Engaging Science, Technology, and Society

ORIGINAL RESEARCH ARTICLE

Origin Stories of the 'Grants Uranium District' in Northwestern New Mexico: Archives, Memoirs, and Exploratory Boreholes in the Production of Geological Regions

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Abstract

The "Grants uranium district" of northwestern New Mexico yielded more uranium ore than any other mining district in the United States during the Cold War Period (1947-1989). After the national market for uranium collapsed in 1979, the mines were slowly abandoned and the mills were decommissioned. More than ninety-eight percent of what was mined remains on site as toxic mine wastes, overburden, and mill tailings—in a landscape fractured by underground mine workings, punctured by exploratory boreholes, and saturated with the liquid waste discharged from the uranium mines and mills. Designated as a national "sacrifice zone," the former mining district constitutes egregious cases of environmental injustice and racism, as well as deeper impositions of settler colonialism. The former mining district overlaps multiple Native Nations and their broader ancestral homelands, as well as Nuevomexícano ("Hispano/Indo-Hispano") land grant allottees, and rural white ("Anglo") majority settler towns and communities. Returning to the origin stories of the mining district and the broader geological region, this article traces the epistemic production of the geophysical landscape by questioning the relationship between boreholes, geologic archives, and the memoir genre in geology. This style of historiography offers a critique of the historical background papers in geologic memoirs as one way of reading against the archival grain, and exposing the physical and material impacts of dispossession resulting from mineral exploration. Situated within anthropological traditions of science and technology studies and critical studies of settler colonialism, this article aims to contribute to emerging scholarship in "geological anthropology" and "political geology."

Keywords

anthropology of mining; geological anthropology; political geology; STS Underground; geological gaze; geologic memoirs; archive

To cite this article: De Pree, Thomas. 2024. "'Origin Stories of the 'Grants Uranium District' in Northwestern New Mexico: Archives, Memoirs, and Exploratory Boreholes in the Production of Geological Regions." *Engaging Science, Technology, and Society* 10(3): 37–64.
https://doi.org/10.17351/ests2023.2323.

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Introduction

During the second half of the twentieth century, the "Grants uranium district" of northwestern New Mexico provided nearly half of the total uranium ore produced in the United States for federal nuclear weapons production and commercial nuclear energy development (McLemore and Chenoweth 2017, 1). By the turn of the century, as the economic value of the uranium ore declined, the domestic market collapsed and the mining district closed. The mines were abandoned and the mills were decommissioned and buried in the tailings piles they once produced. More than ninety-eight (>98) percent of what was mined remains on site as toxic mine wastes, overburden, and mill tailings in a landscape fractured by underground mine workings, punctured by exploratory boreholes, and saturated with the liquid waste discharged from the uranium mines and mills (Ceto and Mahmud 2000, 30). This article places focus on the environmental impacts of exploratory borehole drilling, in historical hindsight.[1]

Designated as a national "sacrifice zone," the former mining district constitutes egregious cases of environmental injustice and racism, as well as deeper impositions of settler colonialism. Long before it became known as a distinct "geological region" by geologists of the Atomic Energy Commission (AEC)—before the geologic maps and memoirs, and before the drilling, pumping, blasting, mining, hauling, and milling—the high desert landscape of northwestern New Mexico was (is and will be) known as *Haaku, Kawaika, Shiwinna, Dinétah,* and many other significant Indigenous place-names. The former Grants uranium district overlaps multiple Native Nations and broader ancestral homelands, including parts of the Navajo Nation (*Diné Bikéyah*) and the Pueblo of Laguna (*K'awaíka*), adjacent to Acoma Pueblo (*Haaku*) and Zuni Pueblo (*Shiwinna*). The legacy of uranium mining has produced compounding environmental health risks and vulnerabilities in overburdened Indigenous communities responding to the cumulative effects of multiple toxic legacies from mineral and energy resource extraction industries (including coal, oil and gas). Although the mining district also overlaps *Nuevomexícano* ("Hispano/Indo-Hispano") land grant allotments and white ("Anglo/Anglo-Saxon") majority settler towns and communities, Indigenous communities have experienced a disproportionate amount of environmental health burden and inadequate public health services, which have exacerbated intergenerational traumas from successional regimes of settler colonialism and capitalism through mineral and energy resource development.[2]

[1] Note that many of the exploratory boreholes were never addressed for closure by a state regulatory program. The mills were decommissioned under federal regulatory programs with supervision and licensing. The mines were abandoned according to state regulations with supervision, and the state regulated the decommissioning of mill tailings' piles until 1985, when it gave the program to Nuclear Regulatory Commission (NRC). For more, see for example, Gilbert 2014; Johnston 2007; Kuletz 1998; Lorenzo 2017; Pasternak 2011; Voyles 2015.

[2] There are more than 160,000 abandoned hard rock mines in the Western US (more than 4,000 are abandoned uranium mines); and an estimated 600,000 Native Americans live within 10 kilometers of an

The canon of Native and non-Native scholarship published in response to the legacy of uranium mining and energy resource extraction in the US Southwest is broad, diverse, and growing.[3] Scholars of Native American and Indigenous studies at the University of New Mexico have established rigorous programs of critical inquiry that unsettle the founding myths and origin stories of settler colonialism and capitalism by bringing attention to the political-economic growth and conglomeration of "transnational energy corporations," and the making of local "resource colonies."[4] In her concluding chapter in *Economic Development in American Indian Reservations* (1979), historian Roxanne Dunbar-Ortiz remarks on the making of resource colonies by describing how, "Racism tends to let the culprit off the hook and to blame the victim for his situation" (ibid., 153). She provides the example of the Bureau of Indian Affairs' statement that "poverty is a self-fulfilling prophecy" produced by a "reservation subculture" (1969, 356; as cited in ibid., 153). With her refusal of this blame-the-victim narrative, Dunbar-Ortiz shifts our attention away from a cultural pathology of local communities, toward a broader political-economic analysis of the industrialization and proletarianization associated with the exploitation of mineral resources by transnational energy corporations in so-called "underdeveloped reservations" (ibid., 153).[5]

In this article, I will extend this form of analysis and attempt to build on these diverse bodies of literature by questioning the origin story of the Grants uranium district, and by showing how discourse of "discovery" conceals the exploitation of local knowledge and local resources by blaming the people who have been exploited. The concept of "representational rhetorics," illustrated by environmental anthropologist Paige West, is particularly helpful here for identifying, "what material effects these forms of rhetorical representation have in the world and how these material effects reinforce structural inequality" (2016, 11). I pursue questions about how discourses of "discovery"

abandoned hard rock mine (Lewis et al. 2017). Proximity to mine waste has proven to be a significant exposure variable in recent environmental health research (e.g., Erdei et al. 2019; Harmon et al. 2017). There is a long record of local Native and non-Native settler communities requesting official state and federal public health studies, but such broad research and action at a scale sufficient to address the local health needs in northwestern New Mexico are conspicuously absent. The public health literature that does exist is often ignored and receives scant citation. Southwest Research and Information Center (SRIC) has been collecting public health data and independently publishing environmental information for over 40 years, and the regional environmental health literature has flourished in recent years through the University of New Mexico Metal Exposure and Toxicity Assessment on Tribal Lands in the Southwest (METALS) Superfund Research Program, which is supported by the National Institute of Environmental Health Sciences (NIEHS), and the ECHO NBCS and DiNEH Projects, also funded by National Institutes of Health (NIH). For example, see Hoover et al. 2019; Lewis et al. 2017.

