Cataloguing Minerals, Part Two: Re-imagining Mineral Catalogue Descriptions to Address Colonial Legacies

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Abstract

Minerals are uniquely tied to colonialism, labour, and environment; however, those relationships have traditionally not been described in mineral catalogues – an omission that limits curators' ability to account for mineral histories. This paper re-imagines mineral cataloguing practices to restore historical, cultural, and environmental contexts that were stripped away. We describe the roles of citations; linked data; provenience and provenance histories; non-standardized and 'unapproved' nomenclatures; positionality; and the need to label archival silences. We examine the risks and practical limitations that arise in attempting to turn this colonial tool against itself. In discussing these issues, we contribute to ongoing dialogues about rendering museum databases and the science of geology more inclusive.

Keywords: minerals; colonialism; cataloguing; museum databases

Short biographical statement

The authors of this paper are the students and faculty involved in the 360° 'Minerals, Museums, and Western Colonialism' programme at Bryn Mawr College, near Philadelphia, Pennsylvania, USA. Hearth is an Associate Professor of Geology and manager of the Bryn Mawr mineral collection. Robbins is Curator/Academic Liaison for Art and Artefacts in Special Collections. Weldon is the Collections Manager for Art and Artefacts in Special Collections. Anderson, Bieber-Stanley, Chernila, Christ, Cosgrove, Hanson-Rosenberg, Hill, Hofstetter, Lazo, Ludlow, Lyster, Myers, Nash, Reed, and Saint-Amour were undergraduate students at Bryn Mawr or Haverford Colleges at the time of the course.

Introduction

> The power to describe is the power to make and remake records and to determine how they will be used and remade in the future. Each story we tell about our records, each description we compile, changes the meaning of the records and re-creates them.
>
> Wendy Duff and Verne Harris, 'Stories and Names: Archival Description as Narrating Records and Constructing Meanings' (2002: 272).

The specimens held in institutional mineral collections are intrinsically related to land, environment, public health, labour, colonialism, and imperialism (see, for example, Das and Lowe 2018; Gelsthorpe 2021; Hearth and Robbins 2022; Armstrong and Oromeng 2024). For example, Bryn Mawr College's mineral collection houses V.0142, a piece of tarbuttite from the Broken Hill Mine in what is now Kabwe, Zambia. This specimen was part of the mineral belt that motivated arch-imperialist Cecil Rhodes to invade what was temporarily named Rhodesia. Broken Hill's mineral wealth funded 'Company Rule' in Rhodesia, then British colonial rule, then white-minority rule. The mine was a major source of lead for bullets used in World War I and, likely, throughout the British Empire. The extraction was carried out mostly by African workers. When the European mine operators decided there were not enough workers, they asked colonial authorities to raise taxes, which forced more Africans into 'choosing' to participate in mine labour (Mufinda 2015: 27). That labour was notoriously dangerous. In 1929 (the year that this specimen was extracted), at least 2,134 African mine contracted silicosis and lead poisoning, and 26 died in accidents (Mufinda 2015: 75). Workers led protests against these dangerous conditions, eventually building strategies of anti-colonial resistance that would make miners instrumental in Zambia's fight for independence. Indeed, V.0142 was extracted just south of the Mulungushi Rock of Authority, a major site of anti-colonial protest and organizing now known as the 'birthplace of Zambian independence' (Bunda 2014). Today, the mine's debris towers over Kabwe, forming a mountain of toxic tailings and slag. A global mine cleanup organization has listed Kabwe as one of the ten most polluted sites in the world (Blacksmith Institute 2013).

None of this information is included in the institution's catalogue record for this specimen. The entry simply reads: 'V.142 Tarbuttite, Broken Hill, SW Rhodesia.' Such a description would not prompt a curator to engage with the histories of this specimen. Any exhibits or community collaborations involving this specimen are not likely to include any of this relevant information – because the information is not attached to the specimen in the database.

