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White Mining's Green Dream: Entropy and the mirage of sustainability in Northern Chile

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ABSTRACT

This article critically examines the "green dream" of lithium mining in northern Chile, framing extraction as indispensable for addressing the climate crisis while obscuring its irreversible ecological, social, and epistemic consequences. Drawing on Bernard Stiegler's concept of *Entropocene*, we introduce the notion of entropic omissions to analyze how extractivist logics not only conceal damage, but degrade the conditions for perceiving, imagining, and responding to it. Based on ethnographic research in the Atacama Desert, we show how these omissions are embedded in both technical reasoning and institutional frameworks—shaping what is made visible, actionable, and imaginable. Through the cases of a mining engineer and a state agency, we trace how entropy is named yet neutralized, acknowledged yet unthought. We situate these findings within broader debates on entropy, extractivism, and sustainability, offering a critique of degrowth perspectives. While degrowth challenges economic expansion and resource overuse, it overlooks the deeper systemic and colonial dimensions of extractive reasoning. We argue that responses to the climate crisis must go beyond emissions reduction to confront the omissions that sustain extractive futures. Emphasizing the urgency of reclaiming critical capacities, this article calls for awaken alternative ways of dreaming beyond the green extractivist horizon.

"Everyone wants a more sustainable world. And for people, especially those most closely linked to the environmental world, this is a big concern. But a more sustainable world is only possible with more mining (…). This is the paradox of mining, because those who think that mining is predatory, or problematic, do not understand that to create a more sustainable world, we need more mining. That is, we want non-conventional renewable energy generation plants, and those plants require three times more copper than is used today in a traditional plant. We all want electromobility, which requires two and a half, three, four times more copper than is needed today, plus lithium. So here is the paradox: a more sustainable world is only possible with more mining (…). So I think we have an obligation to continue to be among the world's leading lithium producers, because that will also help copper and because it will make the world more sustainable. It is a strange situation, but it is true. There is no alternative."

- Chilean Mining Official (2019)

"White people don't dream like us. They sleep a lot, but they only dream about themselves. Their thinking remains obstructed and they sleep like tapirs or tortoises". (*our translation*)

- Davi Kopenawa and Bruce Albert, A Queda Do Céu (Kopenawa and Bruce, 2015)

1. Introduction

These two voices encapsulate the tensions underpinning the promise of a sustainable future. In the words of the mining official, achieving a "more sustainable world" paradoxically involves intensifying mining. In contrast, Kopenawa offers a radical critique of the ways of dreaming and thinking that might be called the 'white dream of mining': a closed horizon where the only solution to climate crisis seems to be technological and extractive intensification, reflecting a self-referential dream. Northern Chile presents itself as a paradigmatic case where these tensions manifest with particular intensity. Its salt flats, mountains, and pristine skies converge with extractive projects that promise solutions to the climate crisis, yet omit the social and ecological costs that such solutions generate. Drawing on Alfred Whitehead and the reflections of

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Isabelle Stengers, we have argued elsewhere (Bonelli et al., 2024) that these omissions are not mere discursive gaps, but active operations that structure sustainability narratives, rendering material and social realities invisible and reinforcing the extractivist logic as inevitable. Where discursive gaps imply a passive silence, active operations refer to how certain realities are made insignificant or invisible by dominant modes of abstraction. Following Whitehead, we understand omissions as effects of abstraction—processes that, rather than simply forgetting, actively shape what is allowed to matter and what is rendered negligible. This is not just about what is left out, but about how absence is produced. In this way, the imagination of alternative futures is shut down, legitimizing the contradictions of extractivism. The white dream of mining, then, not only perpetuates these tensions, but also embodies a form of self-referential thinking that, as Kopenawa points out, dreams only of itself.

In this article, we propose the "green dream of white mining" as a heuristic for analyzing these paradoxes. This dream, which reflects and amplifies the extractivist logic expressed by the Chilean mining authority, is not just a narrative, but a way of thinking and acting that produces and organizes worlds. It promises sustainability through technological fixes that depend on the intensification of mining, projecting a horizon where a "green" future can only be achieved through the increasing exploitation of resources (Blair et al., 2023; Fornillo et al., 2024; Jerez et al. 2021; Weinberg 2023; Weinberg and Figueroa 2024). Like the "white dream" described by Kopenawa, the "green dream" imposes a self-referential framework that naturalizes these dynamics as inevitable, dictating unique imaginaries of what a sustainable world means and closing off the possibility of other futures. In this sense, it functions as an "infernal alternative" (Pignarre and Stengers, 2011): one that secures its own perpetuation by blocking the imagination of alternatives and legitimizing the contradictions inherent in extractivism. As Pignarre and Stengers argue, infernal alternatives create a logic where each action only deepens the original problem, reinforcing a dependency on a system that produces crises rather than resolving them.