[3] For example, see Brugge et al. 2006; Gilbert 2014; Johnston 2007; Kuletz 1998; Lorenzo 2017; Ortiz 1980; Pasternak 2011; Reno 1981; Voyles 2015.

[4] Nafziger in Dunbar-Ortiz 1980; Ortiz et al. in Dunbar-Ortiz 1979.

[5] On "cultural pathology," see Simpson 2014.

are linked to acts of dispossession, beginning with the "historical background" and the naturalized chronology that are often represented as a matter of fact. I then compare these questionable stories of "discovery" with the biographies and bibliographies of AEC geologists, as represented in their geologic memoirs about the *geogenic* formation of the Grants uranium region. By taking account of different origin stories, I aim to pluralize our understanding of how the geological region came to be.

How was the discipline of geology applied in rendering the "Grants uranium district" legible for the extraction of uranium ore resources? By pursuing this question through the archives of the Geologic Information Center at the New Mexico Institute of Mining and Technology, this article traces the emergence of the "Grants uranium region" and the "Grants uranium district" as toponyms (or place-names) and an area of geologic exploration and research. I am interested how geologic information was collected, compiled, and archived in ways that made and continue to make mining districts legible in the eyes of the state (Scott 1998), and the eyes of the corporation (Kirsch 2014), while fracturing Indigenous land and local knowledge (Ortiz 1980). Situated within anthropological traditions of science and technology studies (STS) and critical studies of settler colonialism, the Geologic Information Center becomes a significant space and place to think about the current political lives of settler-colonial state archives. This article engages with recent scholarship in "Geological Anthropology" (Oguz 2020), "Political Geology" (Bobbette 2023), "STS Underground" (Kinchy et al. 2018), "ExtrACTION" (Jalbert et al. 2017), and "anthropology of mining" (see Jacka 2018) by focusing on the (ab)use of archives in mineral resource exploration and the knowledge-production of "geological regions" (e.g., d'Avignon 2023; Kneas 2020; Özden-Schilling 2020; Schilling 2013; Turkel 2007). My aim is to advance areas of research at the intersection of STS and political ecology by studying the relationship between speculative fiction and scientific fact in the geologic archives of mineral resource exploration.

The memoir genre in geology offers many possible ways for analyzing the epistemic production of the geophysical landscape. The "geologic memoir" is not just a historical source of the past; it is also a particular kind of ethnographic data—a "graphic artifact" that mediates the relationships between broader networks of human and more-than-human social actors and "the associations emerging through the production and circulation of documents" (Hull 2012, 21).[6] I will examine the socially interactive role of geologic memoirs as graphic artifacts that influence the knowledge-production of particular geological regions, and physically alter local landscapes and

[6] My analysis of "graphic artifacts" clearly diverges from Hull's approach to "current files" and his assumption that archives are not currently socially active in bureaucratic registers McLemore and Chenoweth 2017, 28 and 30). The graphic artifacts identified here are not just documents that have been retired into the archive as "historical background," or sources of the past; rather, they take on secondary social lives in the current political moment. Also see Ann Stoler's encouraging work for anthropologists engaged in the historical and archival turn in post-colonial scholarship to shift analytical perspectives from "archive-as-source to archive-as-subject" (2002, 87).

ecosystems through exploratory borehole drilling. I leverage Matthew Hull's concept of graphic artifacts to analyze three specific geologic memoirs that were applied in the production of the Grants geological region: *Memoir 15: Geology and Technology of the Grants Uranium Region* (Kelley 1963), *Memoir 38: Geology and mineral technology of the Grants uranium region 1979* (Rautman 1980), and *Memoir 50C: Energy and Mineral Resources of New Mexico: Uranium Resources* (McLemore and Chenoweth 2017).

How do these geoscientific knowledge products interweave with colloquial stories and place-names, and other forms of representation that attempt to reinforce the primacy of settlers, settler institutions, and extractive industries on Indigenous lands? The commingling of geologic memoirs and local folklore is an inherent part of the production of geological regions, through the chronicling and periodizing of the successive mining booms, and through the ongoing speculation of a new mining boom.[7] The "historical background" papers in these geologic memoirs are a form of representation and interaction that circulate at multiple spatial and temporal registers. The chronologies and periodizations represented in these geologic memoirs work at ordering and controlling the narrative of past events, but they also forecast the future of mineral resources. By asking how geological knowledge was applied in rendering the mining district legible for the extraction of uranium ore, we can probe the logic of economic geology in recent chronologies and periodizations of the Grants uranium district.

This article focuses on the formal periodization scheme of the foremost experts on the economic geology of uranium in New Mexico. Virginia McLemore and William Chenoweth (ibid.) list five historical periods of mining in the Grants uranium district: "radium boom" (1918–1923); "vanadium production" (1926–1940), "post WWII" (1948–1970), "uranium boom" (1970–1982), and "a new uranium boom" (2008–present). Critics of this contentious form of historical periodization have expressed their critiques to me by reframing the final period as "the Nuclear Renaissance that never happened" (see De Pree 2019, 24). Indeed, no uranium mining has actually occurred during this final period. I am curious about how geologic memoirs both document the past and impose themselves on the future by *promising* the eternal return of mining from the ruins of the former mining district.[8]

[7] See Adam Bobbette's *The Pulse of the Earth: Political Geology in Java* (2023):

> The assumed divide between modern science and local knowledge is tenacious, even though it is not real. It is therefore not well understood how science and local knowledge not only shaped each other but also went on to inform broader geological narratives of earth's history (ibid., 5).

[8] See Mike Fortun's STS work on discourse of "promising," which calls for "an ethnography of 'forward-looking statements' and their performances in an international political economy" (2008, 11). Geologic memoirs can also be viewed through the lens of "prognosis," which describes new ways of modelling, planning, and forecasting the future of natural resources (Mathews and Barnes 2016; Ferry and Limbert 2008; Kneas 2016, 83).

These graphic artifacts are discursive products of "discovery" made possible by the physical research activities of geobotanical sampling, airborne reconnaissance, geological modeling, and perhaps most consequentially, exploratory borehole drilling. My argument in this article will be that geologic memoirs are suspended in webs of interrelations through the Geologic Information Center, and they are associated with noticeable social-environmental impacts on the landscape of the former mining district. Exploratory boreholes provide the cross-disciplinary linkages between the accumulation of economic and geologic knowledge and information through the epistemic production of geological regions (Schilling 2013; Özden-Schilling 2020). Boreholes connect knowledge produced on the surface with the otherwise speculative resource materiality of the underground.[9] Boreholes also connect hydrogeological conditions on the surface with the groundwater aquifers below.

