Using Grounded Theory to Understand the Archival Needs of Geologists

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Abstract: Unpacking “small science,” this chapter focuses on the recordkeeping practices of geologists as embodied by their field notebooks. Used to record observations and to document data collection, field notebooks represent “dark data” secreted in the “long tail” of science. This case study addresses geologists’ use and reuse of field notebooks, their provisions for long-term preservation (if any), and their understanding of archival and archiving principles and practices. The chapter begins by reviewing relevant literature on dark data and its reuse, on geologists, and on archiving. Second, it lays out the basic framework of Grounded Theory and suggests that the constructivist variant of Grounded Theory advocated by Kathy Charmaz is most appropriate for this case study. Third, it weaves together the theoretical insights of Grounded Theory with a specific delimited case study centered on geologists and archiving practices. It then describes the various stages of Grounded Theory and the ways in which these iterative and symbiotic stages relate to our work with geologists and their field notebooks. It presents preliminary results from our work with geologists and links those results to archival concepts. Finally, it engages the broader challenge of reflective and interpretive theory development and underscores the potential of constructivist Grounded Theory to facilitate new communication—and collaboration—between archivists and practitioners of “small science.”

In the end, inquiry takes us outward yet reflecting about it draws us inward.¹

-Kathy Charmaz

Introduction and Context

In their daily lives, citizens and scholars alike may underestimate the importance and impact of geological data. But as the US National Resource Council concludes, geological materials can be used and reused “to address issues that are important to all.”² In particular, they lend themselves to hazard assessment, to basic and applied scientific research, to discovery, assessment, and enhanced use of national resources, and to education and public awareness. The reuse of geological data can prove pivotal, for instance by supporting emergency responses to natural disasters, in helping scientists and policymakers reevaluate risk potential following earthquakes, and in helping researchers grapple with climate change. On a more granular level, however, scientists frequently reuse geological materials to verify the locations of any ambiguous data points mentioned in professional publications. These stakeholders verify such data point locations by revisiting raw data—data frequently captured and preserved only in the field notebooks of academic or professional geologists.

As Kalpana Shankar observes, “How individuals develop a professional voice and identity, and negotiate them amidst the expectations of their research discipline and broader profession, is reified in the artifacts of their study, the practices they engage in, and…the texts they create.”³ Undergraduate and graduate education in geology—as well as geologists’ subsequent socialization into a relevant community of practice—teaches aspiring geologists to make and to keep detailed field notes as a crucial part of their professional development. The US Geological
Survey (USGS)’s Geologic Materials Repository Working Group (GMRWG) and the National Research Council (NRC) of the National Academies both classify field notebooks under the umbrella of scientific data. Indeed, the GMRWG characterizes such data as “ancillary geologic records” that prove indispensable for documenting research projects and sample collections. But this data too frequently is overlooked or lost.

For a geologist collecting data, field work involves hiking to a remote location with tools such as a Brunton (a compass-like device), a rock hammer, a hand lens, a vial of acid, and a field notebook (also called field notes). Perhaps the most important of these materials, the field notebook is used to record scientific observations and to document the process of data collection. These notebooks often constitute the only record of a geologist’s experiences in the field until these data are distilled into a published report. Field notebooks include notes about locations visited, lithography observed, and station identification for samples collected (rocks, fossils, etc.). They may also include sketches and other information about the events of the trip; in this way, a field notebook may resemble a diary. Ultimately, field notebooks constitute a pivotal part of the work of those scientists who have been trained similarly and who conduct research in one to two-person teams. These scientists represent the backbone of so-called “small” science.

This chapter describes the process of conducting a research project using Grounded Theory to study archiving practices of small science. A case study, it focuses on geologists who are actively conducting research and who use field notebooks in their everyday work for a multiplicity of purposes ranging from basic reference to historical research, and mapping projects to verifying secondary and derived data against the source. Most importantly, these users may need data hidden away in field notebooks to develop new research questions, to embark upon new research projects, and to verify previous findings. Thus we tackle a fundamental research question: how can archival scholars use constructivist Grounded Theory to explore—and potentially to streamline or to improve—the archiving practices of both academic and professional geologists? Under the aegis of this research question, we examine geologists’ conceptions of “archives” and “archiving” as well as their level of awareness of the possible (reuses) of archival materials such as field notebooks. Similarly, if geologists are aware of these archived notebooks, do they (re)use them and if so, how? We also analyze the searching processes of those geologists who do (re)use field notebooks and discuss how best to foster such (re)use. Finally, we solicit geologists’ opinions on the long-term preservation of their artifacts and on the perceived roles and responsibilities played by archives and archivists. Overall, we seek not only to flesh out the processes followed by geologists as they search for and retrieve field notebooks qua archival materials, but also to develop theory on their information needs and skills.