This dream is not only a closed horizon, but also expresses a situation of double bind (Bateson et al., 1956): a logical trap in which any action leads to unsatisfactory results. The quote from the Chilean mining expert illustrates this paradox clearly: "A more sustainable world is only possible with more mining (…). It is a strange situation, but it is true. There is no alternative." Here, the idea of "there is no alternative" resonates as a conceptual device that reinforces the infernal character of the statement, closing the space for imagining ways of inhabiting and relating to the world beyond extractivism. For those who dream this dream, extraction is not only a necessary condition, but an inevitable destiny. Building on Bateson's framework, Köppel and Scoville-Simonds (2024), who have also published in this journal, have highlighted how lithium extraction operates within this double bind logics, where communities are compelled to accept mining as a condition for global sustainability while simultaneously bearing its socio-environmental costs.[1]

As noted by anthropologist Thomas Eriksen (2016), whose recent passing leaves us with an enormous legacy of critical reflection on the Anthropocene, this double bind is not simply an ethical dilemma, but a structural contradiction inherent to our time. Eriksen explored how the dynamics of global growth generate insurmountable tensions at various scales, from everyday lives to macroeconomic policies. Referring specifically to the paradox of growth and sustainability, he highlighted how people are pressured to act in environmentally responsible ways, while their lives remain tied to a carbon economy, escalating this contradiction to the political and economic level. This double bind, as a conceptual structure, naturalizes a logic where "no matter what a person does, they cannot win" (Bateson et al., 1956:251). In this configuration, mining is positioned as the only path to sustainability, even as it perpetuates irreversible damage and forecloses the imagination of alternative futures. Thus, extractive models not only destroys ecosystems and fragments communities, but also configures an epistemological limit, trapping critical thinking in a self-referential and tautological horizon.

Unobstructing the green dream of white mining – unobstructing this infernal alternative (Bonelli, forthcoming) – implies an effort to liberate thought from the colonial impositions that obstruct it, as Kopenawa suggests. This is precisely what we propose in this paper: to unobstruct thinking in those places where the infernal alternative acts as a form of epistemic coloniality, extracting not only the territories, but also the capacity to think and dream other possible worlds. To begin opening up this obstructed horizon, we suggest that it is not enough to describe the contradictions of extractivism in terms of measurable *impacts* or *externalizations*.[2] These frameworks, while useful, often remain entangled in managerial logics that assume damage can be quantified, mitigated, or compensated. What is needed is a vocabulary capable of addressing the irreversible, the unmeasurable, and the structurally foreclosed. The concept of *entropy*, as we begin to explore it here, allows us to think through these more profound losses—losses that are not only ecological but also epistemic. It helps us name how dominant ways of knowing and acting in the world progressively undermine the very conditions for imagining and enacting alternatives.

2. Thinking from the entropocene

The exploration of the "green dream" presented in this text stems from a collaboration that intertwines ethnographic storytelling with in-depth theoretical reflection. Within the framework of the ERC worlds of Lithium project, we have jointly explored the entropic implications of extractive dynamics in Chile, while also revisiting debates on degrowth and sustainability. Drawing on shared readings—including works by Bernard Stiegler (2015, 2018, 2021)—we have developed the concept of *entropic omissions* through ongoing conversations, public presentations, and experimental writing practices. This article is the result of that collaborative effort to think through the limits of green transitions from both empirical and conceptual perspectives.

Our understanding of omissions builds on Alfred North Whitehead's (1925) proposition that abstraction is never neutral. As Isabelle Stengers (2022: 31–32) recalls, Whitehead urged philosophy to remain vigilant toward the dominant modes of abstraction that acquire "predatory power" by rendering what they omit insignificant. In this view, omissions are not accidental oversights, but structural operations embedded within the logics of world-making. They determine what becomes intelligible, what is excluded from view, and what forms of damage or possibility are systematically erased. Whitehead called these active exclusions *negative prehensions*: ways in which aspects of reality are dismissed within perceptual or evaluative processes. These absences are not passive—they help constitute how reality appears, what matters, and what can be imagined. In this article, we mobilize the notion of *entropic omissions* to describe how dominant narratives of sustainability—especially those surrounding lithium extraction—actively conceal the irreversible transformations of territories. These omissions are not only discursive; they shape what is thinkable and actionable. The term *entropic* adds a particular analytical force to *omissions*. It signals that what is being left out is not only forgotten or sidelined, but actively degraded—materially, epistemically, and affectively—through processes that are cumulative and difficult to reverse. Entropy refers to a

[1] Köppel and Scoville analysis reveals the narrative of inevitability that consolidates extractivism as the only conceivable path. Expanding on their work, we will introduce the concept of *entropic omissions* to examine how these dynamics are systematically concealed.

[2] Fabiana Li (2015) has described how mining companies and state agencies construct "equivalences" by translating diverse environmental and social concerns into standardized technical metrics. This process of commensuration often neutralizes political conflict by rendering complex realities manageable within technical frameworks.

condition in which the very capacity to imagine alternatives erodes over time. In coupling entropy with omission, we aim to describe how green dreams reproduce extractivism not just by what they say, but by what they make unthinkable.

Stiegler's work has been central to our analysis of the entropic dynamics shaping the *Entropocene*. Drawing on Claude Lévi-Strauss's radical proposal to rename anthropology as "entropology"—a discipline aimed at critically examining the disintegration caused by human activity (Lévi-Strauss, 1976 [1955])—Stiegler redefines the Anthropocene as the *Entropocene*.[3] This period, as he argues, is characterized by the massive acceleration of entropy, manifesting in both material degradation and the psychosocial erosion of human capabilities (Stiegler, 2018:51). His concept of "generalized proletarianization" (Stiegler, 2015:45; 2018:78) highlights how creativity and care are reduced to automated functions, reinforcing unsustainable forms of existence. Building on Marx's original formulation, Stiegler expands the notion of proletarianization beyond the economic realm, revealing its entropic reach into the psychosocial and cultural fabric of existence. While Marx's proletarianization marks the disempowerment of workers through the alienation from the means of production, Stiegler's "generalized proletarianization" traces the erosion of knowledge, care, and creativity under the logics of automation and technological externalization. This is not simply a material condition but an existential unraveling—a disintegration of the capacities that sustain collective life. In the *Entropocene*, as Stiegler names this era, such processes extend beyond the domain of labor, stripping societies of their ability to imagine and regenerate, while consolidating the entropic dynamics that foreclose alternative futures. It is in this expanded frame that proletarianization emerges not only as a historical condition but as a planetary force, shaping the disarticulated horizons of a planet increasingly at odds with itself.