This article will conclude with consideration of how geologic memoirs are cited in the current political moment, in efforts to address the hydrogeological impacts in the former mining district. In 2018, while carrying out ethnographic fieldwork in Grants, I met a geochemist named Earle Dixon who had decades of experience studying the environmental impacts of uranium mining throughout the region. Dixon had advanced a form of "forensic geochemical investigation," a method for "fingerprinting" mine-water discharge. By adopting M. L. Jensen's "light sulfur isotope" analysis—a technique that was first published in *Memoir 15* (Kelley 1963) for the purpose of uranium mineral exploration—he hypothesized that it would be possible to use this unique sulfur isotope signature of the uranium ore in the Grants district to trace the impacts of mine-water discharge. By citing geologic memoirs in a movement away from their initial intended ontological and nomological purposes, Dixon's use of *Memoir 15* makes a compelling case for what the educator and literary theorist Gayatri Spivak (2012) calls *ab-use* of the archive. Spivak sets up to engage with the kind of "archival power" Elizabeth Povinelli describes which "authorizes a specific form of the future by domiciling space and time" (2016, 148), and challenge the dominant "archival drive" toward establishing the origin (the ontological) and asserting control (the nomological).

Methods and Methodology

The archival evidence presented herein was initially collected for the "historical background" chapter of a broader ethnographic research project that began in 2014 through an internship as a graduate student researcher at the Multicultural Alliance for a Safe Environment (MASE). MASE is a regional NGO that supports the actions of five local grassroots groups: Eastern Navajo Diné Against Uranium Mining (ENDAUM), Red Water Pond Road Community Association (RWPRCA), Laguna-Acoma

[9] Boreholes by themselves do not connect geological sciences with economic speculation. Geologists need to interpret, combine the data to create "strat columns," cross sections, and geologic maps showing ore grade in rendering a regional 3-D map of an ore mining district.

Coalition for a Safe Environment (LACSE), Bluewater Valley Downstream Alliance (BVDA), and Post-71 Uranium Workers Committee (Post-71). Each core group organized in response to the legacy of uranium mining and the environmental health disparities and vulnerabilities that have resulted, and they work in collaboration with Southwest Research and Information Center (SRIC) and New Mexico Environmental Law Center (NMELC).

From 2017 to 2019, I returned to northwestern New Mexico through a HASS graduate fellowship from Rensselaer Polytechnic Institute to carry out a multi-locale ethnographic research project on the diverse forms of expertise involved in monitoring and managing mine waste and mill tailings, and the relationships between so-called "stakeholders" from transnational mining corporations, government agencies, and local communities in their deliberations about the possibilities and limitations of cleaning up abandoned mine lands. From 2020–2023, I was appointed as a postdoctoral fellow at the University of New Mexico Health Sciences Center, as key personnel in the Community Engagement Core of the Metal Exposure and Toxicity Assessment on Tribal Lands in the Southwest (METALS) Superfund Research Program, and as an instructor in environmental science at Southwestern Indian Polytechnic Institute (SIPI).[10] Through transdisciplinary, multi-locale ethnographic research, I have continued to examine the diverse forms of expertise across categories of stakeholders and the dense entanglements of science, technology, and politics invested in cleaning up abandoned uranium mines (AUMs) in northwestern New Mexico.

I supplemented my ethnographic fieldwork with archival research in the Geologic Information Center at New Mexico Institute of Mining and Technology, which is a specialized library that contains geologic data on the state's mining and petroleum industries, including more than 5,000 maps, roughly 5,000 reports and publications, over 2,000 photographs, and about 1,200 theses and dissertations (GIC n.d.). Not only does it house the physical paper documents that make mining districts legible and tangible, but the center also maintains a database of digital files. During the course of my research in the archives of the Geologic Information Center at New Mexico Tech, I studied the logic of economic geology as a graduate student in Dr. Virginia McLemore's course, GEO571: Geology and Economics of Industrial Minerals. I also taught a general education history course at New Mexico Tech called, "Atomic America" (Fall 2020), which introduced students at a state mining school to a critical lens for viewing the contents of the Geologic Information Center. Much of the research data presented below are from the archival research of this project, but my ethnographic experiences have shaped my reading of these materials.

Methodologically, I am following Paige West's (2016) adaptation of philosopher Henri Lefebvre's concept of "the production of space" by showing how discourses of "discovery" and other rhetorical representations of nature (and culture) connect with the material effects of dispossession. Lefebvre's *trialectic* conception of the production of space opens our purview to the relationship

[10] I do not necessarily represent the perspectives and opinions of my institutional affiliations.

between what we perceive, conceive, and live directly, albeit differently (ibid., 229). Despite their criticism, spatial historians, geographers, and anthropologists have retained Lefebvre's three key terms and concepts of—

1. "Spatial practice" (e.g., "routes and networks," which paradoxically produce "the most extreme separation between the places that link us together")
2. "Representations of space" (e.g., the conceptualized space of scientists and engineers; their "canons" and semi-coherent "system of verbal signs")
3. "Representational space" (e.g., "space as directly lived through its associated images and symbols") (Lefebvre 1991, 38–46).

I will piece together my argument about the epistemic production of geological regions by tracing the relationship between the *representational space* of the Geologic Information Center; *representations of space* in the form of geologic memoirs; and the *spatial practice* of exploratory borehole drilling across the Grants uranium district.

"Historical Background": The Apocryphal Story of Paddy Martinez

The apocryphal story of Paddy Martinez is the most commonly told story about the "discovery" of the Grants uranium district.[11] This story commenced many of the interviews I conducted with people from the area; it was the prelude to renditions about uranium mining in many of the oral histories I listened to and read; and it can be found in the historical background sections of almost all of the regional geologic memoirs on uranium resources. As if the "Grants uranium district" came into being overnight in the middle of July 1950, brought about by Paddy Martinez's discovery of uranium in the Todilto limestone near Grants. Such "discoveries" are often portrayed as anomalous events, exceptional moments or occasions in time, rather than acknowledging the broader trends from which they occur and reoccur. These snapshots are archived and canonized as historical facts that are part of a naturalized chronology and master narrative about the origin and order of things.

Posthumously inducted into the National Mining Hall of Fame in 1992, after his death in 1969, Martinez was the 80th inductee. On his webpage in the Inductee Database a description begins this way:

> This native New Mexican, a Navajo, made the initial discovery of uranium in the San Juan Basin, the most important uranium-producing area in the United States. The region yielded in excess of

[11] I am using the term "apocryphal" to indicate questions of authenticity and authorship, dubious origins, as well as questions about what remains hidden by the story. The Greek adjective *apókryphos* means "hidden, concealed, obscure," from the verbal adjective *apokrýptein* which means "to hide (from), keep hidden (from)" (Merriam Webster Dictonary n.d.).

> $25 billion in uranium and contained 60 percent of the known uranium resources in the nation. (National Mining Hall of Fame and Museum 1992).

Martinez was featured in *Time*, *Life*, *True West*, and *Reader's Digest* as a "one of a kind" polyglot, "respected and remembered for his contribution to mining and to mankind." (ibid.) From the yellow rock on display at the New Mexico Mining Museum in Grants with a label that says, "JUST LIKE THE ROCK FOUND BY PADDY MARTINEZ," to the parks that have been named after him, these artifacts and features of the landscape are made from the fantastic and embellished settler folklore and lure of uranium mining in northwestern New Mexico.