The chapter begins by reviewing relevant literature on dark data and its reuse, on geologists, and on archiving. Second, it lays out the basic framework of Grounded Theory and suggests that the constructivist variant of Grounded Theory advocated by Kathy Charmaz is most appropriate for this case study. Third, it weaves together the theoretical insights of Grounded Theory with a specific delimited case study centered on geologists and archiving practices. Fourth, it documents the various stages of Grounded Theory and how these iterative and symbiotic stages relate specifically to our work with geologists and their field notebooks. Fifth, it presents
preliminary results from our work with geologists and ties those results to archival concepts. Finally, it engages the broader challenge of reflective theory development.

**Literature Review**

As scholars such as Jillian Wallis et al., Catherine Marshall, and Kalpana Shankar note, archivists usually receive scientists’ data only after their findings have been published or after the researcher retires.\(^6\) As a result, important information regarding the context, origins, and provenance of scientists’ records—in short, information imperative for future reuse—may be lost. Moreover, publications represent only “a distillation and stylized version of the processes by which the primary documents are created”; they are not the archival record per se.\(^7\)

Publication occurs semi-regularly and thus published documents cannot depict the ongoing practices implicated in the scientific endeavor. These documents also represent science in its most idealized linear form. As such, many other artifacts such as field notebooks are understudied. These personal scientific records exemplify what Bryan Heidorn calls “dark data” that remain sequestered in the “long tail” of science.\(^8\) Perhaps overgeneralizing, Shankar nonetheless underscores a vexing paradox: “these records which are of grave import to the research enterprise become ‘nothing’: They are created day after day, ‘written up’ in conference papers and posters, and ultimately shelved in countless laboratories, never to be consulted again.”\(^9\) Dark data, as Heidorn generalizes, accumulate because “no one is paying attention.”\(^10\)

Case study work allows archival researchers ipso facto to test such broad generalizations. The work of scholars such as Wallis and her colleagues, Marshall, Shankar, and Heidorn suggests an urgent need for scholars to address the “upstream” practices of natural scientists, especially this abundant dark data. The long tail of science serves as a “breeding ground” for new and innovative science, despite being often “less well planned, more poorly curated and less visible to other scientists.”\(^11\) Such information tends to be underutilized at best and lost at worst.

Researchers in archives have not yet tackled geologists’ recordkeeping practices, much less those that occur upstream. In the broader field of Library and Information Science, Julie Bichteler and Dederick Ward, Bichteler, and Lura Joseph among others, have addressed various aspects of geologists’ information-seeking practices.\(^12\) Similarly, with the notable exceptions of Karen Gracy and Paul Conway, archives scholars have not employed Grounded Theory as an analytical tool\(^13\). Still, Anne Gilliland and Sue McKemmish make an eloquent and persuasive case for adding Grounded Theory to archival scholars’ toolkits.\(^14\) To this point, then, the geological and archival literatures probing geologists have remained siloed. But they might profitably be brought together under the auspices of constructivist Grounded Theory, specifically to examine the archiving practices of geologists regarding field notebooks.

**Grounded Theory**

Developed by sociologists Barney Glaser and Anselm Strauss in the 1960s and codified in *The Discovery of Grounded Theory* (1967), Grounded Theory is a systematic and purposeful research method used both to gather data from the field and to develop theories directly from them.\(^15\) Based on their experiences with terminal hospital patients, Glaser and Strauss propagated Grounded Theory as a response to the positivist hegemony undergirding the social sciences in the mid-twentieth century. Positivism enshrined objectivity, neutrality, replicability, and
falsification as primary concerns of empirical research. Embodied by a purportedly objective observer, positivist methods strove to discern causal explanations, to extricate facts from values, and to make predictions about a world seen as external and knowable. Thus Glaser and Strauss both challenged the prevailing methodological consensus among scientists and delineated strategies for engaging in qualitative research. More specifically, their work combated longstanding arguments that qualitative methods remained impressionistic or unsystematic or both; that qualitative efforts represented mere preludes to quantitative strategies; that qualitative methods could not generate theory; that the stages of data collection and data analysis must remain discrete; and that the division between theory and research must be upheld.16

Despite their original collaboration, Glaser and Strauss ultimately differed over the conduct and significance of Grounded Theory. For example, Glaser added a distinction between substantive codes and theoretical codes as well as a distinction between open and selective coding. Conversely, by 1990 Strauss and Juliet Corbin had developed a purportedly “systematic” Grounded Theory that prescribed that the coding process center on axial coding (a position they subsequently dropped); finally, they created a “conditional matrix” to analyze conditions and consequences ranging from the immediate situational to the international.17 Moreover, students of Glaser or Strauss or both such as Kathy Charmaz (constructivist) and Adele Clarke (postmodernist) spearheaded a new generation of Grounded Theorists. Charmaz asserts that neither data nor theories may be discovered; rather, “We construct our grounded theories through our past and present involvements and interactions with people, perspectives, and research practices.”18 Meanwhile, Adele Clarke proposes “to supplement basic grounded theory with a situation-centered approach that in addition to studying action also explicitly includes the analysis of the full situation, including discourses—narrative, visual, and historical.”19 Each of these scholars has pushed Grounded Theory in new and productive ways.

