, involving 'communities of relevance' [45] and broader participation (e.g., [46]). Where the energy and mining domains dominate discourse and decision-making, geology itself becomes heavily politicised and unequal [47]. Future permits will likely be obtained by consistent commercial pressure on a resistant government, and will involve new taxation and governance arrangements. Highlighting unequal power relationships between local (marginalized) communities and the powerful mining sector is at the core of political analysis of mining conflicts and their environmental and social elements [48, 49]. In addition, the debate on changing political power relations is mostly missing in social acceptability research [44, 47].

This study is partial, concentrating on the perceptions of 'communities of relevance' including school students and local politicians, but we nest the mine proposal within European Green Deal aspirations and policies. We highlight the commercial issues around lithium production and consumption, including socio-political challenges for (and contradictions of) the EU Green Deal.

European resource policy and supplies of critical raw materials

In 1900, Europe "accounted for more than 50% of global mineral production", but this fell to under 5% in 2018 ([50] p. 209–210). The 27 EU member states consume 15–20% of worldwide non-ferrous metals production [51]. The European Commission has released some alarming documents, highlighting the EU's strong dependence on the import of raw materials, processed materials, and components and assemblies for energy and mobility transition [4, 6, 52, 53]. Among the technologies analyzed in a 2023 Foresight Study for the EU (including renewable energy and e-mobility technologies), Carrara et al. [6] identify supply risks for several technologies: the EU share of global production volumes is only 2% of the raw materials for Li-ion batteries, 4% of processed materials, 3% of components and 6% of assemblies (i.e., units of assembled components, such as motors, generators or compressors).

The production of Li-ion batteries requires critical raw materials, including lithium, nickel, cobalt, and graphite. Within the EU and 'associated' overseas territories, only Finland and New Caledonia-Kanaky (as a French overseas territory) extract cobalt, and their share in global production is less than 2% (2,584 tons of 134,476). EU member countries only produce 0.02% of mined graphite in the world. For nickel, the share is 8.3% (234,557 tons) of global production, because New Caledonia-Kanaky alone produced 186,284 tons in 2021 [54, 55].

For solar photovoltaics, the situation is no better: 4% of raw materials used are extracted in Europe, 12% are processed, 11% of the components are manufactured, and 2% of assembly is carried out. Carrara et al. [6] also analyze the EU's dependency on related key critical raw materials. No rare earth elements are currently being mined in EU countries, although deposits have been found in Sweden, Finland, Greece, Spain, and Greenland (an autonomous country within the Kingdom of Denmark). Instead, 100% of the rare earths used for permanent magnets globally are produced in China. Similarly, 77% of the world's lithium supply is extracted in Australia and Chile, while 56% of it is processed in China and 32% in Chile [6]. In addition, considering a paradigm of energy and mobility transition, the projected increase in the global demand for nickel will be more than ten times higher in 2030 than demand was in 2020, according to a High Demand Scenario (HDS). For cobalt, the demand will be nearly 9 times higher and for graphite more than 20 times greater (HDS) [6].

In light of the challenge of securing a reliable supply of raw materials that are considered to be crucial to Europe's economy, the European Commission created a list of critical raw materials for the EU, which is regularly updated. The 2023 list includes 34 mineral raw materials (see Table 1).

In debates about the European Green Deal, there is disagreement about whether the proposals simply encourage business as usual by investing in a "climate-neutral" economy [56]—merely substituting fossil fuels with renewables, requiring large capacitors that use lithium and other minerals. On the one hand, a 'decoupling' argument suggests that renewable energy enables the decoupling of economic growth from the negative environmental impacts of energy use. On the other hand, critics and opponents of the Green Deal argue that the continent should be implementing a genuine energy and mobility transition, reducing net demand not only through efficiencies and substitution, but also through reduced consumption (e.g., [57, 58]).

From a broader economic perspective, the EU has stuck to a green growth strategy, although a communication in October 2022 promoted an "economy that works for people", implementing a pillar of a social rights action plan ([59] p. 7–8). In a speech on 13 September 2023, President von der Leyen said: "When it comes to the European Green Deal, we stay the course. We stay ambitious. We stick to our growth strategy. We will always strive for a fair and just transition!" [60]. Concerning the Critical Raw Materials Act, she said that the regulation "will bring us closer to our climate ambitions" [53]. The Act sets clear benchmarks for domestic extraction and processing capacities: by 2030, at least 10% of the EU's annual consumption for extraction, and 40% of the EU's annual consumption for processing [53]. Many scholars

Table 1 Critical raw materials (CRM) list of the European commission. Sources: [3, 4]

Bauxite	Boron/Borate	Germanium	Magnesium	Copper	Titanium metal
Antimony	Cobalt	Hafnium	Manganese	Phosphorus	Tungsten
Arsenic	Coking coal	Helium	Natural Graphite	Scandium	Vanadium
Baryte	Feldspar	Heavy rare earth elements	Niobium	Silicon metal	Nickel
Beryllium	Fluorspar	Lithium	Platinum group metals	Strontium	
Bismuth	Gallium	Light rare earth elements	Phosphate Rock	Tantalum	

have expressed doubts about the co-evolution of (economic) growth and a just transition (e.g., [61]). Dunlap and Riquito ([58] p. 4) also argue that "the celebration of green capitalism (or 'green growth') by the EC policies disables not only profound socio-ecological remediation strategies, but also marginalizes post-developmental and degrowth trajectories suitable to rural populations… already stabilizing ecosystems and climates."

Reducing the climate crisis to a simple question of atmospheric carbon levels [57] ignores the fact that e-mobility and energy transitions are requiring an ever-increasing quantity of mineral resources, e.g., cobalt, nickel, and also lithium, leading to new forms of environmental harm and new CO_2 emissions from production and transportation, as well as local environmental and social impacts. While post-development and degrowth trajectories [62] are still marginalized or little understood in EU policy circles, a recent survey completed by 789 global researchers who have published on climate change mitigation policies showed that 73% of all respondents expressed views aligned with an a-growth or degrowth position, with a-growth being favored [61]. The inference is that respondents, from the natural and social sciences, but also economics and applied sciences, are skeptical about the EU's green growth paradigm.