In this project, we re-envision mineral cataloguing as an effort to reconnect specimens to their human and ecological contexts. In Part 1 (Hearth et al. 2024: 15-28), we critiqued historical mineral cataloguing practices, situated mineral cataloguing within the literature on knowledge systems, and demonstrated how mineral cataloguing is guided by and reinforces invisible worldviews. That paper reviews connections between the eighteenth- and nineteenth-century European push to document all of nature and frames this perspective within colonial and imperialist practices and ideologies. It also makes clear that revising catalogue description practices should not be referred to as decolonizing geology or museums, but rather understood as a necessary first step toward materially reparative projects.

Here, in Part 2, we reimagine what a mineral catalogue *could* be. We propose new categories and fields to break with 'the inescapable inertia of terms or categories already in use' (Bowker and Star 2000: 117). Inspired by cataloguing for other collection types (art, archaeology, etc), we propose practices that preserve mineral specimen histories and link those records across institutions. Our practical goal is to enable catalogue users to address mineral histories through exhibits, writing, community partnerships, and more. We also hope that catalogue records might become tools for activists; contemporary communities with cultural or historical relationships to these materials; descendants of workers; and geologists looking to understand the relationships between their discipline and broad social processes like colonialism.

Throughout the essay, we illustrate our suggestions using specimens housed within the Bryn Mawr College mineral collection. When possible, we apply them to one particular mineral: V.4476, a piece of azurite and malachite from the Tsumeb Mine of what is now Namibia. In Part 1 (Hearth et al. 2024: 15-28), we reviewed 99 years of cataloguing V.4476, finding that its cataloguing has always been limited, eg, 'V.4476 Azurite, Tsumeb, Otavi, S.W.Africa'. In an online appendix to this paper, we provide an example of a revised catalogue entry for V.4476, applying the ideas presented here to this particular specimen; please visit: https://mawr.life/cataloging_appendix, where it will remain editable as we make improvements to our recommendations over time. We choose not to provide a static and definitive catalogue format and entry for V.4476, because we hold cataloguing to be an iterative, dynamic process, continually inviting revision, and because we want our recommendations to be applicable

across the various software programs employed by different mineral collections. Below, we summarize the core ideas that shape our re-imagined approach to cataloguing minerals.

Reconceptualizing Mineral Catalogues

I. Citations are required.

> How well I remember the dataless collection of specimens in a small museum which became data-rich during cataloguing as the inexperienced operatives interpreted the examples given in identification manuals as offering a singular truth which could then be imposed on the objects themselves.
>
> Simon Knell, *Museums, Reality and the Material World*, (2007: 12)

Mineral specimens are only objects – just complicated dirt. Histories cannot be extracted from them; they must be extracted from texts and then linked to the object. This is a fundamentally different kind of data than (for example) a mineral's classification, which can be assigned based on measurable properties of the object. V.4476 has been catalogued at least five times (see Part 1, Hearth et al. 2024: 15-28). None of these catalogue entries includes citations, because each claims to be the authority on V.4476. How do we know V.4476 comes from the Tsumeb Mine? Because the catalogue says it does.

Recontextualization *requires* citations. It is actively damaging to a record to write, 'Copper ores from this site were central to the economy of the Ovambo Kingdom of Ondonga,' without including the citation: '(see summary in Hearth 2021).' The citation allows the statement to be examined critically, and, if necessary, revised. Thoughtful citation is an invitation to productive challenge. It acknowledges *from where* we are sourcing our understanding of this object's history and invites collaboration in revising that understanding when new information or more knowledgeable parties arrive.

I. 1. Thoughtful Citation Involves Critical Assessment and Acknowledgment of Positionality
Linking records to references opens new possibilities – but also new problems. Particularly in colonial contexts, most histories are written from the perspective of the colonizer – how should these be linked to the catalog? For example, for V.4476, the key pre-twenty-first century history of the Tsumeb Mine (Söhnge 1967) details early German settler experiences in Tsumeb, including rich details such as the musical instruments the German mine engineers played in their free time, as well as specific anecdotes about individual Germans and their families. Simultaneously, this book reduces African communities' roles in mine labour, Tsumeb culture, and the long conflict over Otavi mineral rights to 'trouble with the natives' (Söhnge 1967: 17) and frequently mis-identifies key African leaders.