At base, constructivist Grounded Theory “aspires to understand, and eventually generate theory from, participants’ perspectives and interpretations, from how they ‘construct’ their worlds.”20 It guides researchers in their direct data collection, their management of data analysis, and their development of a theoretical framework that explains the process being studied.21 Ultimately, Grounded Theory draws its substantive usefulness from addressing a delimited problem in a specific situation. Researchers in a variety of fields, from sociology to education, cultural studies to science, technology, and medicine studies, have relied upon Grounded Theory, albeit in diverse and not always complementary ways.

The research processes and stages involved in Grounded Theory indicate a general directional path but they overlap and may be repeated. The conduct of Grounded Theory research involves iteratively collecting, coding, and analyzing data and marshaling the information gathered to determine what data to collect next and where best to find it in order to develop a theory as it is emerging from the data.22 Potential data sources include surveys, observations, and case studies. Data may also comprise preexisting interviews, observations, videos, documents, drawings, diaries, memoirs, newspapers, biographies, historical documents, and autobiographies. These data, “detailed, focused, and full,” may push the researcher to reconsider her data collection methodology or to consider themes emerging from existing data or both.23 Thus Grounded Theory promotes both flexibility and focus through “thick” description.24 Ultimately, to place gathered data in context during grounded theory research, a researcher should start with concepts
that explain or promote sensemaking in the context of the study and conclude inductively by making theorized connections between what she sees in the data and the larger world she seeks to describe.25

This study’s use of Grounded Theory is necessarily an exercise in intellectual bricolage. Though it is rooted in the pioneering work of Glaser and Strauss, more specifically, it relies primarily upon the framework of Grounded Theory as propagated by Kathy Charmaz. Charmaz advocates a Grounded Theory perspective that focuses on individuals over methods, that respects diverse and complex local worlds and multiple realities, and that minimizes jargon and recondite diagrams and conceptual maps. Finally, Charmaz’s constructivist Grounded Theory embraces a strategy of active coding that reveals the researcher’s agency in bringing queries to the data, in making decisions about categories, and in accepting and reflecting upon the personal values and experiences she brings to her analysis.26

The Praxis of Grounded Theory

In this section, we refer to our study on field notebooks to exemplify the process of conducting Grounded Theory research. Upon starting such a study, a Grounded Theory researcher first posits a general subject or problem, perhaps but not necessarily framed loosely by a disciplinary perspective. In this case, one of the authors, Ramdeen, worked as a professional geologist before entering the field of Library and Information Science. As such, she brought to this study her own broad knowledge of the field of geology and her particular situated experience with both creating and using field notes. More specifically, this study gestated in a conversation. Knowing of Ramdeen’s work as a librarian and archivist, an academic geologist contacted her to ask whether she knew of an appropriate place to deposit field notebooks for long-term preservation upon a faculty member’s retirement. This geologist thought that field notebooks are quite valuable and typically searched for them via personal networking. In other words, he asked researchers in his domain directly to share their materials. But he expressed some confusion: where did such materials belong other than in a scholar’s personal collection?

Despite Ramdeen’s own intellectual and professional background, however, she had not considered the issue; in fact, she had assumed that such notebooks belonged in the archives or libraries in the faculty member’s home institution. Thus she felt unsure how best to advise him. Reflecting upon this conversation, we wondered whether any scholars had addressed this issue not from the point of view of the home organization, but rather from the perspective of the user—geologist. Indeed, the conversation engendered two important if overlooked questions that we returned to time and again: First, in what types of venues, archival or otherwise, should geologists’ field notebooks be archived? Second, what strategies do geologists employ to search for these items?

After discerning a general subject or problem, the researcher next ensures that Grounded Theory is the appropriate method for her purposes. Given the lack of scholarly work done on geologists’ archiving practices, Grounded Theory—specifically constructivist Grounded Theory—seemed ideal. This decision had important ramifications; as Kathy Charmaz notes, “How you collect data affects which phenomena you will see, how, where, and when you will view them, and what sense you will make of them” and we found this true indeed.27 Hewing to Grounded Theory, we
avoided theoretical preconceptions and relevant literature at the outset, thus ensuring we would not subsequently force our data to “fit.”