In our work, we connect this diagnosis with the logic put forward by our mining expert, whose framing—introduced at the beginning of this text—presents mining as an indispensable sacrifice for a sustainable future. This perspective, rather than challenging entropic dynamics, reinforces them by operating as a double bind: it proposes solutions that perpetuate the very conditions they seek to overcome. In this framework, the "infernal alternative" not only closes off the imagination of other possible futures but also naturalizes the intensification of the crisis as inevitable. By mobilizing a critical reflection on entropic processes in northern Chile, we propose understanding mining not only as a material process of extraction but also as a practice that profoundly transforms the capacity to imagine alternative futures. We suggest an analytical sensibility aimed at understanding how extractive practices contribute to the climate crisis not only through environmental destruction but also by proletarianizing the critical capacities of territories and communities, consolidating a closed horizon of extractivist inevitability.

2.1. Resisting entropy in the Entropocene

Building on Bernard Stiegler's redefinition of the Anthropocene as the *Entropocene*—a period marked by the erosion of material, cultural, and psychosocial capacities— we now briefly trace a genealogy of entropy to illuminate how this concept helps us rethink the logics of sustainability and extractivism. Originating in nineteenth-century thermodynamics, entropy marked a turning point in scientific thought. Sadi Carnot and Rudolf Clausius demonstrated that energy transformations are never fully efficient: part of the energy is irreversibly lost, a degradation captured by the term "entropy." Later, Ludwig Boltzmann extended this insight through statistical mechanics, showing that systems naturally evolve toward disorder because such states are statistically more probable. In the twentieth century, the concept traveled beyond physics. Erwin Schrödinger (1992 [1944]) introduced the idea of *negentropy* to describe how living organisms maintain internal order by increasing disorder in their environments. Alfred Lotka (1945) further expanded this view by proposing that humans resist entropy not only biologically, but also culturally, through exosomatic instruments—technologies, tools, and social systems that restructure the world while generating new forms of disorder.

These ideas converge in the work of Nicholas Georgescu-Roegen (1971), who brought entropy into economic theory. He argued that economic processes, like physical ones, are entropic: they transform low-entropy resources into high-entropy waste. For Georgescu-Roegen, this entropic degradation is not merely environmental—it undermines the very conditions for sustained economic and social life. His work laid the foundation for ecological economics and revealed a fundamental contradiction in development thinking: that the very processes used to preserve life and growth are those accelerating irreversible loss. In this article, we build on this legacy to rethink the promises of green extractivism. Entropy is not just a physical law, but a conceptual lens through which to perceive how energy, time, and imagination are being exhausted—often silently—under the guise of sustainability.

This historical trajectory allows us to see how entropic dynamics are not merely scientific abstractions, but active forces shaping the extractivist logic at the heart of the "green dream" of white mining. As the Chilean mining expert declared, "A more sustainable world is only possible with more mining." Such statements trivialize entropy, reducing it to a technical matter while overlooking its deeper material and temporal implications. The expansion of mining, framed as an indispensable sacrifice for sustainability, exacerbates the irreversible transformation of landscapes, ecologies, and communities. These *entropic omissions*, as we call them, render the costs of extractivism invisible, consolidating a narrative of inevitability that forecloses the imagination of alternative futures.

Scholars such as Daniel Ross, a close collaborator of Bernard Stiegler, extend these reflections to argue that technical and economic systems, much like biological systems, can either intensify entropy or foster regeneration through exosomatic functions (Ross, 2018:26). This dual possibility underscores the urgent need to rethink sustainability as a practice of regeneration rather than an extractive inevitability.

By briefly tracing the genealogy of entropy, we argue for responses that resist extractive logics and reclaim the capacity for ethical and epistemic regeneration. Drawing on the insights of Lévi-Strauss, Stiegler, and Wynter, we highlight the ways extractivist logics perpetuate entropic degradation. As stated in the introduction of this special issue, Sylvia Wynter (2003) critique of the coloniality of "Man" is particularly resonant here, as she underscores how this construct overrepresents certain ways of being while marginalizing others. Wynter's call to dismantle these colonial grammars aligns with Stiegler's emphasis on regenerating critical capacities and affirms the necessity of imagining alternative horizons.

In the Chilean mining context, this perspective exposes the entropic realities hidden behind corporate narratives, illuminating pathways toward a future that resists the inevitability of extractive horizons. These approaches critique the dynamics of extractivism and serve as tools for reconfiguring forms of knowledge, care, and coexistence in the face of climatic and epistemic crises. In this light, the green dream of white mining operates not only as a narrative of sustainability but also as a mechanism that obscures the entropic realities of extractivism. By naturalizing irreversible transformations and framing them as technical necessities, it consolidates a horizon where degradation is trivialized and regeneration is foreclosed. Addressing this logic requires exposing the colonial grammars and omissions that sustain it, opening pathways to imagine and enact futures beyond extractivist inevitability. Yet, as we turn to northern Chile, these omissions reveal their material and epistemic force, as corporate narratives reduce entropy to a calculable problem, detaching it from the lived realities of landscapes, ecologies,

[3] For an in-depth exploration of Stiegler's development of the concept of the Entropocene and its genealogical ties to thermodynamic, biological, and psycho-social entropy, see Alombert 2024.

and human and non-human communities. The following vignettes do not aim to "apply" the concept of entropic omissions, but rather to show how they emerge through specific discursive and institutional contexts. These moments in the field reveal the ways in which entropy becomes thinkable, speakable—or silenced—in extractive regimes.