Besides the lack of degrowth strategies, there is currently no common EU mining industry development policy, and no common exploration strategy. Mining directives must be implemented through national laws. Mining, permits, licensing and environmental impact assessments (EIA), are a matter of national sovereignty. They differ widely across the EU member states. The timeline from successful exploration to the start of resource extraction is on average 15 years, often more. In addition, only about 1 out of 1,000 exploration projects makes it into production; all others do not meet the feasibility requirements or are halted along the way during the many years of project development (because of financial problems, resistance movements, or other reasons).

Lithium extraction, use, opposition, and support

Lithium plays an important role in the European Green Deal, so here we dig deeper into lithium extraction, supply, and European mining projects. In 2021, about 230,000 tons of lithium oxide (Li_2O) contained in primary ore were produced from global mining operations, increasing in 2022 to 345,829 tons, occurring in only eleven countries in the world, led by Australia, Chile, and China. The three countries together provide 92% of the mined Li ore (Fig. 1, [8]). In Europe, Portugal's output was around 210 m. tons in 2022 [8], which makes up less than 0.06% of the global total—although more mines are being planned or developed in the country, and across other parts of Europe.

Current lithium extraction is mainly from two ore types: 'hard rock' pegmatite, which is a highly fractionated SiO_2-rich granitic rock composed of quartz, feldspars, mica and Li minerals, and 'brine' Li, which is recovered from highly saline solutions forming in salt lakes in very dry desert climates [22]. World reserves of

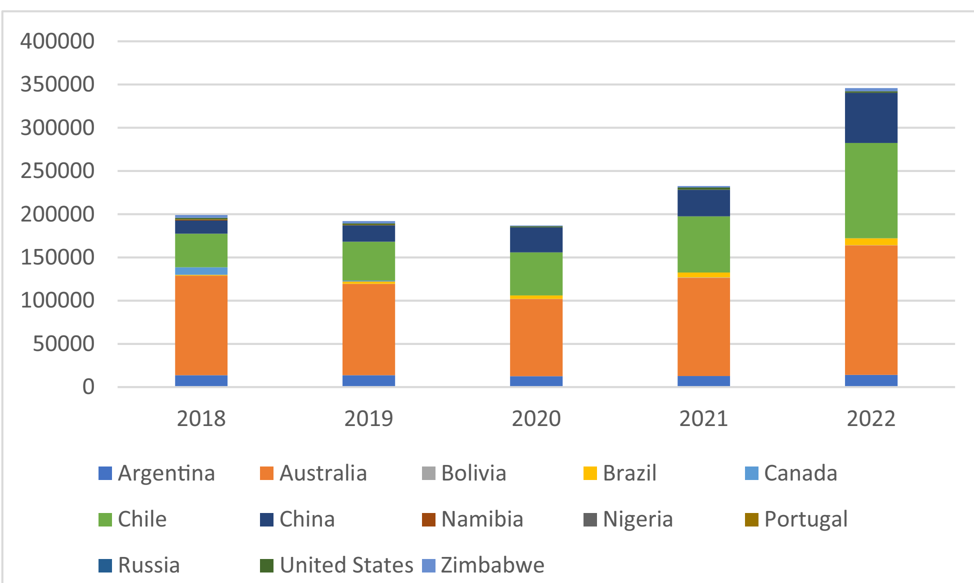

Fig. 1 Evolution of lithium mine production in metric tons from 2017 to 2022. Source: [8]

21 million tons [63] are mainly composed of brine Li, but current production in Australia, Brazil, and Zimbabwe focuses on hard rock Li. Other Li ores such as tuff, buried lake sediments, and those in geothermal environments currently do not play a major role, but are listed as part of the global resources of 86 million tons [63]. Australia accounts for around 50% of the global lithium supply from hard rock pegmatite (spodumene) deposits (Fig. 1). The Li deposits found in Europe are predominantly of this hard rock variety, either in pegmatite, rare metal granite, greisen, or as the mineral jadarite that only occurs in the Serbian deposit, forming from an ancient, now buried saline lake. Ore grade in hard rock deposits is usually given as Li_2O (Lithium oxide), although this is just a theoretical component of the silicate minerals, e.g., in spodumene. The extraction process is economically costly, involving drilling and explosives to break up the rock, followed by roasting it at high temperatures, crushing, and followed by sulphuric acid leaching [5]. It largely relies on fossil fuel use for energy, akin to fracking, coal mining, or oil drilling.

Lithium is mainly used in the electromobility sector (54% goes to rechargeable batteries, compared to 10% for ceramics and 9% for glass manufacture). Other raw materials for batteries such as Co, Ni and graphite are also seeing an escalation in demand, and Ni and Co have many applications other than battery production. Some other minor uses of Li include air-conditioning technology, nuclear energy, and some pharmaceuticals [64]. Global demand for lithium ores for energy and mobility transition is expected to increase more than current global production can supply. The demand will be 18 times higher in 2030 than in 2020 (under the High Demand Scenario) [6] and with less certainly in subsequent decades. In the EU itself, compared to 2020, "lithium demand for batteries … is expected to grow 12 times as large in 2030 and 21 times as large in 2050" ([6] p. 8). It is estimated that about 78 new lithium mines need to be opened simply to satisfy global demand up to 2035. Compared to the cumulative production over the past 37 years, the forecast lithium production in 2050 will be 1.2 times higher (Fig. 2). Considering the wish to reduce minerals dependency from non-European countries and the long time-frame to set up new mining projects in Europe, EU countries are unable to meet even recent growth in global demand with localized production. In addition to promoting mining projects in Europe's backyard and exploring recycling, it seems highly necessary to reduce lithium demand in European industries, something all but absent from the European Green Deal discourse.