Having determined a general subject or problem and having verified the appropriateness of employing Grounded Theory, the researcher transitions into sampling. The sampling phase of Grounded Theory research revolves around collecting data that will yield interesting comparisons among the processes examined. Sample selection exerts a “profound” effect on the quality of the research.\(^{28}\) Theoretical sampling, more specifically, is “the process of data collection whereby the researcher simultaneously collects, codes, and analyzes the data in order to decide what data to collect next.”\(^ {29}\) She discerns any areas where more information is needed, for instance to help build or develop the theory, to fill in gaps in the dataset, or to resolve any ambiguities or inconsistencies. Sampling continues until the researcher has reached theoretical saturation, the point at which the researcher has collected enough data that similarities are seen over and over, and new data does not compel the development of new categories.\(^ {30}\) In sum, the researcher should abjure sampling decisions before her theory begins to emerge, should home in on new sites potentially useful for theoretical development, should choose sites for comparative purposes instead of for cases, and should aim for conceptual variation across various sites.\(^ {31}\)

Following these stipulations, we began our initial sampling process by contacting the researcher who first broached the subject with Ramdeen. He elaborated upon his process of searching for and using field notebooks. Better still, he referred us to other geologists who he thought would provide insight, thereby jumpstarting our sampling process. For instance, his referrals led us to an interview with a geologist stationed with the state government who had recently developed a process to capture field notes digitally, a phenomenon we had not considered.

Initial sampling persisted by way of personal contacts, snowball recruitment, and networking and informal conversations with professionals at the Geological Society of America’s annual meeting. Indeed, conference recruitment permitted us to meet researchers we otherwise would not have encountered. Two concerns persisted, however, as we proceeded with our initial sampling process. First, we agonized over how to circumscribe our sample population—or if we should do so at all. On the one hand, a researcher hopes data will prove flexible and help answer her research question(s). On the other, describing the studied group may be hindered if the population is too dynamic. In this vein, geology as a discipline comprises but one part of the larger field of Earth Sciences; thus scientists in this broader field often invest themselves in more than one domain. Our initial sample, more specifically, included two paleontologists. Similarly, in fleshing out our sampling process, we spoke to scholars outside of academia, namely geologists working in state or federal government or in the private sector, each of whom brought a different perspective on the process. Though we felt some trepidation about embracing such a diverse sample, we were pleased to find that every one of these geologists used field notebooks. What was more, they described their notebooks in similar language and used those notebooks for the same broad purposes, though personal habits and idiosyncrasies invariably emerged. In many areas we felt that we met the burden to achieve “saturation” in our data collection.

Second, we felt concern about possible gaps in the initial sampling population. For example, although we diligently sought out an academic geologist whose pedagogy includes field work methods, our schedules never jibed. Thus as sampling and analysis progressed, we wondered
how this lacuna might affect our analysis. Despite a researcher’s best efforts, then, some gaps in the data may well persist. Grounded Theory, however, accommodates such gaps.

In Grounded Theory, sampling exists in a reciprocal relationship with data collection. Data collection usually involves a combination of in-depth participant interviews and observations. A researcher should ferret out diverse data sources, begin collection with unstructured methods, facilitate dialogue between data and analysis, and refine her methods of observation as her theory emerges. She is “an active sense maker of what is seen or heard in the research context.” In other words, she seeks to discern truth but also engages in self-reflexivity. Finally, she should evaluate her data for its depth and its scope as well as for its suitability for capturing empirical events.

First, in-depth interviews provide the researcher both flexibility and purportedly increased analytic control over their material. As such, interviews may be unstructured and the questions the researcher poses may evolve. Such interviews are relatively lengthy; take place one-on-one and face-to-face; allow a greater expression of the interviewer’s self; and demonstrate the participants’ personal commitments to multiple interview sessions. Second, observations allow a researcher to accrue information about activities that participants may find difficult to describe. Body language and gestural cues may provide rich data. Third, sundry documents may be a useful source of rich data.

Our semi-structured interviewing strategy took root in a guiding set of broad questions that were refined iteratively over the course of the interview process. We posed these broad questions to the first set of geologists and subsequently determined areas either important to add because interviewees highlighted their importance or because they stood out when we reviewed our notes. But serendipity also played an important role. After one interview, for example, we realized that we had not asked a single one of our questions. Rather, the interviewee had addressed these questions (and a good deal more) as part of the flow of conversation.

Many of the participants consented to secondary interviews. These allowed for follow-up, clarification, and verification of statements. In one particularly striking—and serendipitous—case, the interviewee requested that one of our researchers meet with him in his office. As a result, he showed her documents and described geological field techniques not amenable to articulation over the phone. In sum, interviewees’ intellectual generosity was inveterately present. Furthermore, we selected an appropriate population and followed the prescriptions on interaction suggested by Charmaz in order to build trust.

On the other hand, we gathered data outside of our interviews. For example, one participant mailed us color scans of a field notebook he had recently used in a project. Reviewing the documents, one of our researchers recalled discussing the study with a faculty member not affiliated with the study. The professor had asked about the archival process for field notebooks: specifically, what preservation strategies might be needed, especially related to potential digitization of these artifacts. At the time, Poole thought these questions likely fell outside the scope of the project. Seeing the scanned selections from the notebooks, though, he reconsidered ultimately and he included this connection—the conversation and the questions it engendered—in his memo writing.
Even at this early point, moreover, the iterative nature of the process became evident. For example, we initially requested that participants speak about their own experiences in creating and maintaining field notebooks. Unfortunately, this topic yielded information that fell outside the scope of our research question. As such, we retrenched to some extent, instead querying researchers about their broad uses of field notebooks. Thus we found that Grounded Theory encourages this sort of interrogative evolution.