In his book, *Fight Back: For the Sake of the People for the Sake of the Land* (1980), Acoma scholar Simon Ortiz questions this historical fiction. He describes the relationship between "discovery" and exploitation, and the making of time over place:

> In the Grants area for years it was popular knowledge that Paddy Martinez, a Navajo Indian, had discovered uranium. . . But that's not quite true. Grants and the U.S. system could have us believe it was as simple as that: it would reiterate the idea of the Indian bringing his own fate upon his head... There were any number of explorations for uranium since the 1940's in New Mexico. . . There was knowledge that there were substantial uranium ore bodies in the Southwest, and all they needed was time to make a "discovery" and a place where there would be no problem in exploiting (ibid., 64)

Ortiz elaborates in a poem entitled, "It Was That Indian," which recognizes the reasoning behind the representation of Martinez as "the one who discovered uranium . . . that Indian who started that boom" (ibid.). The Kodak color photographs of Martinez authorize his status as a historical marker in the form of a brochure referenced and celebrated by the Chamber of Commerce.

The brochure is like the historical highway marker described by David Samuels. The highway marker denoting Geronimo's surrender on Arizona's Route 80 commemorates "that historic day, [that] forever ended Indian warfare in the United States" (Samuels 2004, 52). Samuels remarks on how such markers indicate the "finality of the past," as though something was here and now it is gone, seemingly unrecoverable. Marking the beginning and the end of things, peoples, and places produces a naturalized chronology that welcomes the hubris of natural realism by which so-called "historical background" can be presented as a succession of events and series of facts that reify the "chronological ascendancy of Bureau Americans" (ibid., 52).[12] Such dominating settler relations with

[12] A dominant gesture of settler colonialism in the US Southwest has long been recognized in terms of settler time and temporality cast over Indigenous lands, spaces and places (Basso 1996; Deloria [1973] 1994; Masco 2006; A. Ortiz 1969; Fowles 2013). Disciplinary geology is constituted upon the transformation of space into time: from radiocarbon dating; to mid-twentieth-century studies on the "chronometric potential of the isotopes of uranium" and "geological time-keeping potential of radioactivity" (Hagen 1992, 101); to the stratigraphic sciences that turn the layers of earth into a "geologic timetable." In addition to the retrograde temporality of

Indigenous peoples are not only chronological; they are also teleological. Traci Voyles introduces the concept of "progressive teleologies of injustice" to make sense of the apocryphal stories of Paddy Martinez:

> Origin stories, like Paddy's and like the "vanishing race," are narratives that set a teleology in motion: they seek to explain how we begin to progress, from here to there, as a nation or an industry. Teleologies have long been ways in which a kind of "natural" progression—of society, history, knowledge, or even industrialism—is understood to occur (Voyles 2015, 98).

Setting the "background" really matters here. Mark Rifkin describes how:

> . . . asserting a shared modernity or presentness of Natives and non-natives implicitly casts Indigenous peoples as inhabiting the current moment and moving toward a future in ways that treat dominant non-native geographies, intellectual and political categories, periodizations, and conceptions of causality as given—the background against which to register and assess Native being-in-time" (2017, viii, ix).

Rifkin asks how "to pluralize temporality so as to open possibilities for engaging with Indigenous self-articulations, forms of collective social life, and modes of self-determination beyond their incorporation or translation into settler frames of reference" (ibid.). Leveraging post-Einsteinian notions of time, he focuses on particular kinds of "temporal knottings" where time is not absolute; time is contingent upon relative motion and frames of reference. In this article, I argue that discourse of the Martinez "discovery" is part of a temporal knotting that can only be understood by accounting for other frames of reference, and by pluralizing origin stories that open our purview to many possible sources of emergence.

I refuse to tell the story of Paddy Martinez.[13] In what follows, it will become clear that Martinez did not make the initial discovery of uranium in the region, nor did his discovery lead to the development of the largest deposits. I have encountered many other sources of evidence that support the argument that uranium was "discovered" in the Grants area many years prior to the Paddy Martinez "re-discovery." Consider this composite sample from a collection of oral histories shared with me by Bluewater Valley Downstream Alliance (BVDA):

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geology, it is clearly a speculative discipline that looks forward into the future. The concept of "deep time" has been used by historians and anthropologists of geology to refer to epistemological and ontological orientations toward the past, origins, emergence and evolution, genesis and development (McPhee 1998; Rudwick 2005); as well as deep forward-looking visions, future imaginaries and speculative futurisms, which can be observed in the practice of prospecting for mineral resources, as well as managing the future risks of radioactive waste disposal (de la Torre III 2017; Galison and Moss 2016; Ialenti 2020).

[13] See Traci Voyles' book *Wastelanding* (2015) for a composite narrative and discussion of various renditions of the Martinez story, and for her critical analysis of such "progressive teleologies of injustice" (ibid., 97–102).

> Quimby ("Tink") Ferris was a student of geology. He walked up on this little outcrop of carnotite and recognized it. He staked three claims in July of 1945 or '46. Of course, we knew about it then, but we didn't publicize it. We kept it kind of quiet because it was new.[14]

Paddy Martinez was staged as "instrumental in getting it off center because we were keeping it quiet" (in De Pree 2019, 89). What caused the initial proliferation of the Martinez story, of all the other stories of discovery, was the promotion of the event by Atchison, Topeka and Santa Fe (AT&SF) Railroad—the company that owned the mineral rights to the land on which Martinez found the uranium-bearing tyuyamunite ore. This is part of a temporal knotting that can only be understood in juxtaposition with other origin stories.[15]

McLemore and Chenoweth offer the most detailed accounts of the extensive history of uranium exploration and exploitation in the Grants area, but they ultimately attribute "the uranium boom" to Paddy Martinez:

> The initial discovery of uranium mineralization in the Grants uranium district was during the 1920's . . . however, it was the discovery in 1950 by Paddy Martinez in the Todilto Limestone that started the uranium boom. Paddy Martinez discovered tyuyamunite at what is now known as the Haystack-Section 19 mine (2017, 57).

Such discourse of discovery conceals the emerging market in the region from the 1920s to the 1950s, and the story of how uranium became an economic "resource." In their report, *Uranium Prospecting and Exploration in New Mexico* (1954), Wolfe and Carlson stage the "re-discovery" of uranium similarly by discounting past discoveries: "In the northwestern portion of the state, the earliest report of the presence of uranium in the Grants area was in 1913. However, it was the "re-discovery" of uranium in the Spring of 1950 by Paddy Martinez, a Navajo Indian, on lands controlled by the Santa Fe Railway that has since led to the present widespread mining development of uranium ores in the Grants vicinity" (ibid., n.p.). A paper in *Memoir 15* titled "History of Exploration" by Paul Melancon repeats this discourse of re-discovery: "Paddy Martinez, a Navajo Indian prospector, is responsible for the discovery that was to develop into the most prolific uranium-producing district in the world. Although his discovery was made in 1950, uranium minerals that were known to occur near Grants had been recognized in the early twenties (*Preface*) and mapped on the outcrop in 1948" (Melancon in Kelley 1963, 3). In each of these narratives of re-discovery, Paddy Martinez is made to be responsible for the mining boom in the region, even as they acknowledge deeper historical patterns of discovery as early as 1913.