Europe's external reliance on lithium supply worries the European Union and national governments. According to Carrara et al. [6], 41 lithium plants are planned in Europe. In addition, half of them already require an investment of €12–18 billion (Wehrspohn, pers. comm. 2023). The first could operate in Guben, Germany, requiring an investment of €730 M. Production capacity of 24,000 tons of lithium hydroxide monohydrate (LHM) per year would

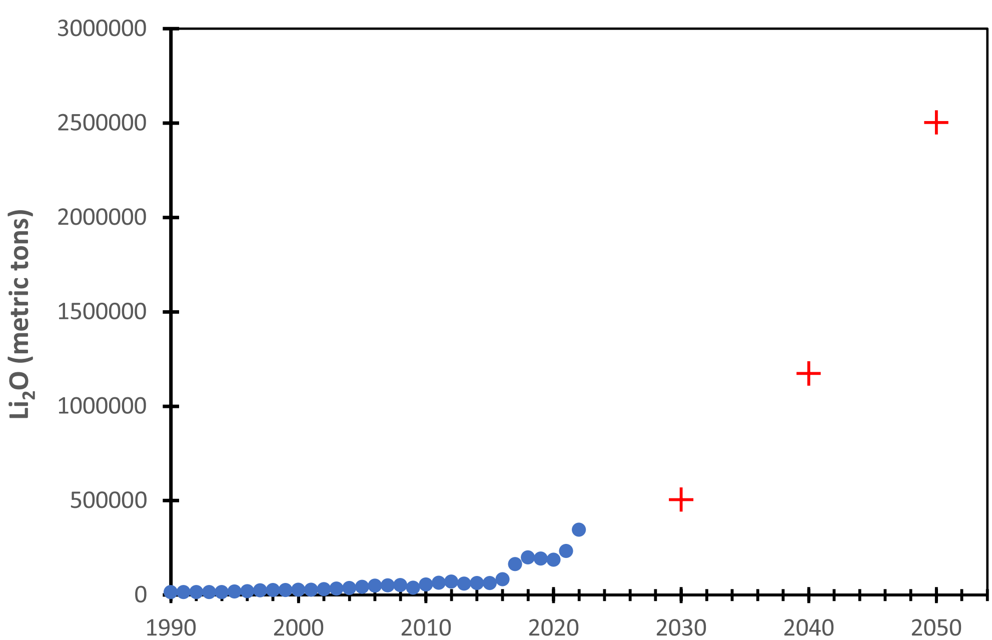

Fig. 2 Global mine production of lithium expressed as Li_2O from 1990 until 2021 [54]. Estimates of future demand from DERA (German Mineral Resources Agency) [65] for 2040, and Carrara et al. [6] and WMD [63] for 2030 and 2050 for strategic technologies only

support batteries for about 500,000 electric vehicles (EVs). The plant will have a zero-waste strategy and should be ready to operate with around 1,000 employees in 6–7 years [66].

Levels of social acceptance of lithium mining in Europe differ, although there is a tendency towards local opposition. Social and environmental impacts associated with the development of deposits and uneven power relations have led to anti-mining movements in Serbia, Portugal, Spain, and elsewhere (see, e.g., [23, 58]). For instance, Savannah Lithium's Barroso Lithium Project in Portugal, which is yet to start production, is facing considerable public resistance, including demonstrations and strikes [58]. The Barroso region is the epicenter of the lithium rush in Portugal, and the project is expected to be the largest open-pit lithium mine in Western Europe. According to Savannah [67], Barroso is Europe's most significant resource deposit of hard rock spodumene lithium and can supply approximately 0.5 million vehicle battery packs per year. Dunlap and Riquito [58] investigated the resistance movement in Covas do Barroso, a village close to the future mine. Local respondents all stated that they were against the project, citing noise, water pollution, and a preference for their traditional and healthy agricultural lifestyle [23, 58]. As a harbinger of what Europe's lithium production boom may bring, anti-mining protests have also been held in major Portuguese cities. The lack of local citizen participation in decision-making in the Barroso Project led Saleth and Varov [23] to suggest the region is becoming a 'sacrifice zone'. Moreover, in 2023, Portuguese Prime Minister António Costa stepped down after investigations into alleged corruption in his administration's handling of lithium mining and hydrogen projects [68]. The scandal troubles the EU's hunt for CRM.

Rio Tinto's above-mentioned Jadar Lithium Project in western Serbia, a candidate country for EU-membership, has identified a lithium resource of 136 million tons containing 2.5 million tons Li_2O at an ore grade of 1.5%. A potential of 21 million tons of boron oxide have also been reported, boron being an important commodity for the glass and chemical industries with primary production led by Turkey (52%), with no production within the EU. Jadar is unusual as it defines a new geological type of Li deposits: the mineral of value, jadarite, is hosted by lacustrine evaporites in a sedimentary basin. The deposits have been claimed to cover 90% of Europe's current lithium needs [69]. Although exploration was well advanced, the Serbian government halted the project in 2022 due to resistance locally and nationwide. Thousands of people took the streets of Loznica and Belgrade, predicting a catastrophe for Serbia's 'breadbasket'. The region around the lithium development is responsible for around a fifth of Serbia's total agricultural production [70]. Ivanović et al. ([71] p. 9) highlight that communities were not willing to sacrifice their land for the "promise of economic opportunities that could potentially lead to landscape degradation". Đorđević et al. ([69], p. 1) highlight in a recent paper that their studies reveal "substantially elevated downstream concentrations of boron, arsenic, and lithium in nearby rivers as compared to upstream regions". With the potential opening of the mine, the authors argue that the problems will increase, for example, with planned mine tailings and landfills that will occupy an area of 20 ha filled with 360,000 t/year of mine waste. The landfill area will be located next to the Korenita and Jadar rivers, "which are prone to heavy flooding of the surrounding areas" ([69], p. 2).