**Exemplary memo excerpt:**

> I wish I had asked the subject to clarify what he considered to be included in the greater concept of a field notebook—one thing that came up as a separate but associated artifact was a printed map that accompanied the notebook when in the field. This has details and notes written on it at stations and locations beyond those included in the notebook. But is it usually stored separately? Should it be considered a different document?

Proceeding in tandem with sampling and data collection, memo writing constitutes a key part of Grounded Theory work. It frees the researcher “to theoretically develop ideas (codes), with complete freedom into a memo fund, that is highly sortable.”\(^{37}\) Whether paragraphs or pages, memos “cumulatively develop the core of the emerging theory”; as such, they contain the “logic of analysis” in the categories, properties, and exploration of their interrelationships.\(^{38}\) Memos allow the researcher to “define the properties of each category; specify conditions under which each category develops, is maintained, and changes; and note the consequences of each category and its relationship with other categories.”\(^{39}\) They proved invaluable throughout the Grounded Theory process; more pointedly, memos are funneled into the process of concept development, a process addressed below.

During the data collection process, a researcher continually writes memos as a core aspect of her iterative analysis. This analysis in turn influences the data sampling process. Before conducting our interviews, therefore, we had already captured data through memo writing. In particular, Ramdeen reflected on the conversation that had first piqued our interest in the topic of archiving geological artifacts such as field notebooks. Further, she ruminated over her own (rather limited) knowledge of field notebooks. The ideas that these reflections engendered influenced our decisions both in the sampling process and in question development. Complementing this pre-interview memoing, we wrote memos both on our formal interviews and on our casual conversations. Through these outlets we tested ideas and made holistic connections that we might otherwise have overlooked had we kept each segment of data siloed.

**Exemplary memo excerpt:**

> My third participant emphasized the importance of historical field notebooks (notebooks from the late 1800s and early 1900s) as part of his search process. What connections can I make between his search strategy and the search processes outlined by my other geologists? Are other geologists aware of this possibility for use or reuse? Do they avoid archives because they believe archives would not have field notebooks or do geologists simply not value older notebooks?
Finally, we maintained notes during the interview process and subsequently used them in our reflective memo writing. Similarly, during and after each conversation as well as during the transcription process we wrote memos encapsulating our thoughts and reactions. We transcribed interviews by listening to the recordings at half speed and typing out precisely what was said. Transcription funneled into coding as we processed the individual interviews and determined next steps for sampling.

Perhaps the most important stage of Grounded Theory, coding, involves “naming segments of data with a label that simultaneously categorizes, summarizes, and accounts for each piece of data.”40 It “distills data, sorts them, and gives us a handle for making comparisons with other segments of data.”41 An emergent process, coding represents a “pivotal link” between collecting data and developing emergent theory to explicate it.42 Codes emerge from the language, meanings, and perspectives of the researcher and her participants; as a result, it facilitates examination of hidden assumptions in the language of the researcher or her participants or both. Overall, coding involves Glaser and Strauss’s notion of “constant comparison,” an ongoing process of juxtaposing new and old data and reassessing codes and focused concepts derived from those codes.43 As Charmaz concludes, “coding and recoding not only leads you in new directions but also directly to theoretical sampling of your new categories as well.”44

Various Grounded Theory researchers have adduced four classes of coding: initial, focused, axial1, and theoretical. During initial coding, the researcher scrutinizes fragments of data, e.g., words, lines, or segments, through a close reading of the data while remaining open to all possible theoretical avenues. This process helps the researcher to discern any gaps in the data early on in the process. Initial coding should be done with speed and spontaneity in order to keep a fresh perspective: some codes will fit while others will need refinement.45

Some researchers favor coding programs such as NVivo or ATLAS.ti, yet coding by hand using Excel better suited this research team. While these tools offer advanced options for coding process, they can be difficult to manage for the uninitiated research team. Software programs engender concerns over hamstringing the analysis and settling for superficiality as well as demanding qualitative analysis be shoehorned into a single method. More importantly, hand coding allowed us more flexibility in how we sorted and reorganized the codes as we moved into the conceptualizing and theorizing phases. During initial coding we reviewed the data line-by-line, identifying the process or topic represented in the data. We avoided undue specificity during this process as these codes represented ideas that would lead to categories later during focused coding. During the initial coding, perhaps reflecting our lack of experience with Grounded Theory, one of our researchers found herself giving a line of text more than one code. All the same, we endeavored to capture our impressions of the data and their implications without overanalyzing our thoughts. In the initial process, we reused codes occasionally, but overall we abjured preconceived standards for coding the text. Coding terms included “drawings and text,” “interpretations of what seeing,” “problems with personal shorthand,” “not taught how to search,” “spatial searching,” “older generation more knowledgeable of searching,” and

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1 In axial coding, the researcher pinpoints one open coding category on which to focus (the “core”) and then returns to data to construct categories that pivot around this “core.” We found this approach unduly constricting and chose not to engage in it.
“weighing the value against crunch time.” In developing these codes we followed Charmaz exhortation to “Pursue telling terms.”