[14] BVDA as cited in De Pree 2019, 89. Note that before 1945, any information about the location of radioactive minerals was classified as a matter of national security.

[15] Thinking of Kathryn Yusoff's book, *A Billion Black Anthropocenes or None*, I am interested in how "origin stories bury as much as they reveal about material relations and their genealogies" (2018, 59).

These claims of re-discovery can be viewed as "scenes of apprehension," to borrow Audra Simpson's term, which describes how disciplinary formation is linked to the dispossession of Indigenous peoples through the accumulation of information—canons of literature on particular anthropological (and geological) regions (2014, 70). Scenes of apprehension structure the conditions of possibility for a kind of "cultural pathology," like the blame-the-victim narrative Dunbar-Ortiz calls out, which reproduces the social relations of settler colonialism and capitalism under a fiction that reifies "the idea of the Indian bringing his own fate upon his head" (Ortiz 1980, 64). Simon Ortiz has become an important source for unsettling this "historical background" by providing the groundwork for alternative historical, archaeological, and sociocultural perspectives in US Southwest area studies (see Voyles 2015; Fowles 2013; Masco 2006). Against this historical background, we can examine the application of geologic time and the geological knowledge production that made the Grants uranium region legible for extraction.

Geologic Memoirs as "Graphic Artifacts"

The toponym of the Grants uranium district emerged in the work of William ("Bill") Chenoweth and his colleagues at the Atomic Energy Commission (AEC) Raw Materials Division in Grand Junction, Colorado circa 1950. Research on the uranium resources of the Grants mining district continues today through Virginia ("Ginger") McLemore's work at New Mexico Bureau of Geology and Mineral Resources housed in New Mexico Institute of Mining and Technology in Socorro. Other synonymous placenames include the "Grants uranium region," "Grants uranium belt," "Grants Mining District," and "Grants Mineral Belt," which index broader communities of geological research in the region (Kelley 1963; Rautman 1980; Turner-Peterson, Santos, and Fishman 1986). All of these different toponyms refer to an area of northwestern New Mexico that extends roughly one hundred miles east-west, from Laguna Pueblo to Gallup, and twenty-five miles north-south, mostly north of Interstate 40 (I-40).

Chenoweth's experiential accounts, memoirs, maps, reports, and other graphic artifacts stand out as some of the most comprehensive efforts in applying geologic time to make the "Grants uranium district" legible for the extraction of uranium ore resources. Chenoweth's life project was dedicated to and driven by the advancement of geological knowledge and preservation of geologic information. One source, *The Daily Sentinel*, a local newspaper in Grand Junction, Colorado, spins it this way: "Chenoweth was the Google of the Colorado Plateau before search engines were even the stuff of dreams." (Anon. 2019) The report portrays an 82-year-old Chenoweth as a life-long geologist who is "on so many levels . . . a national treasure" (ibid., n.p.). While working on his BA in geology from Witchita State University, he attended a summer field school in the Zuni Mountains in 1950, supported by the New Mexico School of Mines.

According to the report in *The Daily Sentinel*—

> Chenoweth traveled to the Southwest on behalf of the Atomic Energy Commission (AEC), then the Energy Department, as a geologist and as a branch chief for both agencies, mapping mines,

> studying uranium resources and generally keeping his finger on the pulse of the uranium business and the people who ran it. (ibid., n.p.).

These projects supported his master's thesis in geology from the University of New Mexico in 1953. Funded by the AEC, Chenoweth's thesis offers a study of the Morrison Formation in what was Valencia County (now Cibola County), New Mexico. He was employed by the AEC thereafter to work on exploratory drilling projects for uranium in the Navajo Nation in northwestern New Mexico and northeastern Arizona. He lived in Grants, New Mexico before transferring to the AEC's central regional office in Grand Junction, Colorado in 1964. After being appointed to the position of Chief of the AEC Geologic Branch at the Grand Junction office in 1970, Chenoweth began studying uranium ore deposits in Wyoming and South Dakota and was responsible for the activities of geologists of the AEC in 14 western states (McLemore and Chenoweth 2017, 50).

When the AEC Raw Materials Division established a regional office in Grand Junction, Colorado, they housed the archive on uranium ore resources throughout the Colorado Plateau in the Four Corners area of the Southwest—an archive only rivaled in depth and breadth by the Anaconda Company library in Grants, New Mexico. The AEC archive now lives in the Geologic Information Center at New Mexico Tech in Socorro (GIC n.d.); whereas Anaconda's collection became the Anaconda Geological Documents Collection (AGDC n.d.) at the University of Wyoming in Laramie. In addition to these documents and other graphic artifacts, Chenoweth's memory of these early experiences, at a time when records were either top secret or scarcely kept, has been called upon where gaps appear in the official record to inform the legal proceedings for the Radiation Exposure Compensation Act (RECA).

With his encyclopedic and bibliophilic drive, Chenoweth collaborated with colleagues at New Mexico Tech and the New Mexico Bureau of Geology and Mineral Resources (formerly the Bureau of Mines) in curating geologic information, which has found an array of applications in uranium districts throughout the United States and internationally. Geologic models of uranium ore genesis in the Grants uranium district have been applied to identify other uranium ore deposits around the world. According to McLemore and Chenoweth: "Knowing the source of uranium is important in understanding how the Grants deposits formed," and for establishing "geologic deposit types" and "geoenvironmental models" that can aid in locating uranium districts elsewhere (2017, 29). Another historical account from a geologist reads—

> Most of the ore in Grants is in sandstone, as it is in the other uranium districts of the United States. The United States deposits of this type have provided a model for exploration around the world. (Wright in Rautman 1980, 22).

Chenoweth and colleagues' "graphic artifacts" have taken on subsequent social lives beyond their initial intended application for uranium exploration in the Grants region by making new mining districts legible for uranium resource extraction across the globe, and borehole data were in tension with, and contributed to Chenoweth's work.

Consider McLemore and Chenoweth's *Memoir 50C: Energy and Mineral Resources of New Mexico: Uranium Resources* (2017), which was published by the New Mexico Bureau of Geology and Mineral Resources. Though there is no consensus on the origin of the uranium deposits of the Jurassic Morrison Formation sandstone, the memoir accounts for the different models that trace the origin of uranium in the region. The "brine-interface model" and "lacrustrine-humate model" both synthesize earlier ideas and research. Numerous isotopic studies suggest a potential source of uranium from a volcanic arc of plutons and other volcanic features that were active during the Jurassic Period, and dispersed ash into the atmosphere (and/or through hydrothermal interaction) that sedimented in large briny Cretaceous lakes—in this case, the San Juan Basin where the Grants uranium district is located. It is within this context that McLemore and Chenoweth underline the "intimate association" of uranium and vanadium in humates during "early diagenesis." These competing hypotheses formulated in the Grants uranium region became the basis for a geoenvironmental model that was used for uranium exploration in sandstone worldwide (ibid.; Wright in Rautman 1980, 22–35).