By contrast, the Zinnwald Lithium Project in the Erzgebirge mountains of Germany, near the Czech border, has the support of local former mining communities. Mining ceased in the 1990s after the German agency Treuhand decided mining of tin and tungsten had become uneconomic due to low raw material prices. Exploration defined a total resource (measured and indicated) of 193.5 million tons at a grade of 0.478% Li_2O [72]. Production is planned at 12,000 tons per year of battery grade Li hydroxide. The Li grade is lower than at the Wolfsberg project, and the mineral of interest is not spodumene but zinnwaldite, a Li-bearing mica. Processes to extract Li from zinnwaldite are already fully developed, as well as recovery of tin and tungsten as byproducts. Inclined access to the ore body underneath an existing tourist heritage mine will come from a tunnel drilled into the footwall. Infrastructure, including a processing facility and road and railway access, is already in place.

Methods

A political geology approach (cf. [12, 13]) helps to understand the interplay of geological and social–political conditions associated with the supply of CRM for the green transition. We focus on youth and political perceptions of the proposed Wolfsberg project, querying how it is embedded within relations of power, including significant commercial pressures to supply lithium. The project is, therefore, positioned in cross-scale networks of energy policy (at national and international levels, including the European Green Deal) (cf. [11]). However, local geological conditions also matter, since these determine the viability of any proposition to extract lithium.

Our analysis includes an extensive review of scientific articles, media and policy reports, and investor communications issued by the project developer, European Lithium; a field trip with university students to the site of the Wolfsberg Lithium project; semi-structured interviews held with local politicians and the CEO of European Lithium; and an empirical study conducted among local secondary school students. We focus on the two municipalities most affected by the project, Wolfsberg and Frantschach–St. Gertraud, both located in the region of Carinthia in southern Austria. The head office of European Lithium is based in Wolfsberg and the deposit itself is in Frantschach. A processing plant was initially planned for Wolfsberg, but the plans have changed, with processing currently being proposed in Saudi Arabia.

The fieldtrip to the Wolfsberg Lithium project site took place in June 2022, as part of a seminar on resource governance and environmental justice (Master of Education in Geography and Economics) at the University College of Teacher Education Styria in Graz (Austria). It included a visit to the drill core storage facility and laboratory, a guided tour of the existing mine with its exploratory excavation, and a discussion with the European Lithium CEO and another employee.

Semi-structured interviews were conducted in late 2022 and early 2023 with the CEO of European Lithium and the mayors of the two affected municipalities. Recorded interviews lasted between 1.5 and 3 h. The mayors were interviewed online (respectively, on 11 November 2022 and on 11 January 2023), while the CEO of European Lithium was interviewed in his office in Wolfsberg (on 12 January 2023).

In June 2023, to further enhance our insights into the social acceptability of the project in the local area, Baumann conducted an empirical study among 196 young people from two secondary schools in Wolfsberg and Frantschach, to investigate their perceptions of the Wolfsberg project, lithium use, and the energy transition. The survey instrument had both single-response and open questions, and used the online tool 'LimeSurvey'. The respondents were between 10 and 18 years (37% male, 61% female and 3% gender-neutral).

Previous research on the green transition in the EU, and on geological fingerprinting and traceability research at the Austrian Montanuniversität Leoben informed our understanding of the project context. Fingerprinting of minerals allows verification of a product back to a specific point of origin, ideally from any point in the supply chain [73]. This is likely to be part of future minerals policy, for example, to locate where smartphone materials originate from.

Results and discussion: the Wolfsberg lithium project in Austria

Against this background, we now explore the geological, social, and political aspects of mining in Austria, with a particular focus on the sector's significance for the implementation of the European Green Deal. The Wolfsberg project is located close to population centres and agricultural areas. We consider its geological and social feasibility, and prospects for social acceptance by local communities and politicians, and wider Austrian society.

Austria's mining sector

A peculiarity of the Austrian mining sector is that the government is not active in promoting mining to meet European needs, and there is no national mining strategy. After World War II, the Austrian mining sector enjoyed a prosperous period, but production has since decreased. In 1974, iron ore extraction was about 3.76 million tons per annum, falling to 2.4 million tons by 2019 [74]. The government has no specific funds for exploration or other mining-related activities, and development of mineral deposits is now left mainly to international junior companies. Although there is ongoing mining in Austria (e.g., tungsten ore in Felbertal/Mittersill and iron ore in Erzberg/Eisenerz), no new mining project for metals has been successfully implemented in the last 40 years. Mining in general is a hot potato for politicians, given its bad environmental reputation in the eyes of the electorate. It was not referred to in the former coalition agreement between the Conservative and Green parties. Politicians have avoided making statements on future mining developments, only doing so when placed under pressure, as demonstrated by a recent debate over fracking in Upper Austria [75]. Even the country's environmental protection laws do not explicitly and sufficiently cover the peculiarities of mining development. This is in part explained by a complex regulatory structure in Austria. By contrast, to comply with the EU Green Deal, Austria encourages circular economy initiatives. It currently gives a Reparaturbonus [76] to private consumers who wish to repair their smartphone, laptop, etc., contributing 50% of the repair costs. This is in line with recommendations made by Ignjatović et al. [77] to reuse and regenerate products or components, to extend the useful life of products, and to eventually rethink products, so that they become a service. However, a circular economy for battery storage is yet to emerge.