In the most specific variety of initial coding, line-by-line, the researcher simply names each line, an approach that “works particularly well with detailed data about fundamental empirical problems or processes whether these data consists of interviews, observations, documents, or ethnographies and autobiographies.” The researcher breaks data into its components, pinpoints the actions upon which they rest, looks for tacit assumptions, unpacks implicit actions and meanings, compares data, discerns any gaps in the data, and ponders the larger significance of points. Through line-by-line coding, ultimately, the researcher teases out implicit concerns and focuses on the nuances of language. Line-by-line coding helps her to refocus her subsequent interviews.

Next, we leveraged initial codes to help identify gaps in the data we had collected. We also elicited categories that we hoped to explore further in future sampling. For instance, one interviewee mentioned the Field Records Collection of the United States Geological Survey (USGS) (<http://www.cr.usgs.gov/fieldrecords/>). The USGS system provides users with the ability to search by keyword(s), but its finding aids fail to offer basic functionalities such as searching by geographical region or by geological terms. Struck by this interviewee’s knowledge of and engagement with an archival affordance as fundamental as a finding aid—though he did not know exactly what a “finding aid” was—we wondered how many geologists might know about finding aids. Even in the case above, the interviewee requested information on finding aids in order to create one for himself, not because he thought external archives or archivists might be helpful allies, a most useful as well as serendipitous piece of information for us as researchers. Similarly, in the case of those geologists who were aware of the existence of finding aids, we wondered how useful they had found them to be. Thus this initial coding work helped us to develop a category and subsequently to refine it over the course of our other interviews.

More directed, selective, and conceptual than initial coding, focused coding represents a move toward synthesis. Focused coding permits the researcher to “sift” through her most frequently emerging initial codes and to revisit their effectiveness. In other words, comparing data with data provides the analytical foundation for focused codes; the researcher then compares her data to her emerging codes and refines them further. Finally, theoretical coding follows focused coding. It allows the researcher to clarify possible relationships among categories developed in focused coding: theoretical codes are integrative and provide form to focused codes. At best, theoretical codes add precision, clarity and cogency.

Following Charmaz, after the initial coding of each interview, we created a secondary worksheet in which we first sorted the codes and then developed theoretical codes. At this point, we began to identify relationships suggested by the codes. These relationships included groupings such as “examples of use of field notebooks,” “expressions of value,” “search process,” and “barriers.” For each of these theoretical codes we also created descriptions. For instance, we described “barriers” as “Examples or comments about the barriers to access or other problems encountered while using, searching or managing field notebooks – includes duplicates from searching. Not all barriers are related to searching, some are about management/preservation.”
During the coding process, we continually wrote memos. Corbin and Strauss describe three types of memos that occur during this stage: code memos, theoretical memos, and operational or procedural memos. Code memos describe and detail codes and their underpinning assumptions. Theoretical memos suggest ideas about codes and their (inter)relationships. Finally, operational or procedural memos deal with the methodological aspect of the project and thus with the entire procedure of the study.

First, we created memos to reflect on our initial codes, pausing intermittently to reflect on what the data represented. We used theoretical memos to describe relationships: we thought about why certain codes should be grouped together and more important, what those groupings represented. We also wrote memos about codes that did not seem to “fit” neatly into a single category (for example, “reaction to error processing”) or codes that seemed effective outliers.

Procedural memos lent themselves to capturing the details of our research process. We periodically revisited these memos to refresh our memory and to reflect on the steps we had taken (and their sequence). These memos facilitated the coding process: never did we need to recreate our research process from memory. This saved time and effort which proved particularly useful as our codebook evolved into a far larger document over the course of our analysis.

Despite a researcher’s conscientiousness, problems may crop up in her coding. For instance, a researcher might code at an overly general level, neglect to identify actions and processes in favor of topics, overlook the specific ways persons construct their actions and processes, foreground personal or disciplinary instead of participants’ concerns, code out of context, or use codes to summarize rather than to analyze. As a self-checking mechanism, the researcher should consider four questions: How does her coding reflect the incident or described experience? Do her analytic constructions begin at this point? Has she forged clear connections between data and codes? Has she refrained from translating language into academese?

Varying in their degree of abstraction, categories and properties emerge from the data during the coding process. In all likelihood they emerge initially at a low level of abstraction; over the course of the process, however, they become increasingly abstract and allow integrating concepts to emerge. As Charmaz notes, “the properties of the category remain implicit until theoretical sampling and interpretive rendering make them explicit.” In Grounded Theory, categories channel into the development of concepts and concepts in turn channel into the development of theory. “We choose to raise certain categories to concepts because of their theoretical reach, incisiveness, generic power, and relation to other categories.” Elevating categories to concepts involves further analytic refinement and delineating their relationships to other concepts.