3. Entropic omissions

3.1. Entropic omissions in the Atacama salt flats[4]

We recall one of our visits to one of the world's largest lithium extraction plants, located in the heart of the Salar de Atacama. Gaining access was no small feat: weeks of negotiations culminated in a rare opportunity to witness the inner workings of the green dream of white mining up close. Beneath a relentless sun in the driest desert on the planet, the extreme landscape seemed to constantly remind us of the very conditions that make industrial extraction possible. The Salar de Atacama, touted as essential to the global energy transition, also embodies the tensions outlined in the introduction: promises of sustainability colliding with irreversible transformations and invisible losses.[5] During our visit, the price of lithium was at historic highs, with a tonne of lithium carbonate fetching over $70,000. This figure, reflecting speculation and rising demand, imbued the operation with a feverish energy that reinforced the narrative of extractivist inevitability.

Felipe, a metallurgical engineer, greeted us with pride and pragmatism. Onboard his van, we drove for miles past brine ponds, each one more monumental than the last. In front of the largest halite pond, he explained the technical process:

"In this pool, the chemical brine contains 0.2 per cent lithium," he said. "When the halite precipitates, the remaining brine is transferred to other pools. This process takes 14 months, during which the pool loses mass through evaporation and precipitation." Each pond stretched one kilometer long and 300 meters wide. Felipe detailed the continuous flow:

"We extract 1600 liters of brine per second from the aquifer. Every day, 80 trucks of lithium leave here, 1600 cubic meters in total." With a calculator in hand, Felipe translated these dynamics into economic figures:

"There are about 7000 tonnes of lithium carbonate here. At $70,000 per tonne, that's 490 million dollars. All the lithium production is paid for by the potassium; it's all profit."

Felipe's narrative focused on efficiency and profit. According to him, producing a tonne of lithium cost about $1500:"If demand keeps going up, hopefully the Chinese will buy more."

In this discourse of numbers and profits, the irreversible dynamics we outlined in the introduction were conspicuously absent. What dominated was the re-materialization of the global economy under the discourse of sustainability (Hickel, 2020), while the entropic dynamics remained unacknowledged. Felipe did not see entropy, at least not in this pool.

Towards the end of the tour, Felipe led us to a smaller pond: a scaled-down version of the production cycle. There, he invited us to a sensory experiment. Wearing blue gloves, we touched the lithium chloride, which he described as oily, similar to olive oil. When water was added, an exothermic reaction released heat.

"Thermodynamically speaking," he explained, "the energy of the reaction generates heat. There must be some entropy, a disorder between particles that generates this release."

Although the reaction dramatized the chemical process, Felipe reduced entropy to a technical abstraction, disconnected from the irreversible transformations that structure the extractive project. Massive water evaporation, fossil-fuel-driven pumps, and widespread environmental degradation were conveniently left out of the efficiency narrative. In this context, Felipe unwittingly embodied the figure of the agent of disintegration described by Lévi-Strauss, with one crucial difference: the inability to recognize the entropic dynamics that inform his practice. The paradox of the green dream of white mining, as we have described, is reduced here to mechanical locomotion: a cyclical, controlled movement of materials. Water evaporates, brine concentrates the lithium, trucks transport the material to the chemical plant, and dollars return as profit to finance the next cycle. The tour of the lithium extraction plants in the Salar de Atacama allowed us to observe how the green dream of white mining deploys a narrative of inevitability that decontextualizes entropy, reducing it to a technical abstraction severed from the irreversible dynamics that affect landscapes and local communities.

3.2. Entropic omissions and institutional ignorance in the management of salt flats[6]

A similar way of thinking can be observed in one of the many diplomatic activities undertaken by SERNAGEOMIN, the National Geology and Mining Service of Chile, regarding potential future transnational projects for the exploration and exploitation of lithium in various salt flats located in northern Chile. In these activities, we observed an extractive logic that operates not only through industrial machinery but also through the institutionalization of scientific ignorance, as acknowledged by their own officials, due to constant underfunding that limits their technical capabilities. One of them commented on these limitations:

" Although Chile officially recognizes 53 salt flats, international reports often cite around 60, reflecting a broader geopolitical narrative of abundance, we can only gather information on one salt flat per year... It's not enough. We are 53 years away from knowing all the salt flats. It's simply not enough."

The same official mentioned that more than a decade ago, it was decided within the service to work solely with data produced from field observations and not with samples collected from the field, since the extreme salinity and the lack of specialized laboratories outside the capital made analysis nearly impossible. SERNAGEOMIN, as the state agency responsible for productively promoting the country's salt flats, operates under a mandate that prioritizes the generation of data to promote resource extraction, despite facing serious financial and technical limitations. This contrast is telling: while the private sector is rapidly expanding its operations, driven by the global lithium boom and historic market prices, the public agency tasked with understanding and monitoring these territories can barely explore one salt flat per year. This institutional inability to address the ecological and social complexities of the salars illustrates how the extractive model operates not only on materials but also on knowledge, institutionalizing ignorance that perpetuates structural inequalities in lithium management.