The Weinebene lithium deposit and its relevance for the EU CRM strategy

The hard rock, vein-type spodumene (Li pyroxene) deposit in the Koralpe mountains of Carinthia in southern Austria was discovered by mineralogist Heinz Meixner in 1966, and exploration took place from 1981 by the Austrian government company MINEREX. However, it was halted a few years later due to low Li prices and lack of demand, and then transferred to BBU (Bleiberger Bergwerks Union), a private company, in 1988. BBU went bankrupt in 1991, and the rights were sold to KMI (Kärntner Montanindustrie), which was operating a hematite (iron oxide) deposit nearby. In 2011, KMI sold the concession rights to the Australian-based company Global Strategic Metals (GSM) for €9.7 million + 20% VAT. In 2014, GSM separated out the Wolfsberg project from its other mining projects in Australia and created European Lithium, now ASX listed on the stock exchanges in Perth and London. After extensive drilling, European Lithium made the resources that were determined in a 1987 pre-feasibility study by MINEREX compliant with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves ('the JORC Code'). This means that exploration discoveries, mineral resources and ore reserves need to be publicly reported following a set of minimum standards to inform investors. In February 2024, European Lithium merged with Sizzle Acquisition Corp. to form the Critical Metals Corporation, which is now listed on Nasdaq [78]. However, for the present, the developers retain the name European Lithium for the Wolfsberg project and the ASX-listing. The company, whose market capitalization exceeded US$ 250 million prior to 30 June 2023 [9] and which is also engaged in lithium projects in Ukraine [79], withdrew, however, from the Vienna stock exchange in 2020 [80].

As of 2022, the Weinebene deposit was assessed at 12.9 Mt grading 1% Li_2O, with measured and inferred resources of 9.7 Mt, and measured resources of 4,3 Mt at 1.13% Li_2O, a higher concentration. The deposit consists of spodumene-bearing pegmatite veins that are hosted by amphibolite and mica schist of the Koralpe crystalline basement, forming part of the Koralpe–Wölz nappe system [81]. Within the Weinebene deposit, 15 veins reaching up to 10 m thickness and extending for more than 1,500 m along strike have been mapped and intersected by drilling. The veins transect their host rocks almost vertically. They are composed of quartz, K-feldspar, albite, minor muscovite, and spodumene. Minor Nb–Ta–Sn minerals occur as accessories, but are not considered economic at present. The pegmatite intrusions are approx. 260 million years and are thought to have formed from partial melting of lower crustal, mica, and staurolite bearing rocks during the Permian high-temperature low pressure metamorphic event [82, 83].

Over the past 20 years, numerous pegmatites and leucogranites (Fig. 3, yellow circles) in central and southern Austria have been tested for their lithium potential. As a result, pegmatites containing spodumene are highlighted by red circles. Similar Li-bearing pegmatites have been discovered in numerous outcrops within the Koralpe–Wölz nappe system from Eastern Tyrol into Styria in Austria [82–84]; Fig. 3, marked with red circles). However, no advanced industrial exploration activities have taken

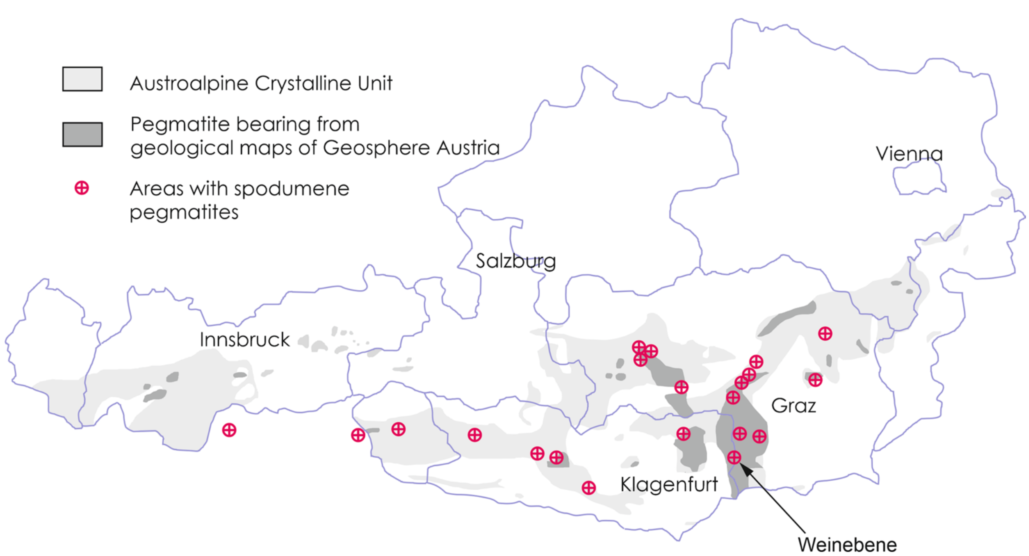

Fig. 3 Pegmatites and leucogranites in Austria, tested for their lithium potential. Source: [85]

place in the region, despite the fact that other exploration concessions cover the area that are in the hands of private owners or companies.

On 8 March 2023, European Lithium released the results of the Definitive Feasibility Study (DFS) for its Wolfsberg project, covering the whole process up to the creation of lithium hydroxide [10]. The DFS was published by the Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia, indicating the extent to which European Lithium is embedded in Australian mining. According to the DFS, the average (steady state) mine production rate is expected to be 780,000t/year, peaking at 840,000 t/year over the Life of Mine (LOM) which is based on an ore reserve of 11.5 Mt, mined over approx. 15 years. This period could be perceived as quite short. At a planned mine production capacity of 780,000 tons per year, 67,000 tons of concentrate could be produced, providing about 10,500 tpa LiOH/year for a period of 20 years. This would be about 4.5% of the world production as of 2021.