Concepts are the base of theories but they must be connected and supported by the memos and other data collected and finally refined into a theory. Concepts generated for theory development should be of two types: analytic (“sufficiently generalized to designate characteristics of concrete entities, not the entries themselves”) and sensitizing (“yield[ing] a meaningful picture, abetted by apt illustrations that enable one to grasp the reference in terms of one’s own experiences”). For the constructivist grounded theorist, these concepts should represent the data as opposed to “discovering order within the data.” These concepts, underpinned by the accumulation of interrelated categories and properties, ultimately funnel into
hypothesis development and in the end, a theoretical framework will emerge. In the development of theory, moreover, concepts should apply to all cases in a generalized way; they should characterize the data gathered and not be examples of the data themselves. But this development must be balanced with theoretical “saturation.” In other words, categories must be saturated (i.e. further sampling yields no additional data) before theory development is broached. Corbin and Strauss advocate selecting a “core category” that represents the main theme of the research. This core category should be abstract, indicated by all or most of the cases, and not forced; it also should expand as relationships to other categories are examined. For example, we found the concept of barriers—barriers that hinder the discovery of field notebooks by potential users—sufficiently broad to capture the statements made by participants as they recounted their search experiences. This potential core concept relates to numerous other developing categories, including geologists’ search skills, the archival processes necessary to manage these materials, and geologists’ opinions on the ways in which these materials are or should be managed.

Developing our study, we confronted challenges, concerns, and even outright limitations. In our initial coding work, for example, we were concerned about both being too general and overlooking a major category or conversely, being too specific and premising undue granularity in our coding. We also worried that Ramdeen’s knowledge of geology and mapping processes influenced our processing of comments. Third, we tried diligently to eschew any preexisting categories for imposing order on the data; rather, we developed our ideas from the data, again in line with Charmaz. Finally, we worried about achieving a sufficiently abstract level of conceptualization when working at theory formation.

Concluding a study predicated upon Grounded Theory is challenging indeed. That said, certain heuristics may be invoked. For example, a researcher may conclude data collection when those data fail to produce further conceptual variation (theoretical saturation), when she pinpoints a core category or particular narrative for study, when she completes integrating analysis into her narrative, when she finishes using memos and coded data to amplify or to modify her resulting analysis, or when she believes a satisfactory theory has emerged.60

Perhaps inevitably, we struggled to learn how and when to stop coding data. The open-endedness of Grounded Theory in this vein can be vexing: how much time and resources must (or indeed, can) be invested to ensure a “finished” Grounded Theory? As we passed through the initial sampling and data collection, for instance, several questions remained. During the coding process some text received the code “older generation more knowledgeable of searching.” Thus we wondered whether to include the age range or years of academic or professional experience of our participants. Indeed, the sample set did not include geologists nearing retirement or those who had recently retired. We realize, though, that a consideration of generational change might usefully capture geologists’ opinions on the digital search process and even on the digitization of field notebooks.

Exemplary memo excerpt:

[Digitization] is still an area of the study that has not been fully explored. It was a question raised by participants and they think it’s important. Should we ask about the
search process before databases? Might older participants have had experience with archives or archiving? Where did these geologists deposit their field notebooks when they retired or where do they plan to (if they do in fact plan)? If they intend to retain them, what is their long term plan (if any)?

Selected Findings: Developing Theory and Telling Stories with Data

The archive’s relationship to field notebooks was a major concept that coalesced from our iterative efforts. Geologists use field notebooks for diverse reasons. Field notebooks and their contents constitute not only “data,” but also historical documents. They may represent the only written record that “transforms” a rock into scientific data: without location information or metadata, after all, rocks are just rocks.

Some scientific data invariably become “lost,” as scholars such as Shankar and Heidorn point out. Some of our participants alluded to such losses, citing failed searches or barriers to searching or access or both. On the other hand, we discerned a number of examples of discovery and use of scientific data sets that demonstrates their value and these findings buttress the need for additional curation activities. Several participants identified curation needs or overarching policies that would improve their ability to retrieve these items, for instance employing new technologies or setting priorities for archiving dark data sets.

But in addressing existing or potential archiving practices, our participants never reached consensus. Most broadly, many geologists differ over optimal disciplinary communication practices. Participants showed considerable uncertainty over a range of basic archiving issues: whether field notebooks constituted archival documents, whether these artifacts belonged in archives, and if they do belong in archives, where and when they should be deposited.

Nearly all of our participants, instead of relying upon archivists and archives, depended upon personal networks in every stage of their research processes. These personal networks prevailed instead of formalized search processes—perhaps not surprising given the socialization process that transpires among these scientists during their education and early career training. Even when the researcher lacked a direct personal connection, her tacit knowledge of the history of the field of geology was crucial in locating field notebooks. Still, personal networks confront limits as well. One participant, for example, spoke about his experience with a scholar visiting from another region. This scholar unsurprisingly lacked the same knowledge of local geologists and their practices as our interviewee and thus struggled to find relevant materials.