One way of providing transparency around references is to describe the positionality of cited sources, for example, with a field like "Bibliography Agent Notes." If the V.4476 record cited Söhnge, it would document for the user that Söhnge was a white South African-German mining engineer, writing in 1967 apartheid-era South-West Africa while working for a multinational mining conglomerate. It would also note that Söhnge's account is subject to critique by Hearth (2021), and that Hearth is a white settler born in the United States, and not a member of any of the communities involved. This field provides more transparency about the citations' possible limitations and biases.

II. Standardized Vocabularies Might be Necessary, Especially for Utilizing Linked Data …

Mineral names are standardized by the International Mineralogical Association (IMA). Place names are based on a variety of standardization vocabularies (for example, the *Getty Thesaurus of Geographic Names*).[1] Internationally standardized naming allows geologists and curators around the world to speak about specimens with a shared language, even though those naming conventions may contain imprecisions that perpetuate harm to or erase some individuals.

In the twenty-first century, these structured vocabularies can also enable interoperability through linked open data, which expands user discovery of materials across institutions. One possibility for utilizing relational data is MinDat.org, a not-for-profit collaborative outreach project that maintains a standardized recording system for mineral localities. Linking locally to data generated by users across the world can expand perspectives and supply more historical context for specimens than any individual researcher ever could (see, for example, Singer 2009, Yoose and Perkins 2013). Some linked data applications might also utilize Geographic Information Systems (GIS) to connect records regardless of naming conventions.

II. 1. … but Standardized Vocabularies Should Not be the Only Terms Included.

Although beneficial for searching and connecting institutions, use of a single naming authority also comes at a cost that runs counter to our aims. The vast majority of IMA-approved mineral names were given by Western scientists to honor other Western scientists (like wollastonite for William Hyde Wollaston or sillimanite for Benjamin Silliman) or to honor Western mineral collectors (like vauxite for George Vaux, Jr, whose collection contains V.4476).

As Pratt (2008) has illustrated, standardized naming practices are part of the European hegemony that European natural historians reinforced around the world:

> Natural history's naming is … directly transformative. It extracts all the things of the world and redeploys them into a new knowledge formation whose value lies precisely in its difference from the chaotic original. Here, the naming, the representing, and the claiming are all one; the naming brings the reality of order into being (Pratt 2008: 32).

'Vauxite' illustrates Pratt's point. Vauxite and its cousins metavauxite and paravauxite were first described and named based on specimens found in the Siglo XX Mine in Bolivia. These type specimens (or reference samples) were described in published works in 1922 by Samuel Gordon, who was collecting in Bolivia on an expedition funded by George Vaux, Jr, and the Philadelphia Academy of Natural Sciences. Vauxite's name connects it permanently to the wealthy white American who sponsored its extraction and erases any relationship it had to Bolivia or Bolivians, particularly the workers who opened the Siglo XX Mine. Notes from Gordon's expedition suggest that workers already had names for the minerals in the mine; these were discarded in favor of 'vauxite.' Thus mineral naming – like most natural history – involved extracting the unique components of the world and relabeling them in Western contexts, then declaring those Western contexts universal and standard. Hearth et al. (2024: 15-28) examines this extractive approach in more detail.

For most common minerals, there are more *non*-IMA names than IMA-approved names. At many of the localities represented in the Bryn Mawr Mineral Collection, Indigenous communities were actively mining, smelting, or otherwise using the minerals prior to colonization – and had developed their own terminologies. Additionally, mine workers often developed specialized vocabularies for the minerals they encountered.

Cataloguing a mineral *only* by its IMA name continues the extractive relationship with the natural world and ignores all other communities and traditions. However, eliminating the IMA name would reduce the usefulness and discoverability of the object and hinder shared discourse. Another way to confront this within a catalogue might be to rename the 'Mineral Name' field more accurately, as 'IMA-approved Mineral Name'. This reframing signals that the IMA name is *one* name, rather than rendering that choice invisible and inevitable with a general field such as 'Specimen' or 'Mineral Name' It also allows for an additional field: 'Non-IMA-approved Mineral Names.' Such a field opens wider possibilities and new concerns.