Although *Memoir 50C* describes the geogenic origin stories of uranium ore, my counter reading identifies the *anthropogenic* origins of the social life of uranium ore. The locus of historical agency is not necessarily in the uranium ore itself, but the geologic studies of ore genesis conducted by Chenoweth and colleagues that rendered mining districts legible for extraction. I am resisting the geological determinism inherent in many historical accounts of the Grants uranium district, which entertain an "ore hypothesis," as if the uranium ore itself determined the course of social and political action (cf. Mellor 2018).

Memoir 50C synthesizes two older graphic artifacts that indicate the emergence of a robust epistemological paradigm for the application of geological knowledge in the Grants uranium region: *Memoir 15: Geology and Technology of the Grants Uranium Region* (Kelley 1963), and *Memoir 38: Geology and mineral technology of the Grants uranium region 1979* (Rautman 1980), both published by the New Mexico Bureau of Geology and Mineral Resources. By the 1960s and '70s, geological theories, explanations, and models for uranium exploration, mining, and milling experienced tremendous growth and development. *Memoir 38* resulted from a conference that attracted over 800 geologists and other scientists, including people from six foreign countries. Field trips had an overflow crowd of 260 geologists, and 46 papers were presented at the 1979 symposium that aimed to build on the canonical *Memoir 15*, the *locus classicus* of geological knowledge on the topic of uranium mining in the US Southwest (Kelley 1963).

Though uranium mining in the region subsided considerably by the 1980s, grinding to a halt by the '90s, this was a period of most intensive scientific research on the Morrison Formation of the "Grants uranium region" (Turner-Peterson, Santos, and Fishman 1986). This scientific pursuit was endowed by the National Uranium Resource Evaluation (NURE; 1974–1984), which was implemented by the Grand Junction Office of the US Atomic Energy Commission (and its successor agencies) in order to assess the nation's remaining uranium resources and identify favorable areas of mineralization. The evaluation included geochemical surveys, compilation of quadrangle geologic

maps, geophysical surveys, quadrangle assessments for uranium resources, miscellaneous geologic investigations, and drilling projects (McLemore and Chenoweth 2017, 21). Its "sound technical base" served as a scientific exemplar that expanded the possibilities for the application of geological theories and models for mapping uranium ore resources. These predecessor studies also led to a synthesis titled, *A Basin Analysis Case Study: The Morrison Formation Grants Uranium Region New Mexico* (Turner-Peterson, Santos, and Fishman 1986), which was published by the Energy and Minerals Division of the American Association of Petroleum Geologists.

Geologic memoirs can be read as graphic artifacts that are instrumental in the production of geological regions. Consider the geophysical implications of geologic information within recent environmental histories and anthropologies (inflected by STS and political ecology) of mineral resource exploration (d'Avignon 2023; Kneas 2016, 2020; Schilling 2013, Özden-Schilling 2020; Turkel 2007). Anthropological perspectives on resource materiality place emphasis on the temporal dimensions of when resources are made legible and manipulable, and the conflict and incommensurability with local experiences (Ferry and Limbert 2008; Li 2015). Thinking of such anthropological analyses of resource temporalities, David Kneas (2016) introduces the concept of "prognosis" to analyze the double effect of the economic speculation of a junior mining company, as a way of "diagnosing" and "forecasting," whereby economic speculation becomes entangled with messy interventions to determine the fate of mineral resources. Even the "historical background" papers in these geologic memoirs attempt to forecast the future of new mining booms through a local folklore of the eternal return of an abandoned mining district.

Thinking with the concept of prognosis, I want to introduce the analytic figure of the exploratory borehole to expose the speculative discourse of mineral resource exploration and its material impacts, which draws our attention to the formation of underground knowledge and expertise (Kinchy et al. 2018, 23), and the making of extractive economies and industries (Jalbert et al. 2017). I am thinking with an emerging body of literature in STS to adjust the focus on different connections between speculative fiction and scientific fact in geologic memoirs. As noted by Abby Kinchy, Roopali Phadke, and Jessica Smith in their work on "STS Underground" as a field in formation, "while speculation is inherent to scientific practice, it is especially central to any efforts to work underground, given that it cannot be directly visualized, touched, or manipulated outside of excavation or sampling" (2018, 31). In his book *Annals of the Former World*, a formative text in the history of geology, John McPhee suggests: "All science involves speculation, and few sciences include as much speculation as geology" (1998, 133). Fewer yet include as much speculation as economic geology. How does speculative fiction blend with scientific fact, as local knowledge blurs with the production of geoscientific knowledge?

Geologic memoirs are instrumental in *informating* geological knowledge of uranium resources; and they are complicit in the production and circulation of "state maps of legibility" (Scott

1998).[16] According to James Scott, they are not just maps: "Rather, they were maps that, when allied with state power, would enable much of the reality they depict to be remade" (ibid., 3). In her analysis of gold prospecting in Senegal, Robyn d'Avignon (2023) describes how state map-making technologies become instrumental in applying claims of power over knowledge, resources, land, and people. In response, d'Avignon calls for multi-vocal histories of "discovery" to be included in the co-production of subterranean knowledge through ethnographic accounts of the struggles over mineral discovery, and the cultivation of knowledge about the underground (ibid.).

Robyn d'Avignon's work on geological mapping is part of the emerging field of "Geological Anthropology" (see d'Avignon 2018). Tom Özden-Schilling also makes connections between calculative and imaginative aspects of "inferred resources" by visualizing economic images in geoinformatics; and the "cylindrical samples of rock, or 'core,' [that] must be drilled out from an increasingly fine grid of drill holes so that geologists working on site can visually inspect each meter of material" (2013, 141).[17] Schilling's work on drill holes and core samples connects with his more recent work on the scale of the "imputed geological region" in anthropology and geology, which serves to coordinate work, produce documents, and change everyday discourses and practices, while outlining economies and political scales that become the aspirations of different political actors (Özden-Schilling 2020). Following Özden-Schilling, the next section of this article will focus on the implications of exploratory borehole drilling in making geological regions.

Exploratory Borehole Drilling

In the beginning, more than any of the prevailing geologic conceptual models, borehole drilling was the dominant mode for rendering the Grants uranium district legible and tangible. Since the initial publication of *Memoir 15* in 1963—

> . . .the impact of well-funded exploration programs has increased knowledge of the region's resources. Records of the Grand Junction DOE office indicate that 63,898 holes totaling 64,631,792 ft have been drilled in the area. Average drilling depths increased from 212 ft in 1964 to a record high of 1,651 ft in 1975. (Rautman 1980, 20).

According to Chenoweth and Holen: "Exploration in the region has been influenced by the availability of land, rather than by the use of geologic models" (Chenoweth and Holen in ibid., 17). Caught amid a burgeoning uranium resource extraction industry, and the expansion of the mining region during the

[16] Kim Fortun's concept of "informating" accounts for "how information technology and culture animates change at multiple scales, sometimes provoking critical change in sign systems," and how such "shifts enable articulation previously impossible or unrecognizable" (2012, 6).
[17] Also see David Kneas's (2020) analysis of geological mapping and mineral exploration through "density-depth" profiles.

