From "Ion-Adsorption" to "Ion-Adsorbed" Rare Earths: Terminological Drift, AI Paraphrasing, and the Erosion of Geochemical Precision

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Abstract

The rapid adoption of artificial intelligence (AI) tools for writing and paraphrasing is transforming scientific communication. While such tools can improve linguistic fluency, their misuse, particularly when employed to mechanically rephrase text, may introduce subtle but consequential distortions in scientific terminology. In disciplines such as geochemistry, where terminology is closely tied to processes and mechanisms, even minor linguistic shifts can alter conceptual meaning. This opinion paper examines a growing instance of terminological drift in the rare earth element (REE) literature: the increasing substitution of the established term ion-adsorption rare earths with the grammatically similar but conceptually misleading expression ion-adsorbed rare earths. Ion-adsorption rare earth deposits constitute a distinct class of REE mineralization formed through the adsorption of rare earth cations onto clay mineral surfaces during intense chemical weathering. The defining feature of these deposits is therefore a process "ion adsorption" rather than a static condition of the elements themselves. Through bibliometric analysis of the Dimensions database and examination of recent publications, we document the rapid diffusion of the alternative phrasing in the scientific literature since the mid-2010s, with a marked acceleration after 2020. Notably, several articles display internal inconsistencies in which the correct and incorrect formulations coexist within the same manuscript, a pattern consistent with partial automated paraphrasing or unsupervised text rewriting. We argue that replacing a process-defining noun (adsorption) with a past-participial adjective (adsorbed) subtly shifts interpretation from mechanism to state, thereby weakening the conceptual framework that underpins genetic models, extraction strategies, and environmental assessments of these deposits. More broadly, this case illustrates how automated paraphrasing tools, when applied without adequate domain expertise, may inadvertently erode terminological precision in process-driven sciences. Maintaining scientific integrity in the age of AI therefore

requires collective vigilance from authors, reviewers, and editors to ensure that technological assistance does not compromise conceptual clarity or disciplinary rigor.

Keywords

Rare earth elements (REE); Ion-adsorption deposits; Terminological drift; Artificial intelligence in scientific writing; Tortured phrases; Scientific integrity

Introduction

The rapid rise of artificial intelligence (AI) tools for writing, paraphrasing, and automated text rewriting is reshaping academic publishing. Whereas such tools may assist authors in improving language fluency, their misuse, particularly when aimed at circumventing plagiarism detection software, poses a serious threat to scientific precision by generating tortured phrases (Cabanac et al., 2021). Tortured phrases are awkward, often nonsensical expressions that arise from the misuse of paraphrasing software; they undermine both the clarity and integrity of scientific work (Pourret, 2024). In geochemistry, where terminology is tightly coupled to processes and mechanisms, even subtle linguistic distortions can introduce significant conceptual errors, particularly when terms carry different meanings across scientific disciplines (e.g., *species* in geochemistry versus biology).

In this discussion, we draw attention to a pattern of terminological substitution that has grown markedly in the recent literature: the replacement of *ion-adsorption rare earths,* a term encoding a specific geochemical mechanism, with *ion-adsorbed rare earths*, a past-participial construction that shifts emphasis from process to state. This substitution may arise from limited domain knowledge, cross-language interference, or AI-assisted paraphrasing, or from some combination of these factors. Regardless of its precise origin, its consequences for terminological precision and conceptual integrity are significant. Several recent publications illustrate the problem, most notably cases in which the incorrect term appears inconsistently alongside the correct one within the same article, a pattern difficult to attribute to deliberate authorial choice. By documenting the growing diffusion of this formulation and analyzing its semantic implications, we aim to alert authors, reviewers, and editors to a form of terminological drift that risks normalizing a conceptual distortion through citation and repetition.

Ion-Adsorption Rare Earth Deposits: Why Terminology Matters

Ion-adsorption rare earth deposits represent a distinct and well-established class of rare earth element (REE) mineralization, particularly prominent in southeastern China and other deeply weathered granitic terrains from tropical and subtropical climate zones (e.g., Sanematsu and Watanabe, 2016; Liu et al., 2022). These deposits are defined not by the formation of discrete REE minerals, but by the adsorption process through which REE cations are retained on clay mineral surfaces during intense chemical weathering. The defining feature of this resource is therefore the *process* of ion adsorption, not a static state of the elements themselves (Charles et al., 2023).