II. 2. Collaboration is Ideal … but Citing Communities can be a Stopgap

> Approach learning about the experiences of others with humility, curiosity, and an ethos of *normalizing not knowing*.
>
> Jessica Tai, 'Cultural Humility as a Framework for Anti-Oppressive Archival Description' (2021: 17)

Taking an Indigenous name for a material or place and simply plugging it into a catalogue field divorces the word from its community's philosophies for organizing information (see, for example, Littletree and Metoyer 2015, Phillips 2023). Hayes (2024) has warned about claiming ownership over something which a clan always already owns, be it an object or a name.

With this in mind, cataloguers would ideally list non-IMA names for minerals only after collaboration and consultation with the communities involved. Enumerating the complexities of community collaboration is outside the scope of this paper, and has been explored by others; for example, Weber-Sinn and Ivanov (2020) review how attempted European institutional collaborations with postcolonial communities can become a new form of extraction, failing to upend the power differentials between institutions and impacted communities. Phillips (2023) shares examples of working with communities to expand perspectives on mineral collections in particular. Grimme (2020), too, examines the relationship between provenance research and impacted communities. Practically speaking, such collaborations can take years to develop – if they develop at all (Schorch 2024).

For these reasons, cataloguers attempting to include names from communities to which they do not belong should take care to provide citations, while also articulating their own uncertainties, an important practice in the cultural humility framework described by Tai (2021). In the case of V.4476, the cataloguer notes that copper from this site was historically important to the Kingdom of Ondonga and cites the paper that makes this claim. The cataloguer then cites a 2004 Oshindonga/English Dictionary that lists copper as 'ongopolo, oshikushu' (Viljoen et al. 2004: 71). However, the cataloguer notes that they do not know which type of copper ore Ndongan coppersmiths used, and that a native Oshindonga speaker might name and describe V.4476 very differently. By including Oshindonga copper terms, the record acknowledges the non-universality of the IMA name, which may expand the record's discoverability (see also, Phillips 2023 for an example of a mineral display label that centres the name for copper in the Ojibwe language of Anishinaabemowin). Citing sources and articulating the cataloguer's uncertainties, the record provides a starting point for other researchers, invites collaboration with more knowledgeable parties, and acknowledges the gaps in the catalog. An additional author field, 'Community Feedback,' can be used to note that there has been no community feedback recorded for this specimen, providing additional transparency on the record's limitations.

Place names also require citations to authorities within the communities of origin. For example, the Bryn Mawr collection houses V.8088, a colemanite with a locality recorded as 'Furnace Creek, Death Valley, California, USA'. This is the ancestral (and current) land of the Timbisha Shoshone, who have different geographic names for the place. A revised catalogue entry might list 'Padumpean Nunupi' as an additional keyword in the Locality field, but only with citation to a Timbisha Shoshone authority. In this case, the entry refers to a 2015 letter written to the U.S Nuclear Regulatory Committee by Timbisha Shoshone chairperson George Gholson. In the letter, Gholson shares the Timbisha name for Furnace Creek as 'Padumpean Nunupi' (Gholson 2015). The locality field might also link to testimony that Timbisha Shoshone Elder and Chairperson Pauline Estevez gave before the U.S. Congress in 1999, where she spoke about Timbisha Shoshone naming traditions and criticized the name 'Death Valley' (Estevez 1999).[2] In the absence of resources for collaboration, a cataloguer can learn by listening to what has already been said.

Similarly sensitive is the use of pejorative terms in mineral and place names. For example, in 1977, the IMA approved the name 'eskimoite' for a rare silver-sulfosalt from Greenland. Mindat.org includes a note: 'Named for the "Eskimos", an exonym for, in this case, the Inuit people, the first settlers of Greenland. The term Eskimo is now considered pejorative' (Mindat.org, n.d).[3] We recommend that collections develop in-house policies for handling such terms and enact them with transparency. This should also include consideration of whether and how to display these terms on public interfaces. Similar reparative language practices have been detailed by Archives for Black Lives (2020),[4] Sutherland and Purcell (2021), Bolding (2018), Hughes-Watkins (2018), and Filevska and Blyzinsky (2023), among others.