1960s and '70s, which was dominated by the exploration programs of large oil companies, Chenoweth and Holen's statement seems a bit overrun by non-geological knowledge. Both the early AEC drilling programs, and the drilling regimes of transnational oil companies that succeeded them, were guided more by crude borehole logs than any advanced theories of ore genesis. Boreholes were the main conduits of discovery. Mystified by the distribution of the uranium ore, one geologist observed in the Grants district that:

> The drill remains a reliable diagnostic tool in ore-finding and following the elusive trend. But the faint tell-tale evidences along the route of travel of the ore solutions and their capriciously deposited offspring always lie buried along their devious routes in their hosts. Therefore, our ore-finding techniques are yet, of necessity, in the trial-and-error stage . . . the drilling rig is still a sound diagnostic tool, by the very nature of the things, in the art, if less so in the science, of ore-finding on the Plateau" (Gabrecht 1954, 9-10).

Early exploration for uranium focused on the limestone deposits, which is attributed to the Paddy Martinez "re-discovery," but most of the uranium extracted in New Mexico came from sandstone deposits (McLemore and Chenoweth 2017, 9). According to McLemore and Chenoweth, "The first economic discovery of uranium in sandstone was made on January 4, 1951, east of Haystack Butte in an area called Poison Canyon" (ibid., 15).[18] When Anaconda Copper Mining Company arrived in the early 1950s, they "initiated a diversified, systematic geologic reconnaissance and uranium exploration program" (Wolfe and Carlson 1954). Jack Knaebel from Anaconda Company located uranium in the so-called "Jackpile" sandstone during an airborne radiometric survey over the Pueblo of Laguna (*Kawaika*).[19] According to Memoir 15, "Since the discovery of the Jackpile deposit, about 1,440,000 feet of cored and noncored holes have been drilled in and around it and the Paguate deposit" (Kelley 1963, 167). This particular deposit of uranium ore became the Jackpile-Paguate Mine, which was once the world's largest open-pit uranium mine. More than eighty (>80) million pounds of uranium oxide were produced from the sandstone deposits during 30 years of operation, contributing about thirty percent of the total pre-1971 uranium ore in New Mexico (Chenoweth 1988, 46).

[18] Poison Canyon was named for the abundance of "Locoweed" or "Crazyweed" (*Astragalus*), which produces the phytotoxin swainsonine if grown in soils rich in selenium, posing a health risk to livestock.
[19] A Laguna Middle School curriculum on uranium mining in the region includes a story about how Jack Knaebel became ill while conducting the flyover and vomited after landing the plane; the mine was then named after "Jack's pile" of vomit (Sittnick 1998, 16). I thank Paul Robinson (SRIC) for sharing this curriculum with me. During my ethnographic research, I took account of two other renditions of the naming of Jackpile in conversations with people from Grants who referred to Jack's *pile of feces* as the namesake for the mine.

In the 1950s, airborne radiometric reconnaissance provided the broad-brush strokes that would identify uranium deposits in radioactive outcroppings on the Colorado Plateau. In the report, "Airborne Radioactivity Survey in the Vicinity of Grants, McKinley and Valencia Counties, New Mexico" (1951), Frank W. Stead outlines standards for aeromagnetic measurements and radioactivity measurements. Such aerial surveys were often carried out on a Piper PA-18, 135 horsepower Super Cub, equipped with a Mark VI airborne scintillometer for "rim and grid flying" with flight lines spaced at 100 foot intervals, at a height of 50 ft in order to produce a 15-minute, semi-controlled air-photo mosaic with a scale 1:62,500 (Chenoweth 1957, 10). These ariel surveys were followed by ground reconnaissance in cases where radioactive anomalies were identified, followed by borehole drilling and probing. Geophysical methods for surface exploration would supplement this endeavor, as well as geobotanical methods.

In a report titled "Geobotanical Reconnaissance near Grants, New Mexico," Helen Canon recommends "Uranium analysis of trees growing on the Todilto bench and mapping of selenium-indicator plants on the sandstones of the Morrison formation" (1953, 2). Sponsored by the AEC, Canon also makes a special acknowledgment to the AT&SF Railroad for permission to do her study on their property. Canon discusses how selenium-indicator plants of—

> . . . the preussii group of Astragalus (milkvetch) and Oryzopsis hymenoides (Indian ricegrass) grow profusely along the base of the outcrop of the carbonaceous ore in the Westwater Canyon sandstone member of the Morrison formation in Poison Canyon" (ibid.). She notes that *Atriplex confertifolia* ("shadscale") also absorbs selenium, and piñon and juniper trees "absorb unusual quantities of uranium" (ibid.).

The report produced a feasible method for geobotanical exploration, but its utility was ultimately deemed limited, and it eventually lost explanatory power to other modes of exploration, such as airborne radiometric reconnaissance and exploratory drilling.

As borehole drilling technology became the dominant technique for uranium exploration and exploitation, the logs from borehole drilling informed everything from underground mineral resource estimates, to drilling depths to the uranium-bearing Jurassic Morrison formation. In March of 1955, Lewis Louthman discovered uranium in the Ambrosia Lake region, which would become the most productive of the eight subdistricts of the Grants uranium district. Louthman discovered the Ambrosia Lake trend by examining logs of oil tests at the New Mexico Bureau of Mines and Mineral Resources in order to determine drilling depths to the Morrison Formation in the area around Ambrosia Lake. With this information, he began drilling for uranium and discovered uranium mineralization in the Westwater Canyon Member of the Morrison Formation by the second drill hole. The Ambrosia Lake-Mt. Taylor trend became the largest mineralized area in the Grants district (McLemore 1981). The historical background papers in geologic memoirs are rich with examples of how exploratory borehole drilling connects geologic information with economic resource estimates that are essential in turning "geological regions" into "mining districts."

Beyond the borehole logs and outside the archives, as exploration drilling cuts back through the layers of geologic time, it also continues to impose itself on the future of groundwater resources

across the landscape through its ongoing hydrogeological impacts. Recent basin-wide models show how historic exploratory boreholes have exacerbated the environmental health impacts of the legacy of uranium mining in northwestern New Mexico by serving as conduits that connect contaminated mine water discharged on the surface with underground aquifers. These are the effects of the *geological gaze*. There is an abundance of anthropological literature on "the gaze" of the ethnographer, but we have yet to apply this lens to examine the *gaze of the geologist*. The dominant technology for making uranium resources visible and knowable simultaneously oxidized the underground orebody and changed the valence and oxidation state of uranium from an insoluble tetravalent (+4) state to a soluble hexavalent (+6) state, which mobilizes easily in the environment.[20]

Conclusion: "Ab-use" of the Archive

This article provided a historiography of mineral resource exploration and the epistemic production of a geological region in the US Southwest. This style of historiography offers a critique of the historical background papers in geologic memoirs as one way of reading against the archival grain, and exposing the physical and material impacts of dispossession resulting from mineral exploration. I argued that geologic memoirs and their origin stories are part of a temporal knotting, enmeshed in webs of spatial relation through the representational space of geologic archives; and they are associated with massive geophysical alterations in the landscape from the dominant technology of mineral resource exploration: borehole drilling. My argument unfolded in three parts, as I described the relationship between archives, memoirs, and boreholes:

(1) geologic archives can be experienced as a "representational space," dense with contemporary social interaction and associated symbols and images
(2) the geologic memoir is both a "representation of space" and a "graphic artifact"
(3) the historical figure of the borehole is a form of "spatial practice" that makes many different historical-material, political-economic connections (and separations) in the sociocultural production of nature. Boreholes connect genres of speculative fiction and scientific fact in geologic memoirs, and serve as the cross-disciplinary linkages between the formation of geoscientific knowledge and economic speculation.[21]

In the process, boreholes physically connect the hydrogeological conditions on the surface of the earth with the groundwater aquifers below.