The Wolfsberg Lithium project was expected to include two integrated operations, a mining and processing plant to produce a lithium concentrate (spodumene), and a hydrometallurgical plant to convert the spodumene into battery grade LHM. In their annual report of 2023, European Lithium announced they were granted a total of 20 mining licenses, nearly doubling the footprint for the underground mining operations [9], and production could start in 2025 (Interview, January 2023; see also [10, 86]. The CEO of European Lithium highlighted that the project will not use or produce arsenic or cyanide or sulfur, in contrast to other mines and other commodity chains (Interview, January 2023). However, a flocculent is needed, and sulfuric acid will be used for calcination in a first step of processing on the mine site. Even for this process, an Environmental Impact Assessment is not legally required. The environmental advocates of the Carinthia and Styria regions have expressed serious concerns about the decision of the responsible regional authorities [87]. The hydrometallurgical plant is now likely to be built in Saudi Arabia, as announced by European Lithium and discussed in various national newspapers [86, 88]. To build and operate it, European Lithium has entered into a non-binding Memorandum of Understanding (MOU) with the Saudi Arabian Obeikan Investment Group [9]. The main reason for building the plant offshore is much lower energy prices, estimated at only 5% of Austrian energy costs. Moreover, Saudi Arabia will not require an EIA. The processing plant should produce 8,800 t/y of LHM, with a total production of around 129,000t of battery grade LHM over the LOM. LHM is Li hydroxide monohydrate $LiOH*H_2O$, which typically contains 55–56.5% LiOH.

The product generated in Austria will be a spodumene concentrate, which will be shipped to the processing plant in Saudi Arabia. The Li component in the spodumene is then converted into LHM in a three-stage process: (1) calcination to convert spodumene to the more soluble beta (or klinker) phase ($Ca_2SiO_4*Li_2O$); followed by sulphuric acid roasting (1,100 °C) to produce Li sulphates; (2) impurity removal and Li carbonate precipitation, Li_2CO_3, by reaction of purified Li sulphate with Na carbonate; and (3) precipitation of LHM from reaction of Li carbonate with lime $Ca(OH)_2$ [10, 89]. European Lithium estimates the sales price for LHM in 2025 to be 48,600 US$/t, meaning that the company could sell LHM at 427.68 million US$/year. In addition, feldspar and quartz could be produced as by-products, thus minimizing waste material.

The European dimensions of the Wolfsberg lithium project

The CEO of European Lithium announced that the company has signed a long-term agreement (LTA) with the German automobile manufacturer BMW, which will buy Li hydroxide at a reduced price for a fixed duration of 6 years. BMW aims to produce their own Li-ion-batteries for electric cars. The deal illustrates that the project is already integrated in an international production chain. However, building a plant in Saudi Arabia means a certain alienation from local actors, politicians, and communities, who wanted a longer production chain in Austria, including battery production in the country.

Back in 2017, the European Commission launched the European Battery Alliance, the EBA250, to address the challenge of energy and mobility transition. The overall goal was to build a strong pan-European battery industry to capture a new market worth €250 billion/year by 2025 [90]. Extraction of lithium, essential for Li-ion batteries, is one component of this new European initiative. It is on the EU CRM list (Table 1) and an important mineral for the EBA2050. Saudi Arabian processing would lengthen the commodity chain, making Europe dependent on importing some of its own minerals back from Saudi Arabia, even if the BMW deal ensures the financial viability of the costly Wolfsberg project.

The financial interests of European Lithium, which was already sanctioned by the Financial Market Authority (FMA) in Austria, because ad hoc disclosures were made too late [91], are driving their investment choices. The merger with Sizzle Acquisition Corporation gives them greater access to capital. However, in a recent interview with *Wiener Zeitung*, the CEO of the company highlights that they are about half a billion dollars short [91]. The Austrian government and the EU have no financial stake in the Wolfsberg project. The reduction of lithium ore exports from Latin America and Australia and an eventual 'greener' production compared to extraction in Chile or Argentina is of secondary importance for the company. Even if Wolfsberg begins production in the near future, its share of EU supply and the global lithium market will be rather small, although it could contribute to new resource extraction in the European 'backyard' and greater EU independence of CRM supply. The project certainly has the potential to contribute to broader energy transitions outside the Carinthia region, and to the lofty aspirations of the European Green Deal, but within the constraints of its financial status as a profit-seeking operation.

Municipalities striving for information and local economic benefits

Austria's regulatory system actually allows for limited stakeholder involvement, not binding dialogue around the Wolfsberg project. European Lithium is treading a delicate tightrope between transparency and not 'waking up sleeping dogs' in the region, by trying to avoid local protests (Interview, January 2023). Local political leaders argue for much fuller involvement of local communities and institutions (Interviews, Nov. 2022 and Jan. 2023). Following best practice, local people have to live with the impacts of the mine including environmental damage and social change, and should, therefore, see benefits from the project in terms of jobs, subcontracting, and participation in decision-making.

Both mayors of the municipalities impacted by the Wolfsberg project, Wolfsberg and Frantschach–St. Gertraud, are in favor of lithium extraction in the region. They foresee job opportunities and economic development, and are trying to minimize talk of a 'dirty industry'. They are conscious that lithium is needed for the energy transition. The mayor of Frantschach–St. Gertraud welcomed the original plans to have the whole production chain in the region, especially in his municipality—from lithium extraction to battery production (Interview, Nov. 2022). However, representatives of both municipalities, speaking under anonymity, as well as members of the public have the impression that European Lithium just wants to sell the mining concession and processing plant at an elevated price to a major mining company. In addition, the CEO of European Lithium assured everybody that they aimed to extract lithium ores and process them locally (Interview, Jan. 2023). Our interviews were before the change of company policy, 6 months later, when the Saudi Arabian processing partnership was announced [9]. The wishes of the mayor of Frantschach–St. Gertraud are unlikely to be met, which also means substantial losses of corporate and other taxes that would have gone directly to the municipality budget.

Both mayors criticized European Lithium's communications. They would have liked to have learned more about the project over its 10-year exploration lifetime. European Lithium offers mine visits and communication platforms, and the CEO argued that more in-depth public engagement will take place after project approval, engaging the local population and the municipalities at the 'right moment' and when the project has been fully mapped out (Interview, January 2023). This is likely to be when the project has received Austrian mining authority (Montanbehörde) approval. Involvement and consultations of local communities at this late stage is not best practice, and is out of step with social acceptance criteria and mine approvals in the sector (cf. [14, 92]). Local politicians, municipalities, and individuals do not appear to be seen as full 'partners' by the company.