III. Expanded Keywords Can Illustrate Objects' Relationships with Communities and Places

Standard mineral catalogues reduce localities to mines/quarries, towns, provinces or states, and countries. This is helpful for catalogue users who want to research specimens from a particular mine. But specimens have human, ecologic, and spatial relationships beyond their mailing addresses; expanding the keywords associated with 'Mineral Locality' can help users find those connections.

The catalogue entry prepared around the year 2000 for V.4476 listed its locality as 'Tsumeb, S.W.Africa, Namibia'. But that specimen is geologically related to many other minerals in the Otavi Mountains, including those from Gross Otavi, Grootfontein, and Guchab. These specimens share a geologic history: they were emplaced at the same time, via the same geologic processes, into the same geologic context, and have experienced similar post-formation alterations. Geologically, these specimens are a single set; classifying them by individual mine sites is an artificial separation that makes identifying and using the whole set difficult. These specimens also share a human historical context: the communities that mined at Tsumeb also mined at Gross Otavi, and the colonial processes that operated at Tsumeb spanned the area. Locality keywords of 'Otavi Mountains' or 'Oshikoto Region' could connect these specimens that would otherwise be listed under different towns and mines. Recording this shared context is useful practically for exhibition development, but also epistemically transformative - it locates V.4476 in terms of its broader relationships with place. V.4476 is *of* the Otavi Mountains more immediately than it is *of* the current political state of Namibia.

This more organic, expanded locality keyword system can also highlight connections with places far from a specimen's findspot. The revised entry for V.4476 includes keywords 'Kingdom of Ondonga,' a place located more than 200 km north of Tsumeb. Because the people of Ondonga had centuries-long relationships with copper in the Otavi Mountains, Ondonga is related to V.4476 and Otavi copper through human links. Maintaining that relationship in the catalogue (and citing the papers that document that relationship) reconnects V.4476 to its wider context.

IV. Labourers, Guides, and Local Communities are Inextricably Tied to a Specimen's History

Typically, a mineral catalogue records a findspot. The place of origin is part of what constitutes provenience, a term more typically used to describe collections of archaeology and anthropology – disciplines invested in the human contexts of materials being collected. Provenience refers to any contexts surrounding the origin or discovery of any collection object found in the ground. With most mineral specimens, the collector did not find them sitting on top of the Earth. Applying provenience histories to mineral collections enables an accounting of the many humans involved in collecting a mineral specimen. But this information has not been as deliberately recorded in relation to mineral extraction. Who or what enabled a mineral's discovery or extraction was not valued as much as the specimen itself and its final collector/purchaser's name (Armstrong and Oromeng 2024).

Standard mineral cataloguing practices reduce the mass collaborative effort of mining to one figure: the donor. We advocate here for fields that identify myriad other people involved in a mineral's movement from ground to museum. We start with guides: colonial geologists and mineral collectors were often dependent on Indigenous guides to keep them alive, to show them outcrops of rocks and minerals, and to locate interesting specimens. Yet those guides are rarely mentioned in histories of geology or specimen catalogues. Examples of this phenomenon are numerous: Mayor (2007) showed how the first recognized American mastodon fossils were found by Indigenous guides who led the French Longueuil expedition to them in 1739. Although Longueuil credited his guides with their discovery, he identified them only as 'les Sauvages', not thinking to mention their names or even their community affiliations. Similarly, Hearth (2023) illustrates how Haillom and Herero guides were instrumental in leading European geologists to the copper mines at Tsumeb and Otavi (and keeping the geologists alive along the way). Despite the centrality of these guides and their knowledge, they are not recorded in mineral catalogues.

Once a mineral deposit has been identified for extraction, industrial-scale mining is often required to find museum-quality specimens. This mining is carried out by workers, whose histories, communities of origin, and relationships to the specimens they uncovered are typically omitted from a specimen's catalogue record. Indeed, mine workers themselves have often identified the high-quality specimens, collected them, and sold them to mineral collectors. Ferry (2011) gives a contemporary case study of the considerable expertise that mine workers develop in choosing specimens. But again, the names of these miner-collectors are omitted from mineral catalogues.