For this reason, the correct and scientifically meaningful term is *"ion-adsorption rare earths"* or *"ion-adsorption-type rare earth deposits."* Yet, an increasing number of publications now refer instead to *"ion-adsorbed rare earths"* (Figure 1). This shift, although seemingly minor, reflects a fundamental misunderstanding of the geochemical process involved and, in at least some cases, may bear the hallmark of AI-assisted paraphrasing.

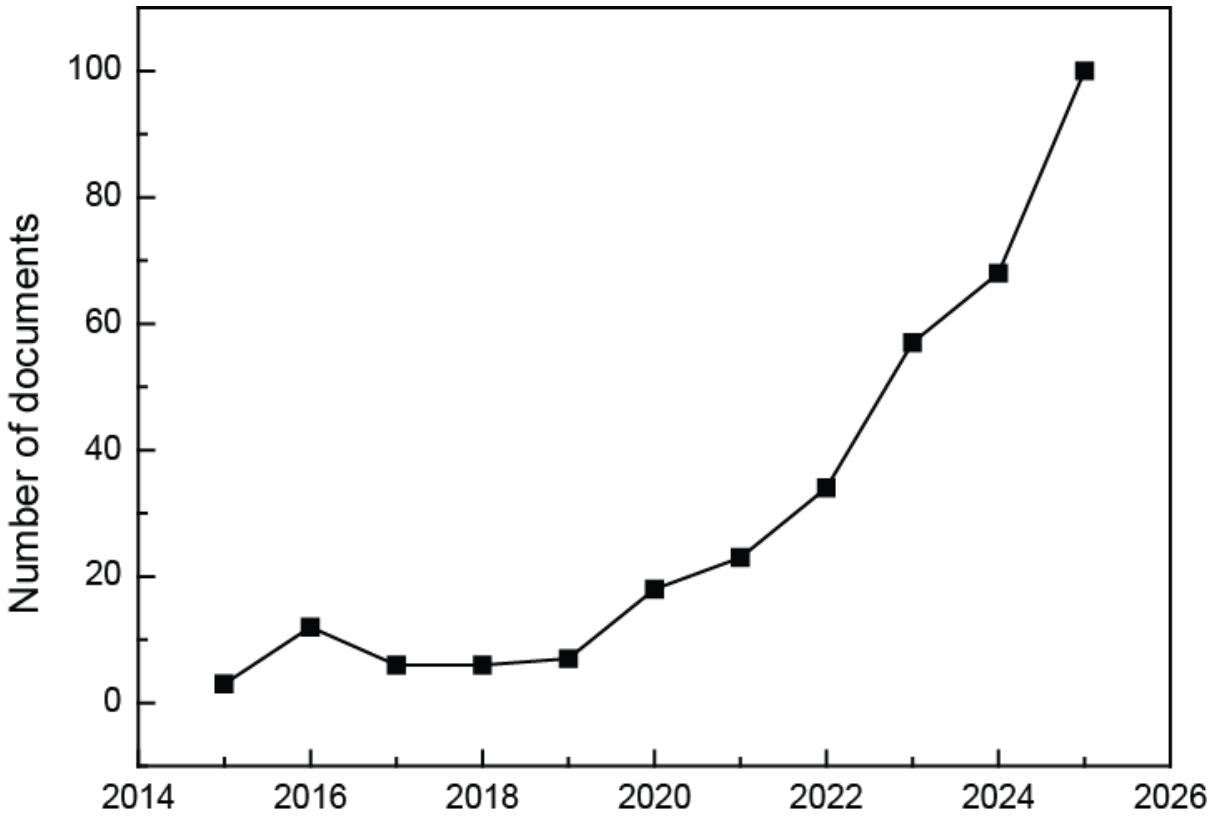

Figure 1. Number of documents containing the phrase "ion-adsorbed rare earths" in their full text, by year of publication (source: Dimensions.ai, queried 21 January 2026). Note that this count is not normalized to total publication output in the REE field over the same period.