Local citizen initiatives and opposition to the project

In November 2022, a citizen initiative was founded to resist the expected increase of road traffic from the transport of lithium ores 30 km to a future processing plant. There were concerns that the underground mine could impact watersheds, but the main issue was about the projected increase in road traffic. At the time of the interview with the mayor of Frantschach–St. Gertraud in Nov. 2022, 131 protest signatures had been collected. The company had provided little information: that around 20 trucks per day would pass through Frantschach–St. Gertraud, but inhabitants feared that the real number would be more like 200. The CEO of European Lithium said he had yet to be contacted by the citizen initiative, and that several trucks from an international packaging and paper company already pass through the village every day. European Lithium settled on the use of trucks, because a cableway or conveyor was going to be too costly, and anyway would have to pass through or over 100 properties, needing permission from every landowner. Today, with the proposal to process in Saudi Arabia, trucks will still be needed and it is expected that the resistance and protest against this traffic will continue, especially as the extracted lithium ore needs to traverse many towns and villages on its way to the port of Trieste in Italy. Around 6–7% of extracted rock will potentially be transported to the harbor. The citizen initiative had prepared concrete requests before the announcement of the plant construction in Saudi Arabia: the installation of soundproof windows, construction of noise barriers, and special asphalt that absorbs noise. There have been attempts elsewhere to use far less polluting e-trucks in the industry, but current models

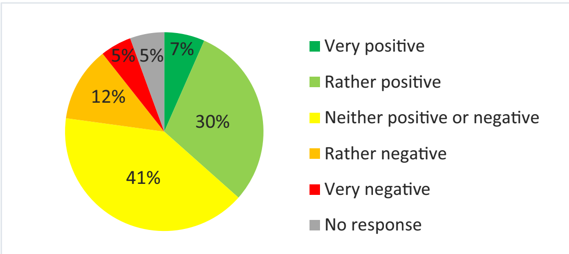

Fig. 4 Perception of the secondary school students surveyed on the Wolfsberg project (source: Authors)

cannot reach the mine due to a 1,000 m climb. The strong "place-based livelihood ties" ([93] p. 685) of this region mean there is a strong likelihood of community protest.

For the present, however, the resistance to mining is still low compared to other lithium projects across Europe, e.g., the Jadar project in Serbia or the Barroso project in Portugal. This may be for several reasons: the relative unfamiliarity with the project in Austria, the lack of a tradition of demonstrations and strikes compared to France or Portugal, the sparse information presented by the media or by the company, and the fact that the Wolfsberg Lithium project is not a spatially extensive, and visible, open pit mine. A 'politics of anticipation', such as that reported by Saleth and Varov [23] around a proposed lithium mine in Portugal, is emerging and social acceptance is tempered by confusion over the anticipated impacts of the mine and ore transport.

Perceptions and knowledge about the project among young people

Our research also addressed the views of non-voting local citizens under 18 years, who are more influenced by personal contacts and social media than by formal politics. A quantitative study among secondary school students in Wolfsberg and Frantschach–St. Gertraud took place in 2023. A small majority of the students surveyed had already heard of the Wolfsberg project (53%

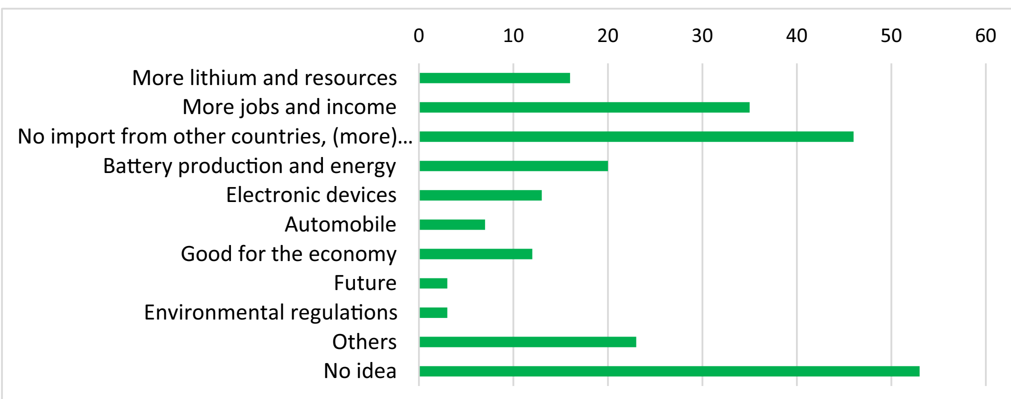

Fig. 5 Positive aspects and benefits of the Wolfsberg projects, according to the secondary school students surveyed (source: Authors)

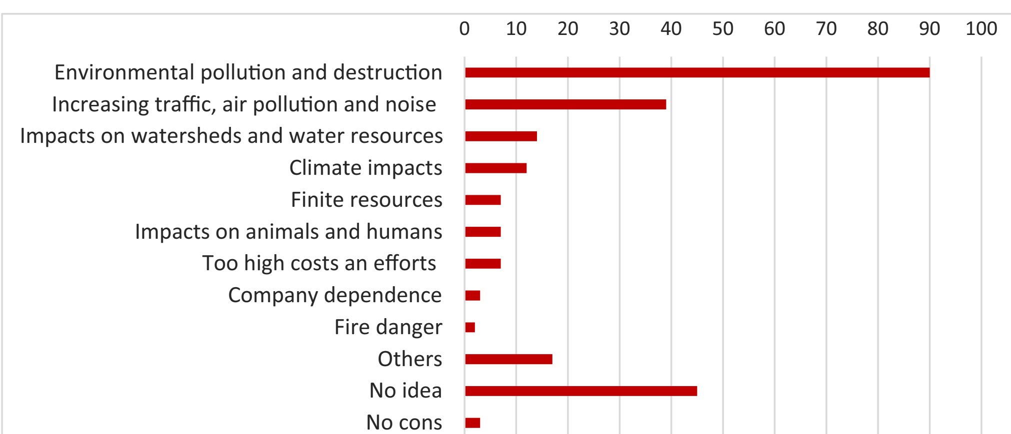

Fig. 6 Negative aspects and disadvantages of the Wolfsberg project, according to the secondary school students surveyed (Source: Authors)