The lack of exploration and adequate monitoring is not merely a technical shortcoming but a structural condition that perpetuates the extractivist model. The estimated 53 salt flats in Chile— of which only four have been subject to direct intervention.—represent not just economic potential but also a living space and evolutionary dynamics that remain profoundly unknown (Bonelli and Dorador, 2021). However, this ignorance does not halt operations or financial speculation. On the

[4] The ethnography at the lithium plant was conducted by Cristóbal Bonelli with anthropologist Marina Weinberg, both members of the ERC Worlds of Lithium. We use "we" here to reflect the collective voice of this article.

[5] In this spirit, Weinberg (2023) has proposed in this journal that in the Atacama Desert, there is no such thing as an "energy transition," but rather a "mining transition" that primarily serves to sustain a capitalist economy rooted in the exploitation of raw materials. This transition, Weinberg argues, perpetuates practices of control, reproduces forms of domination, and ultimately denies life.

[6] The ethnography on institutional management of salt flats was conducted by Andrés Pavez. We use "we" here to reflect the collective voice of this article.

contrary, the lack of knowledge about the *salares* only amplifies the uncertainty surrounding the materials, reinforcing the narrative that extraction is inevitable and that any loss is simply an assumed cost in the pursuit of profit.

In this way, SERNAGEOMIN's work resonates with what we have conceptualized as the green dream of white mining: a model of thinking that not only decontextualizes entropy but also extracts the minimal possibility of imagining alternatives. In the case of the state agency, extraction is not confined to subsoil resources but also extends to the very capacity to understand the dynamics of the salt flats before intervening in them. This institutional model, combining material deficiencies with an ideology of expansion, embodies the paradox described by Georgescu-Roegen: an entropic economy that moves forward without acknowledging the irreversible transformations it generates, without recognizing its own entropic condition. By ignoring the ecological and social complexities, both industrial operations and the institutional limitations of SERNAGEOMIN contribute to the same dynamic: the invisibility of the material and symbolic losses associated with the lithium boom. In this sense, salt flats are not merely resource deposits; they are territories where structured ignorance becomes a legitimizing tool for extractive practices (see Babidge, 2019).

In the *Salar de Atacama*, we observe how entropy, understood as the irreversible destruction of livelihoods and landscapes, is excluded from the narratives that justify extractive expansion. In both SERNAGEOMIN and the industrial plants, entropy is reduced to technical calculations or controllable phenomena, disconnected from its broader implications. This disconnection between industrial calculations, institutional gaps, and irreversible transformations underscores the need to critically examine entropy not only as a physical phenomenon but as a dynamic deeply entwined with the power and knowledge structures that uphold the green dream of white mining.

During our visits to the *Salar*, the technical and economic dynamics underpinning lithium extraction revealed a recurring pattern: the omission of the material and social consequences of entropy. The green dream of white mining reduces irreversible losses to trivial details, embedding them within a logic of inevitability and efficiency.

The case of SERNAGEOMIN reinforces this perspective. Faced with technical and financial limitations, the state agency prioritizes the generation of data for mining expansion, sidelining the ecological and social complexities of the salt flats. Here, entropy is framed as a technical phenomenon isolated from its broader implications. Similarly, in the chemical process described by Felipe, entropy is reduced to a controlled reaction within a "natural laboratory," while institutionalized ignorance renders ecological and social losses invisible, shutting down the possibility of imagining beyond the green dream.

These omissions, which we have termed *entropic omissions*, trivialize entropy by presenting it as a technical issue confined to efficiency calculations. At the same time, they silence the irreversible transformations of territories, reinforcing an extractive model presented as inevitable and limiting the ability to envision alternative futures, subordinating critical thinking to the logic of the infernal alternative and its double bind. Faced with this logic, the challenge is not only technical or economic but profoundly ethical: how can we reconfigure our forms of abstraction to not only reduce emissions, but also reduce *entropic omissions*?

4. From the steam engine to toxic ashtrays

An example of entropy in action that we have already discussed is the steam engine, which, from a thermodynamic perspective, not only generates locomotion but irreversibly transforms coal into ash, degrading the quality of useful energy into dissipated energy. This process underscores how entropic dynamics, far from being abstract or technical, profoundly impact the materiality and temporality of the systems they transform. Similarly, the green dream of white mining operates under logics that render these irreversible transformations invisible, consolidating an extractivist model that not only degrades landscapes and communities but also the very capacity to imagine alternative futures.

In fact, a more compelling example, which expands and directly connects with the case of the steam engine, can be found in Tocopilla, a paradigmatic place for understanding how entropic dynamics and omissions structure modern mining. Tocopilla, a strategic enclave for copper production in northern Chile, was, for much of the 20th century, an essential energy hub for large-scale mining. Here, power generation depended on the massive burning of coal and petroleum coke, a process that left a legacy of a landscape marked by mountains of toxic waste: ash that cannot be reversed or reused due to its entropic nature. These "toxic ash" landfills (see Bonelli et al., 2024) materialize the irreversible dynamics of thermodynamics applied to industrial processes. Available energy becomes waste, a permanent loss. As Cara Daggett (2019:43) points out, "burning coal moves a piston, but no amount of pistons can reconstitute the ash in a lump of coal." This principle, which defies the fantasy of reversibility, finds its ultimate expression in Tocopilla, where decades of fossil fuel burning have left behind ash piles that embody the critique formulated by Nicholas Georgescu-Roegen. In 1971, he warned that the industrial economy should not be conceived as a circular, mechanical system, but as a fundamentally entropic one, in which transformations are irreversible and losses permanent.