[20] Anderson (1984). I am grateful for Chris Shuey's (SRIC) informative lessons on the irreparable damages of oxidized uranium and its hydrogeological fate and bioavailability, as well as Johanna Blake's informative research. Thank you, Earle Dixon, for emphasizing that the oxidation state of sulfide minerals creates acidic conditions further dissolving and solubilizing heavy metals and low pH into water.
[21] Boreholes connect multiple SFs in STS: science fiction, science fact, and so forth (Haraway 2016, 3).

This article concludes with consideration of how geologic memoirs are cited in the current political moment, in efforts to address the hydrogeological impacts of borehole drilling, and other impacts of mining. Consider the geochemist Earle Dixon's "forensic geochemical investigation" and his method of "fingerprinting" mine water in the Grants region. Dixon leveraged the work of M. L. Jensen, "Sulfur Isotopes and Biogenic Origin of Uraniferous Deposits of the Grants and Laguna Districts," published in Memoir 15 (Kelley 1963). According to Dixon: "Jensen wrote a paper in 1963 that was used to explore for uranium; we're using that same concept to fingerprint the water" (De Pree 2019, 223). Looking at Jensen's historical report and their own recent geochemical sampling, Dixon and colleagues selected a "light sulfur isotope" as a tracer that is ubiquitous in the uranium orebody and quite different from other sources of sulfur. The mine water that was discharged has a "fingerprint" you can run through a chemical database. He refers to this method as "poor man's plume chasing" because it does not require more expensive (and environmentally impactful) borehole drilling to monitor the geochemistry of the plume. In this fashion, the graphic artifacts residing in the Geologic Information Center can be leveraged against their initial intended purposes to unsettle the origins and contest the future of a former uranium mining district.

During my experience teaching the undergraduate course "Atomic America" at New Mexico Tech (Fall 2020), Dixon's approach of forensic geochemistry became an alternative lens through which to read materials in the Geologic Information Center as a class.[22] I portrayed Dixon's forensic geochemical research as a compelling case for what Gayatri Spivak calls "ab-use from below," which is a "literary pedagogy" of choosing, reading, and teaching texts in ways that prepare "another space" by exposing "the fault lines in slogans of the European Enlightenment" (2012, 3). I presented Simon Ortiz's critique of the settler origin story as another form of ab-use from below, which allows for the "remaking of history" through a "persistent critique, unglamorously chipping away at the binary oppositions and continuities that emerge continuously in the supposed account of the real" (ibid., 3-4). With this bibliographic strategy of "ab-use," we can select and read texts insubordinately in order to unearth the fractures and fissures (and boreholes) in geologic archives, libraries, and information centers. Spivak's aesthetic pedagogy of ab-use can be applied here to read against the grain of the archive by selecting, reading, and teaching texts in a movement away from their initial intended ontological and nomological purposes. These texts can be used to question the origins of the mining district, and contest the future of abandoned mine lands by restoring the land back to its original conditions prior to mining.

[22] See the "Afterlife of Atomic America" essay on the Disaster STS Network webpage (Disaster STS Network n.d.).

Acknowledgements

Research reported in this publication was supported by the National Institute on Minority Health and Health Disparities (NIMHD), National Institute of Environmental Health Sciences (NIEHS), and National Institute of General Medical Sciences (NIGMS) of the National Institutes of Health (NIH). This project was completed with support from the University of New Mexico Health Sciences Center, Institutional Research and Academic Career Development Award (NIH/NIGMS K12 GM088021), Center for Native American Environmental Health Equity Research (NIH/NIMHD P50 MD015706), and METALS Superfund Research Center (NIH/NIEHS 1 P42 ES025589). The Metals Exposure and Toxicity Assessment on Tribal Lands in the Southwest (METALS) Superfund Research Program (SRP) is the first research program of its kind in the nation dedicated to studying the toxic effects of mixed metals and uranium exposure among Indigenous communities in the US Southwest. This article does not attempt to represent the perspectives of the programs, departments, institutions or grants with which I am affiliated. The content is solely the responsibility of the author and does not necessarily represent the official views of NIH.

I acknowledge the Multicultural Alliance for a Safe Environment (MASE) and the core groups of Red Water Pond Road Community Association (RWPRCA), Laguna-Acoma Coalition for a Safe Environment (LACSE), Eastern Navajo Diné Against Uranium Mining (ENDAUM), Bluewater Valley Downstream Alliance (BVDA), and Post-71 Uranium Workers Committee (Post-71). Thank you for introducing me to the historical and ongoing social, cultural, environmental, and health impacts of uranium mining in the Grants mining district of northwestern New Mexico. Thank you for exposing me to the diverse forms of resistance, resilience, and restoration that have been carried out in response to such massive impacts. I am moved to action by the stories you shared with me, and I continue to carry a deep sense of responsibility to do justice with the time, energy, knowledge, and experiences you have invested with me, despite my limitations. I am also grateful for the technical, scientific, policy, and regulatory information provided by the Southwest Research and Information Center (SRIC) and New Mexico Environmental Law Center (NMELC). For the better half of a century, these technical and legal support centers have been doing the work to address the environmental health disparities and injustices that the US federal government and private mining companies have largely failed to do, despite their accountability for this mess.

Early drafts of this essay circulated among my dissertation committee and other academic mentors: Kim and Mike Fortun, Atsushi Akera, Jerry Jacka, Abby Kinchy, Nancy Campbell; Dana Powell, Donna Riley, Jessica Smith, Paige West, Steven Feld, Louise Lamphere, Luis Campos. I am grateful for their engagement with this work-in-progress and the comments they provided. All errors are mine.

Finally, I want to acknowledge the New Mexico State Bureau of Geology and Mineral Resources at the New Mexico Institute of Mining and Technology for granting me access to the Geologic Information Center. Thank you, Amy Trivitt (Geological Archives Coordinator) and Virginia McLemore (Principle Senior Economic Geologist). You are the knowledge-bearers who bring this archive to life and animate its existence. I am inspired by your capacity and interest in making our

state's geologic information open, accessible, and legible to the public. Thank you, Taylor Dotson, for presenting the opportunity to teach the "Atomic America" course at New Mexico Tech.

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