Figure 1 illustrates the number of published articles containing the phrase *"ion-adsorbed rare earths"* as a function of time. The upward trend, which begins around 2015 and accelerates markedly after 2020, suggests that this nonstandard formulation has progressively diffused through the literature and now appears even in the titles of articles. It should be noted that this raw count is not normalized to the overall growth of publication output in the REE field over the same period; a proportional increase in total publications may account for part of the trend. Nonetheless, the absolute number of articles using the incorrect term, now in the hundreds, is

itself significant. Table 1 summarizes journals publishing more than five such articles, along with citation metrics. Table 2 shows the publisher-level distribution.

Table 1. Journals publishing more than five articles containing the phrase "ion-adsorbed rare earths" in their full text, with associated publication counts and total citations (source: Dimensions.ai, queried 21 January 2026).

Journal	Publications	Citations
Minerals	31	307
Journal of Rare Earths	21	629
Separation and Purification Technology	21	486
Minerals Engineering	15	2648
Hydrometallurgy	12	478
Journal of Hazardous Materials	9	121
Journal of Cleaner Production	8	187
Journal of Environmental Chemical Engineering	7	44
The Science of The Total Environment	6	53
Metals	6	10

Table 2. Publishers of articles containing the phrase "ion-adsorbed rare earths" in their full text, with associated publication counts and total citations (source: Dimensions.ai, queried 21 January 2026).

Publisher	Publications	Citations
Elsevier	199	6465
MDPI	62	402
Springer Nature	39	698
Wiley	8	56
Taylor & Francis	7	307

Documented Occurrences: Internal Inconsistency as a Diagnostic Pattern

A particularly telling feature of the terminological drift documented here is the internal inconsistency observed in several publications: the correct term *ion-adsorption* and the incorrect variant *ion-adsorbed* coexist within the same article, often with markedly unequal frequencies. This pattern is difficult to explain by deliberate terminological choice or by a systematic misunderstanding of the concept. It is, however, consistent with partial automated rewriting, in which only some passages of a manuscript were processed by a paraphrasing tool while others were left unchanged.

Dong et al. (2025), published in *Applied Geochemistry*, provide a clear illustration: the phrase *"ion-adsorbed rare earth"* appears 19 times in their text, including in the title and keywords, while “ion-adsorption” appears only 5 times, almost exclusively in cited references. A similar pattern is observed in Zhou et al. (2024, *Science of the Total Environment*), where “ion-

adsorbed" dominates the authors' own prose (15 occurrences) while "ion-adsorption" is largely confined to bibliographic titles (8 occurrences), and in Li et al. (2026, *Scientific Reports*), where the same asymmetry holds (17 vs. 4 occurrences respectively). Across all three articles, the adjectival form *ion-adsorbed* systematically dominates the authors' own writing, while *ion-adsorption,* the established process noun, persists almost exclusively in cited references, reflecting the terminology of reference literature. This consistent asymmetry across independent publications and journals, rather than its appearance in a single work, is what distinguishes a systemic terminological shift from an isolated editorial choice.

The geographical and institutional concentration of these publications also warrants contextualization. The affiliation analysis reveals a predominance of Chinese research institutions among authors using the phrase *"ion-adsorbed rare earths."* This pattern reflects, at least in part, the geological specificity of ion-adsorption deposits to southeastern China and the correspondingly high volume of research produced in that region. Because Chinese researchers naturally dominate the primary literature on these deposits, any terminological drift originating within this community will also be most visible there. This observation should not be read as a judgment of quality or intent; rather, it suggests that terminological norms may circulate within institutional and linguistic ecosystems before diffusing more broadly through English-language publishing. A normalized analysis, accounting for each institution's total REE publication output, would be needed to assess whether the rate of usage of the incorrect term differs meaningfully across communities, and we encourage such analysis in future work.

From Process to State: The Conceptual Cost of Morphological Simplification

The difference between *ion-adsorption* and *ion-adsorbed* is not stylistic but fundamentally conceptual. *Ion-adsorption* explicitly refers to a mechanism, the reversible physicochemical process by which REEs interact with mineral surfaces (Pourret et al., 2022). This process-based

framing is essential because it explains the distinctive properties of these deposits: their leachability, their sensitivity to ionic strength, and their environmental behavior. In contrast, *ion-adsorbed* is a past participle describing a state, implying that the defining characteristic of the rare earths is merely that they are already adsorbed. This wording subtly but decisively shifts focus away from the governing process, obscuring the dynamic, reversible, and surface-controlled nature of REE retention that distinguishes ion-adsorption deposits from other types of REE mineralization.