Our proposed revised catalogue includes a field for 'Names of Guides, Miners, or Labourers,' envisioning this as a space for individuals, but also communities who sent people to work for a mine. For the vast majority of specimens, this field will remain blank, as that information was not recorded at the time of collection. However, even a blank space reminds users that a chain of people contributed to the extraction of a specimen and emphasizes that geologists and mineral collectors do not single-handedly produce a specimen out of a mountainside.

IV. 1. Corporations and Other Claimants Should be Linked to Specimens

For tracing the movement of a mineral out of the ground and into collections, it would also be useful to have a field naming the corporations involved in a mine. This information can link specimens that are geographically separated but share a common corporate actor; for example, if a user wants to know which specimens come from mines operated at some point by American Metal Climax, Inc. We include this information in our revised catalogue in a field labeled "Land Rights and Relationships," documenting ownership claims.

IV. 2. The Donor's Centrality can be Reconsidered

The "V" in V.4476 stands for Vaux: the name of the collection and its donor, George Vaux, Jr. This practice of identifying specimens primarily by their donor is widespread and problematic (Hakiwai 2014; Kreps 2003; Phillips 2013; Schorch and McCarthy 2019; Stanley 2007). Centring the donor reinforces the importance of ownership over stewardship of objects and can perpetuate the social prominence of donors while obscuring the vast (often colonial) networks they benefited from in obtaining their specimens (Jiménez 2022). Centring the donor collapses into a single person the chain of humans responsible for moving a specimen out of the ground and into a collection, while obscuring the conditions under which that movement happened.

Omitting the donor from a catalogue, though, is not recommended. They, at the very least, represent one person in the chain – often the only person whose name is known to the cataloguer. Donors also often require that their names be attached to their collection as a condition of donation. Even when keeping the donor's name isn't legally required, it is often historically important; the Vaux Collection at Bryn Mawr is known by that name far beyond the cabinets of the mineral storage room.

However, even when the donor's name remains attached, the donor's centrality can be reconsidered. As a catalogue opens new fields to account for labourers, guides, and mining communities, the donor becomes just one member of a constellation of people related to the specimen. There are also more direct methods of decentring the donor. For example, Jiménez (2022) suggests referring to collections by the objects' type or region of origin, so as to shift attention to the objects themselves. Drake (2016) calls for an intersectional approach to collection naming, away from top-down legacy-based description and toward collaborative description wherein creators, or, in this case, additional agents in the creation of the collection, describe themselves and enter their records, deciding whether to insert their own names. Partnerships with so-called source communities can (productively) result in what Schorch (2020) describes as institutions that are '(partly) decolonized and (incompletely) Indigenized by museum professionals who draw on Indigenous perspectives to reshape collecting, exhibiting, fieldwork and research'.

In the case of V.4476, within the cataloguing record, the Vaux name will remain attached to the collection, because it is important to the materials' histories at Bryn Mawr College and in the Philadelphia area. But public-facing reference to the Vaux Collection may be rethought

and need not be continued.

V. The Historical and Social Context is Part of a Specimen's History

Ideally, a mineral record would not stop at naming the people and communities involved; it would also link to information about the broader historical and social context. A field for labour conditions would allow linking to references that deal with recruitment and labour practices, and one for occupational health and safety conditions could link to references dealing with worker health and safety. These are two categories historically omitted from mineral catalogues, but they are important for addressing mining legacies. For example, Robins (2011) details the human and ecological impacts of Spanish colonial silver mining in the Andes, which included extensive mercury poisoning among the workers, most of whom were Indigenous people working under the Spanish *mita* system or enslaved people forcibly brought from Africa. Similarly, Higginson (1989) compiled numbers of miner fatalities and injuries in the Katanga region of the Belgian Congo during the early 1900s, breaking down the data by specific mines and communities. Gelsthorpe (2021) details efforts at the Manchester Museum to tell the stories of labourers in South African gold and Sierra Leone diamond mines. He cites reports from the Witwatersrand Native Labour Association and the Transvaal Chamber of Mines (among others) and photographs from online archives. These records add valuable historical and social context to these specimens; mineral cataloguing systems should have standardized, dedicated fields that link specimens to these kinds of records so that these important associations are preserved.