Tocopilla, then, is not just a geographical location. It is also a material reminder of the ethical and ecological costs of energy production for mining. The toxic ash heaps that dominate its landscape not only testify to entropic dynamics but expose the illusion that modern economic systems can operate without irreparable losses. This place and its waste defy technological narratives that promise sustainability while ignoring the toxic and permanent footprints of industrial processes. Tocopilla, with its ashes and its history, invites us to rethink not only extractive dynamics but also how they extract our capacity to imagine regenerative and ethical alternatives.

Perhaps it is worth noting that the connection between Tocopilla and lithium lies not in their direct production, but in how both territories are ensnared in the extractive logic described by our mining expert as inevitable: *a more sustainable world is only possible with more mining.* This infernal alternative intensifies the very practices that generate irreversible entropic dynamics. In Tocopilla, the energy produced for copper mining feeds the same green dream that drives lithium, rendering its costs invisible and shutting down the imagination of alternative forms of regeneration.

What we aim to establish here is how the green dream of white mining depends on and operates through a systematic omission of the entropic dynamics that structure both extraction and its effects. This dream, underpinned by narratives of technical control and mechanical optimization, trivializes entropy by reducing it to an isolated problem of energy efficiency, detached from the irreversible transformations that shape our *Entropocene* geological epoch. In other words, while thermodynamics teaches us that entropy is inherent in every system, the green dream of white mining instrumentalizes it as a mere variable in systems presented as closed, controllable, and reversible. However, this mechanical framework not only obscures the material losses of extraction but also disables any possibility of critically engaging with the entropic scale of the *Entropocene*.

5. Degrowth, and its limits

Although we share certain critical concerns with degrowth, our aim is not to refine or extend its framework. Rather, we argue that degrowth, as currently formulated, often fails to confront the colonial and epistemic infrastructures that sustain extractivism. *Entropic omissions*, we suggest, offer a complementary but distinct lens to address these historical entanglements. Before us, indeed, numerous natural and social scientists have warned of accelerating entropic processes and the irreversible depletion of ecosystems, while striving to cultivate an

engaged and situated capacity to respond (Haraway, 2016). This effort is informed by the legacy of Georgescu-Roegen, who linked entropy to economic transformations, and whose influence marked milestones such as the *Limits to Growth* report (Meadows et al., 1972). This report, led by Donella Meadows and the Club of Rome, sounded the alarm about the material limits of the planet and the irreversible consequences of economic growth, laying the groundwork for contemporary debates on sustainability and degrowth, particularly in the context of the climate crisis.

In recent years, degrowth has emerged as a sharp critique of the superficial narratives of sustainability and green energy (Hickel and Kallis, 2020). This approach highlights how material and energy consumption has grown exponentially since the 1990s, exceeding planetary limits of mineral extraction and accelerating entropic processes. Moreover, it denounces large-scale geoengineering solutions as high-impact projects of uncertain feasibility (Hickel, 2020). In response to the paradox of the green dream of white mining, degrowth proposes an economic transition that prioritizes human well-being over perpetual growth, aiming to "reduce energy and resource use to restore the economy's balance with the living world in a safe, just, and equitable way" (Hickel, 2020:32).

At the same time, degrowth does not constitute a unified critique of growth or a homogeneous analysis. Instead, it functions as an 'umbrella concept' that brings together diverse theories, critiques, and practices (Barca, 2018). Despite its plurality, it shares an "explicitly normative" orientation that "delineates the contours of desirable democratic transformation processes focused on analyzing, critiquing, and overcoming growth dependency" (Schmelzer et al., 2022:22).

This normativity is reflected in two of the most influential books on the subject: *Less is More: How Degrowth Will Save the World* (Hickel, 2020) and *The Future Is Degrowth: A Guide to a World Beyond Capitalism* (Schmelzer et al., 2022). Both texts build on a critical tradition represented by figures such as Joan Martinez-Alier and Serge Latouche. From the creation of alternative economic indicators to GDP, which critiques its dependence on accelerated consumption and its exclusion of non-monetized activities (Hickel, 2020:169; Schmelzer et al., 2022:33), to a critique of techno-fixes that intensify the crisis rather than resolve it (Hickel, 2020:122; Schmelzer et al., 2022:78–79), these works extend established debates. They also include proposals such as the redistribution of resources through a strong welfare state (Hickel, 2020:182), practical experiments to imagine alternatives to growth (Schmelzer et al., 2022:207), and even a call to reassess our relations with the world from an ontological and animistic perspective (Hickel, 2020:33–34). We suggest that these constructions of future models and political, social, and cultural imaginaries, though presented as "explicitly normative," risk overlooking the decolonial potential of Georgescu-Roegen's thought.[7]

By integrating entropic analysis and recognizing the irreversibility of systems, Georgescu-Roegen calls for a critical reflection on the hegemonic ways of organizing life and questions the foundations of a world centered on growth. His approach introduces two key principles: entropic indeterminacy — the idea that there is no way to predict the exact moment when the entropy of a system will reach a certain level, nor the consequences of reaching that point — and the emergence of novelty through combination — the variability that arises from finite matter due to this indeterminacy. These principles not only challenge existing structures but also inspire negenthropic explorations, fostering a decolonization of technical and economic thinking, aligned with Stiegler's proposals. However, contemporary normative models often rely on predefined formulas, which limits their capacity to imagine new forms of negenthropic organization. This rigidity reduces the complexity of systems and closes off the possibilities opened by their indeterminate nature. Reclaiming this creative and critical dimension in negenthropic imaginaries is essential for moving towards ways of living that not only reject the growth paradigm, but also regenerate possibilities for building more liveable worlds and dismantling dominant extractivist frameworks.