of 182 student respondents). However, 59% of them thought general awareness of the project was low or nonexistent, suggesting the corporate strategy on delaying public involvement is working. Students had heard of it from newspapers, social media, online journals, and from family members. Although the Wolfsberg project is not included in school curricula or textbooks, 65 students (36%) had discussed it in lessons. Fifty-nine (32% of the 186 students who responded to the question) saw it as positive, and 13 (7%) very positive. Again, suggesting some lack of awareness, most students, 80 (43%), had ambivalent perceptions (Fig. 4).

The main arguments they raised in favor of the project (Fig. 5) concern the possibility of local mineral production, with independence from foreign imports (46 responses) and the creation of jobs (35 responses). The students also highlighted the use of lithium ion batteries and electronic devices (laptops, smartphones, etc.) (20 and 13 responses). However, this was tempered with a lack of knowledge of any benefits (53 responses).

The negative aspects of the Wolfsberg project, from the point of view of the students surveyed (Fig. 6), are perceived environmental pollution and destruction (with 90 responses), followed by increasing traffic, air pollution and noise problems (39 responses). Many students (45) had no idea what negative outcomes could emerge. Considering that mining is generally—and specifically in geography curricula and textbooks in Austria—connected to environmental destruction and pollution (e.g., [94]), the concerns of the students are unsurprising. The 2023 curriculum for lower secondary schools in geography and economics highlights that students should identify ecological problems related to energy and raw materials in connection with digitization, and derive their own actions from this [95].

Although our sample refers to a narrow age cohort, combined with other interviews, it suggests the minimization of environmental impacts will be a major imperative and challenge. It is a path to greater consent or the basis for resistance in other mining projects [55]. Environmental impacts are not only ecological, but also perceived emotionally and sometimes viscerally [96]. The question is of disruption to places that people value in the region of a project, since culture resides in places ([97]; see also [23]). All students have a certain connection to the region, because they are either born locally and/or are currently enrolled in schooling there. The empirical study shows that they are interested in the economic development of the region, for example, preferring local battery production rather than simple lithium extraction without further processing: 88 students out of 142 who replied to the question (62%) prefer battery production, 9 did not, and 45 were unsure.

Another factor that emerged among student responses was their thought that at any stage, lithium could be replaced by another substance to produce batteries. Indeed, 135 students (out of 182 who replied to the question) responded that Li will definitely or possibly be replaced as a vital battery component. Only 13 doubted this possibility.

In a place where local politicians complain about lacking communication and commitment from the company, the students' statements confirm the concerns about environmental pollution and destruction, but also the hopes for more jobs and for greater independence from Li imports.

Conclusions

We set the proposed Wolfsberg Lithium project within the context of European energy and mobility transitions, questioning whether the corporate and government focus on mining and processing to meet high demand for lithium is sustainable and of benefit to local people. Our empirical data offer insights into the nature of perceptions, acceptance, and opposition towards lithium mining at different levels. While the Wolfsberg project fits with the European Commission's goal of sourcing more minerals within Europe, and the geological indicators suggest adequate mineral resources, the uncertainty around social–environmental impacts and the non-involvement of local politicians and communities in decision-making limit the project's potential to build social acceptance prior to mining. There is no open dialogue on the future of the Wolfsberg project, nor is there a significant equalization of power relations. Moreover, the company European Lithium is planning to process the extracted Li ores in Saudi Arabia, contradicting its stated aims to reduce carbon emissions and environmental impacts.

This study reveals three crucial arguments. First, localizing lithium and other CRM extraction in Europe's backyard is needed to avoid green colonialism, to reduce import dependency, and to reestablish a connection between extraction and European consumption behavior. European countries have, over decades, exploited mineral resources from the Global South to satisfy their own needs without, or with little, benefit to local people. Second, considering the increasing demand for CRM, and to promote environmental regulation of mining, it is necessary to openly and pro-actively discuss where, how, and indeed whether to mine CRM in European countries. This implies a certain change in power relations, by involving local communities, political authorities, and citizen initiatives in decision-making processes. In our case study from Wolfsberg and Frantschach–St. Gertraud, this would help to reduce uneven benefit sharing and ensure more equitable decision-making. Mining is a bone of contention in Austrian politics, and seemingly capable of alienating voters, which also means geology itself is politicised. So far, neither at the EU scale, nor among nation states, such as Austria, is transparent political debate taking place on the requirements for mining in Europe's 'backyard'. The citizen initiative and the students' perceptions revealed in this study, however, show that local people are highly interested in extraction projects planned in their 'backyard'.

Third—and this is our main conclusion which emerges from the other results—European countries urgently need a strong degrowth strategy to reduce CRM consumption. The reduction of mineral consumption and related extraction should be promoted as a positive—and not negative—economic strategy, as demonstrated by our geo-economic data. The increasing demand inherent in energy and mobility transitions, as they are currently envisioned, cannot be met by localized production alone, but would require further environmental destruction in the Global South. A future strategy needs to be based on the reduction of consumption in Europe, which can and should be combined with recycling of CRM and circular economy approaches. Such a degrowth strategy needs to be supported by political leaders across the political spectrum, and importantly, by European citizens themselves.

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Author contributions
Kowasch, Melcher and Saxinger conducted fieldwork at the Wolfsberg project. Baumann did an empirical study among secondary school students in Wolfsberg and Frantschach-St. Gertraud. All authors, except Baumann, contributed to the writing and reviewing of this paper.

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Availability of data and materials
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