VI. The More-Than-Human World is a Part of a Specimen's History

The fact that a mineral's ecological context has not typically been catalogued is a direct result of European-colonialist mindsets about ecosystems: nineteenth-century natural historians considered rocks and minerals divorced from the living world. In fact, minerals are entwined with biological networks. Minerals are the (literal) bedrock of an ecosystem: the soil from which every ecosystem grows is derived from the rocks below and whatever sediment is blown or washed through. Unique rocks yield unique ecosystems - the carnivorous plants of serpentine barrens evolved specifically in response to the nutrient-poor soils weathered from serpentine bedrock. Entire extremophilic communities arise in evaporitic salt flats. Bedrock mineralogy is as integral to ecosystem character as climate.

This interplay between minerals and ecosystems works two ways. Microbes alter minerals, gleaning nutrients and serving as agents of chemical transformation. We see this in a range of minerals, especially sulfur- and iron-bearing mineral species, with pyrite, a classic example, serving as prey for lithotrophic bacteria. A study by Bhattacharyya (2017) showed that most of the uranium minerals in a pocket of ore in Wyoming had been produced by bacteria that break down uranium-bearing minerals with high oxidation states and transform them into different uranium species. Minerals and ecosystems are intricately interwoven in ways that geobiologists are only beginning to map.

Including a field in mineral catalogues for ecological connections and impact would allow curators to link specimens to papers and studies on specific site ecologies. Although V.4476 does not (yet) have citations related to its site ecology, other specimens do. For example, Bryn Mawr houses V.1636, a halite specimen from the Searles Lake District in San Bernardino County, California. This lake is home to a microbial community that thrives off high salt levels. A study by Blum et al (2012) found that some of these bacteria can feed off arsenic-bearing minerals in the evaporite deposits. This biogeochemical phenomenon illustrates the interconnectedness of the mineral and biological worlds in ways that directly challenge colonialist separation of the living and 'non-living' worlds.

In addition to ecological connections, an ideal mineral catalogue would include a field allowing curators to link specimens to papers and studies on ecological impact. Separating specimens from their environmental and human context is a nineteenth-century approach that allows specimens to be presented as pristine, intensely beautiful natural objects – and to ignore the environmental and human cost of their extraction. Liboiron (2021) draws direct connections among colonialism, capitalism, and pollution, calling pollution 'an enactment of

ongoing colonial relations to Land' (Liboiron 2021: 6). Both the tarbuttite V.0142 described in the introduction and Kabwe's current public health conditions derive from Broken Hill, and that connection can be made clear by linking citations related to the ongoing consequences to V.0142's catalogue record. This linkage is a necessary exercise in remembrance and practically useful for curators trying to present more complex mineral histories.

VII. Minerals Carry Multiple Meanings

> [O]bjects are defined differently in different epistemes – the path to knowing is fundamentally different
>
> Hannah Turner, 'Organizing Knowledge in Museums: A Review of Concepts and Concerns', (2017: 474)

Mineralogists conceptualize a specimen by a set of analytical standards. For an opal specimen, for example, an X-ray diffractometer (XRD) reveals a semi-crystalline to amorphous internal structure, a visible- to near-infrared spectrometer (VNIR) reveals reflectance peaks associated with oxygen-hydrogen bonds, and a scanning electron microscope (SEM) image shows repeating patterns of microscopic silica spheres. Consequently, in some mineral catalogues, it is common practice to link a specimen to its analytical studies (and we recommend continuing this tradition).

However, there are many other ways of knowing a material. For example, Bryn Mawr houses V.2817, a spectacular, radiating cluster of celestine crystals that have been replaced with opal. This specimen is from New South Wales, Australia. Indigenous communities in this area had cultural relationships with and systems for understanding these opals long before British colonization, and some of these continue. For example, the Migration Memories project exhibited at the Lightning Ridge Historical Society and National Museum of Australia included both personal and cultural stories about opal from Indigenous activists and storytellers Aunty June Barker and Uncle Roy Barker (Barker and Barker 2007).[5] Linking the catalogue record for V.2817 to the Migration Memories project and the Barkers' stories emphasizes that XRD, VNIR, and SEM are only a few of the ways of relating to these materials and provides users with additional resources for research.