In particular, the reliance on the state as a neoanthropic agent, expressed by authors such as Hickel (2020), risks neglecting how state dynamics also reinforce neocolonial extractivist logics, while actively shutting down any alternatives. Both our mining expert and the state agency SERNAGEOMIN exemplify this paradox: as state officials, they embody a narrative of extractive inevitability that either omits its entropic character. In both cases, the depletion of ecosystems is promoted, extractive activity continues unabated, and the green dream of white mining generates irreversible degradation on a large scale, whether in Tocopilla or in the Atacama salt flats.[8]

It should also be noted that Latin American states do not have a strong tradition of promoting welfare (see Galeano, 1971), nor do they possess significant industrial development based on growth to sustain such welfare. On the contrary, cycles of boom and bust around certain commodities, shaped by colonial and neocolonial dynamics, have been the historical norm. This is precisely what Uruguayan biologist and intellectual Eduardo Gudynas (2012:138) highlights as central to the new Latin American progressivisms: far from avoiding economic growth, these movements embrace it, attempting to manage it as a mechanism for financing social programmes, which in turn demand new extractivist projects with additional social and environmental impacts. This leads to a vicious, or infernal, circle — a spiral of endless entropic acceleration masked as welfare and growth. Meanwhile, institutional inevitability is maintained, either through omission, as exemplified by our expert, or ignorance, as depicted through the SERNAGEOMIN agency.

This limitation not only restricts the emergence of true novelty by combination, as Georgescu-Roegen described, but also perpetuates what Sylvia Wynter (2003) calls "paradigms of exclusion," reproducing epistemic frameworks that naturalize colonial hierarchies and rationalize exploitation as inevitable. To destabilize these grammars, as Wynter suggested, we must not only imagine alternatives to growth, but also reconfigure the very foundations of how we understand human beings and their place in the world, opening space for ethical and epistemic regeneration beyond the confines of a state-centered and universalizing model.

Rather than opposing degrowth approaches, we propose working alongside them, extending their frameworks to address the entropic dynamics of extractive logics. This perspective builds on what one of us have previously referred to as an "entropological pact" (Bonelli, forthcoming), which emphasizes the need to confront the systemic inertia that perpetuates irreversible processes. Inspired by Stiegler (2015) and his call to combat "systemic stupidity" and reactivate critical thinking, we advocate for approaches that act as stabilizers against entropic degradation, moving beyond fragile equilibriums maintained by state compromises that accelerate such processes (Gudynas, 2012). Instead, we advocate practices that foster ethical regeneration, capable of reconfiguring our modes of knowledge, care, and coexistence, ultimately strengthening our capacity to think. Degrowth, as a sharp critique, accurately exposes the paradox of the green dream of white mining. However, we believe its potential can be expanded by incorporating a decolonial perspective that links the critique of growth to a

[7] Calkins and Zoanni, in exploring alternatives to the dominant extractivist model, highlight how local dynamics of exchange can challenge growth and sustainability understood in a one-dimensional way, offering a more pluralistic and relational approach that destabilizes predefined formulas of degrowth (Calkins and Zoanni, 2024).

[8] For a detailed analysis of the hydrogeological dynamics and impacts of lithium extraction in the Salar de Atacama, including terrain subsidence and groundwater loss, see Delgado et al, 2024. This work highlights how intensive brine extraction has contributed to significant declines in groundwater levels and irreversible transformations in the landscape.

deeper transformation of the structures of knowledge, power, and extraction.

6. Awakening critical thinking: resisting extractivist sleepwalking

In seeking an alternative to the infernal alternative and its function as a double bind, we aim to reactivate a future imaginary that overcomes the closure of transformative epistemic and ethical horizons. Where lithium or copper mining extracts not only minerals but also the very capacity to think, it becomes urgent to revive critical thought. In this spirit, we conclude this article by drawing an analogy between the extractive process of white mining and another, equally extractive procedure within the medical field, through the work of Bosch, *The Extraction of the Stone of Madness* (Fig. 1).

The Extraction of the Stone of Madness, by Hieronymus Bosch, ca. 1494. Oil on panel. Museo del Prado, Madrid. Retrieved from Wikimedia Commons: [https://upload.wikimedia.org/wikipedia/commons/thumb/6/60/Extraction_of_the_Stone_Hieronymus_Bosch.jpg/722px-Extraction_of_the_Stone_Hieronymus_Bosch.jpgt]

In this work, infused with Gothic elements, Bosch portrays, in a satirical tone, a doctor removing a flower from a patient's skull, while a nun and a friar passively observe. This act, presented as a legitimized yet absurd medical procedure, encapsulates knowledge that is accepted without question, despite lacking critical support. Medicine at the time offered answers, deeply entwined with magical, religious, and scientific traditions, closing off the possibility of imagining alternatives. In a similar vein, the green dream of white mining legitimizes extraction under the guise of sustainability, while obscuring the irreversible costs and losses it engenders.[9] This satirical depiction resonates with the mechanisms of *entropic omissions* within the green dream: a narrative that systematically disconnects technical solutions from their broader ecological and social consequences. By focusing on efficiency and technological progress, these omissions trivialize the irreversible degradation of landscapes and communities, embedding extractive logics into sustainability discourses.