More importantly, describing the resource as *"ion-adsorbed rare earths"* suggests that adsorption is an intrinsic or permanent property of the elements, rather than a context-dependent geochemical interaction. This misrepresentation weakens genetic models, blurs comparisons with other deposit types, and dilutes the process-based logic that underpins extraction strategies. In geochemistry, process nouns such as *adsorption*, *ion exchange*, *complexation*, and *incorporation* encode mechanisms, controls, and assumptions. When these structures are altered, whether by human error, cross-language interference, or automated tools acting without domain understanding, the result is not neutral rephrasing but genuine conceptual damage.

The morphological transformation from a compound process noun (*ion-adsorption*) to a past-participial adjective (*ion-adsorbed*) is a characteristic output of AI paraphrasing tools, which routinely convert nominal processes into adjectival forms in an attempt to reduce textual similarity, assuming semantic equivalence where none exists. Whether or not AI tools are the sole or primary cause in any given instance, the linguistic mechanism they exploit, and the conceptual damage it produces, is the same.

Terminological Drift, Scientific Integrity, and Collective Responsibility

The consequences of substituting ion-adsorption with ion-adsorbed extend beyond semantics and touch the core of scientific integrity. The concept of ion-adsorption explains why rare earth elements in these deposits can be mobilized by low-molarity electrolyte solutions, why pH and competing cations exert strong controls on their behavior, and why such deposits present specific environmental risks. When the governing process is removed or obscured by imprecise terminology, the explanatory power of the concept is weakened, and the link between observation, mechanism, and interpretation is eroded.

The introduction of incorrect terminology also initiates a process of conceptual drift. Once distorted phrasing enters the literature, it propagates through citation (as Tables 1 and 2 document), particularly when subsequent authors rely on AI tools trained on already-compromised texts. Over time, repetition may confer a false sense of legitimacy on imprecise expressions, gradually normalizing them within the field. This dynamic is especially harmful for students and early-career researchers, for whom terminology is often the primary gateway to conceptual understanding and disciplinary literacy.

Ironically, such misuse of language may function less as a successful strategy for avoiding plagiarism detection than as a red flag for deeper problems. As demonstrated by systematic efforts to identify tortured phrases in scientific publications, semantically awkward or conceptually inconsistent terminology frequently correlates with superficial engagement with the subject matter or excessive reliance on automated text generation. Rather than protecting originality or credibility, AI-assisted paraphrasing used in this way risks drawing attention to the very practices it aims to conceal.

Safeguarding scientific integrity in this context is therefore a collective responsibility. Authors must acknowledge that AI tools cannot substitute for domain expertise, and that terminological

accuracy cannot be automated. Reviewers should remain alert to subtle but consequential shifts in language, particularly when established process-based concepts are reformulated without justification, or when correct and incorrect terms coexist inconsistently within the same manuscript. Editors and publishers, in turn, must provide clear guidance on acceptable uses of AI and reaffirm that efficiency must not override meaning.

Conclusion

The replacement of *ion-adsorption* by *ion-adsorbed* in descriptions of rare earth deposits is not a trivial linguistic variant. Whether arising from limited domain knowledge, cross-language interference, or AI-assisted paraphrasing, this substitution transforms a process-defining noun into a static adjectival descriptor, weakening the explanatory framework that underpins one of the most important classes of REE mineralization. The scale of its diffusion, hundreds of articles across major journals, with a marked acceleration after 2020, and the internal inconsistencies observed in affected publications together suggest that automated rewriting is a significant contributing factor, even if it cannot be claimed as the sole cause.

If geochemistry is to remain a process-driven science, its terminology must reflect mechanisms, not algorithmic convenience. AI can assist scientific writing, but only when guided by human expertise and disciplinary rigor. Otherwise, we risk replacing precise geochemical language with superficially altered phrases that erode understanding rather than advance it.

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Author Contributions

OP performed the bibliometric analysis. All authors contributed to discussion and writing of the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest relevant to the content of this manuscript.

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