VIII. Blank Fields are Important

For most specimens in our collection, the fields we have laid out would remain blank. Finding the information to fill in these fields is an enormous, time-consuming project that requires significant research skills and resources (eg, Ashby and Machin 2021).

However, blank fields are not only acceptable – they are meaningful and important. They label the silences. They show what is missing (see, for example, Carter 2006). When public-facing, blank fields can represent institutional limitations and invite collaboration. They declare to the public that any given cataloguer is unable to find all the possible meanings for an object. While some ways of knowing can be represented, such holes in the records testify to how much researchers still do not understand about the relationships between an object, its environment, and the people entwined in its histories.

Cataloguers can also describe what is known to be unknown. For example, V.4476's field for 'Non-IMA-approved mineral names' includes a section for a name from the Haillom language – a name the cataloguer did not know. The cataloguer noted: 'At the time of colonization, copper from this site was central to the economy of Haillom San communities in that area (see summary in Hearth 2021). This catalogue entry has no information about mineral terminologies from the Haillom'. This recognition of incompleteness acknowledges the iterative nature of record-building: perhaps a future cataloguer or community collaboration will add details.

IX. Position the Cataloguers

Our reimagined mineral catalogue is grounded in the idea that a mineral carries multiple

meanings: scientific, historical, cultural, ecological. To embody that idea in a catalogue record, we advocate for linking papers, books, archives, and other sources to a specimen. This diffuses the catalog's claim to authority; rather than perpetuating an illusion of mastery, the catalogue is repositioned as a growing collection of known and missing perspectives on a specimen. Moreover, linking data to sites with user-generated content can decentralize the perspectives, gathering meanings for a specimen more diversely and efficiently.

In the end, however, the mineral cataloguer within an institution continues to determine which links to deploy, which categories to fill, and how to fill them. The cataloguer still holds the power. It is therefore important that the cataloguer's potential biases be made as transparent as possible. Tai (2021: 11) points to this as a necessary component of a 'liberatory descriptive standard.' Ideally, each field entry should end with the name of the cataloguer who added the information and the date. Where this becomes cumbersome, an alternative approach might be to employ an additional set of fields that captures the names and positionalities of any cataloguers who have contributed to this record through time. This does not solve the 'one person, one worldview' problem, but it does make transparent some of the limitations of the record and assert the possibility that it can be critically examined and revised.

Conclusions

Mineral catalogues have historically omitted the human and ecological context of specimens' origins. Rebuilding catalogues to preserve these histories is a first step toward enabling curators to respond to issues of social violence in mineral collections. A revised catalogue should integrate citations and linked data to expand the perspectives represented in the records, especially for material and location names. New fields should be created to articulate the human chain that brought the specimen out of the ground: the workers involved, the guides who brought miners to the ore, the communities which grew around mines, and any land or resource rights that were in dispute at that locality. A re-envisioned mineral catalogue might be able to recentre people and ecologies by including the environmental fallout from extraction, unique geo-ecologies, occupational hazards faced by mineworkers, public health impacts, and cultural narratives around materials, both past and current. Statements of the cataloguers' positionality in relation to these materials are also helpful in developing transparent documentation and demonstrating cataloguers' self-awareness about the limitations of their knowledge. In our reimagined mineral catalogue, each entry is forever in draft form. We hope and expect to grow entries, deepen them, and revise them through time. An ideal catalogue entry is only a starting place - a set of leads for future researchers, a set of invitations for future collaborations and community partnerships.

Even if the vast majority of the new catalogue fields we propose remain blank, they are still necessary. They signal that minerals are more than just chemical class and locality: they have human and more-than-human relationships and meanings. Reconnecting these tiny pieces of land to the histories that we have and haven't yet lost is a necessary step in understanding what material repair might be possible.

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