Stiegler's redefinition of the Anthropocene as the *Entropocene* has shaped our understanding of these omissions. He shows how extractive logics not only degrade physical environments but also erode the capacities for thought, care, and imagination. What he calls "generalized proletarianization" describes a situation in which entire societies become dispossessed—not just of material resources, but of their ability to conceptualize futures beyond extraction.

This resonates with Stengers' figure of the sleepwalker: the mobilized scientist who walks forward without vertigo, unaware of the risks or wreckage beneath his feet (Stengers, 2019). In this sense, the green dream of white mining is not a dream in Kopenawa's sense—not a space for alternative possibilities and connections—but a form of *collective somnambulism*. It moves forward with urgency, but without awareness, reproducing the very conditions that make catastrophe inevitable.

This *collective somnambulism* does not emerge in abstract. As we saw with Felipe, even when entropy is named, it is often absorbed into technical vocabularies that isolate it from political and historical context. His formulation, while attentive to irreversible change, remained tethered to a narrative of profit, optimization and efficiency—one that ultimately reproduces the very logic it might seek to question. The mining expert quoted at the beginning of this article embodies this logic too: her statement presents a paradox, legitimizing the intensification of mining as the only path to sustainability while rendering other possibilities unthinkable.

At the institutional level, as illustrated by SERNAGEOMIN, omissions become operationalized through the management of uncertainty. By containing what is unknown within existing technical frameworks, the institution reinforces a narrow epistemology of control—one that obscures the entropic consequences it cannot account for, and systematically avoids opening toward other temporalities or ways of relating to extraction.

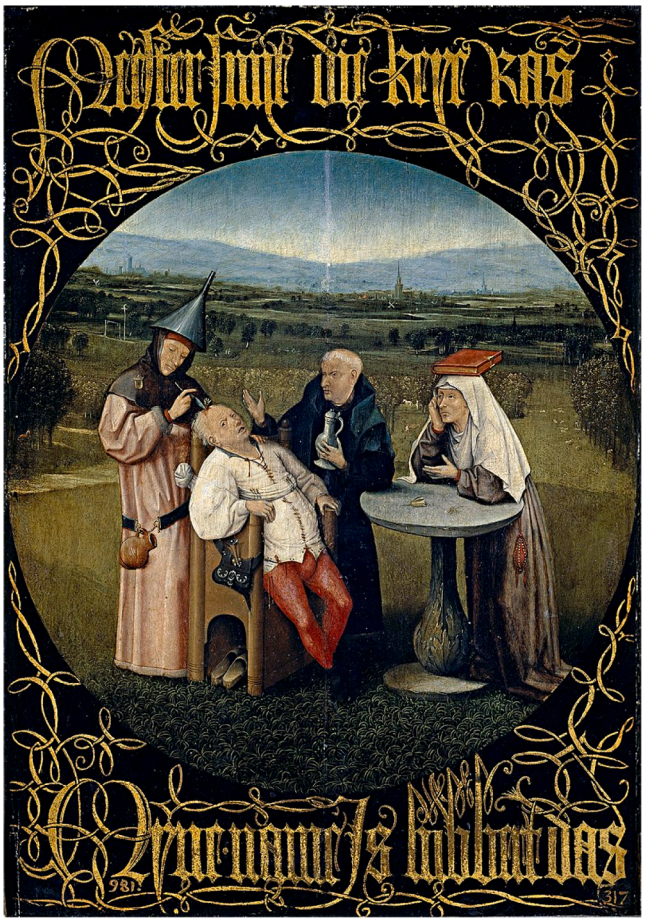

Fig. 1. The extraction of the stone of madness.

But how can one awaken someone who does not feel the vertigo of their condition? Engaging with sleepwalkers is perilous: intervening may cause them to fall, but doing nothing allows the destructive path to continue. While much of the sustainability discourse focuses on quantifiable impacts and the externalization of harm, entropy works differently. It does not displace damage; it erodes the very capacity to register it. This contrast matters: *impact* speaks in numbers, *entropy* in silences. Entropic omissions are not statistical absences but conceptual closures—operations that make certain realities unseeable, unspeakable, or irrelevant.

The challenge, then, is not simply to wake those who do not feel the vertigo of their condition, but to interrupt the conditions that keep them asleep—the entropic omissions that suppress critique, sever consequences from causes, and enclose the horizon of possibility. Resisting extractivist sleepwalking requires cultivating cracks in this closure—spaces where damaged landscapes, fragmented knowledges, and silenced futures might speak again. *Entropic omissions* do not merely erase information; they corrode the imagination. Against this, we argue for a politics of reawakening—an insurgent care that refuses inevitability, and dares to dream otherwise, together.

CRediT authorship contribution statement

Cristóbal Bonelli: . **Andrés Pavez:** Writing – original draft.

[9] For an in-depth analysis of the ideological dimensions of lithium extraction, including the cultural narratives surrounding salt flats and their role in sustaining a "green capitalism" discourse, see Fornillo et al. (2024).

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