Exemplary participant quotation:

“For what we are doing, typically our field areas are based on geographical location. Whether it is a county, you know you’re working on a geological map of a certain county. … [I]t is always latitude-longitude bounded.”

Notwithstanding their heavy reliance upon personal networks, geologists expressed numerous opinions on the affordances they desired to see as part of a standard search interface. But no such
search mechanisms—digital or analog—seem currently to exist. The lack of such affordances stems from two as yet unsolved problems. First, most organizations do not have policies or have not set priorities that address the massive investment of resources necessary to give these scientists the formal searchable system they desire. Second, scientists rarely if ever have the archival skills necessary to deal with their field notebooks, even if they know precisely what they want to do with them. Finally, current finding aids are generally ill-suited for scientific research. Instead they foreground historical information and are based on the name(s) of the scientist(s) who wrote them. This is less than ideal for locating and using scientific collections. Participants desired the ability to search by geographic location and by geological term(s). The familiar question reemerges: what are the roles and responsibilities of archives and archivists in this situation?

Exemplary participant quotation:

[In reference to temporary identification numbers assigned to samples gather in the field.]
“Those numbers, field numbers ... some people around the country had used those and I learned [in the] last couple years that they have actually published on those, on the basis of field numbers instead of requesting that we did give it a catalogue number. So that cost quite a bit of a furor realizing that they were as irresponsible as that, so we've got to coordinate with what has been published ...[as] they used a different numbering system. That will be a special project that will take quite some time but again, we couldn’t do that without X’s field notebooks.”

Our participants evinced mixed feelings about archives and archivists. One eschewed the notion of storing field notebooks in an archive, instead insisting that field notebooks should not be separated from their data sets (i.e., the rock and fossil collections they describe). After all, these notebooks contain raw data and valuable metadata pertaining to the physical samples. But the narrative and historical value of these works militates against such a strategy. Indeed, field notebooks created by geologists in the early United States possess historical information valuable far beyond the domain of geology. Should such field notebooks be deposited in an archive in order to facilitate scholarly discovery by historians and scientists alike? In a digital age, it need not be an either/or situation and conversations in this vein must occur among various stakeholders.

Exemplary participant quotation:

“I just opened the drawer and looked down and thought my god, there’re the notes of [X] and [Y] and [Z], these were things from the 1800s and early 1900s that nobody knew they were there. He had inherited them from other people and obviously someone known they were there originally. ... They hadn’t been seen in over a generation for sure.”

On the other hand, one participant spoke of a set of field notebooks deposited in an archive that were “lost” for generations. In fact, the notebooks disappeared only because nobody thought to look for them (or perhaps knew how); they were “rediscovered” by happenstance. Also complicating efforts to track notebooks, although they continue with the same specialty,
geologists often work for more than one organization during their careers. Thus tracking artifacts such as field notebooks becomes even more daunting, if not prohibitive.

**Exemplary participant quotation:**

The notebooks are in “different places - some of them in the Smithsonian, some of it here, some of it’s in his university town. Some of its with family, so there’s another problem for grasping at historical sense of where’s the body of work is, it’s all over the place. ... [E]very now and then I get a letter from [X] – eureka we made another discovery and now I know what he did from 1922 to 1928 or something like that, missing periods of time gets filled in with little discover moments.”

By dint of their education and socialization into given communities of practice, geologists think in a certain way about their artifacts and how to preserve them. Archivists, by contrast, hail from a quite different process of education and socialization and think in their own way about artifacts and how best to archive them. These patterns of thought may not—are likely not—to match. A starting point for productive dialogue thus presents itself: how can archivists think like geologists and create tools (particularly finding aids) that mimic the processes by which geologists search for and use a specific form of information, the field notebook. Overall, geologists perhaps unwittingly talk in very similar ways if not always in the same actual language about their needs in the archiving process. Even so, they have been unable to bridge the fields of geology and archives to realize their commonalities—as researchers, propitiously, we did so.

These areas represent only the beginning of the rich rewards Grounded Theory confers on the researcher. More areas surely remain yet to be explored fully; we anticipate bolstering our findings as we iteratively employ the method to talk to more geologists and to integrate new information to our extant observations. Similarly, we shall continue to demonstrate to the geological community the efficacy of Grounded Theory and perhaps more importantly, the partnerships and services the geological and archival communities can offer each other.

Currently, we continue to engage in coding data, but in line with Charmaz’s approach to constructivist Grounded Theory, we have also made the transition into theory development. In particular, we began with the concepts developed in the theoretical coding process and through writing, discussing, and reviewing the data have moved to explore where the data, the codes, and our reflections will direct us. Our efforts coalesced into a document in which we examined relationships emerging among these concepts and wrote in free form what these relationships suggest on a higher, more refined, level. We sought to explain what we were seeing and at the same time we deliberated iteratively over potential underlying causes. Some ideas may push us to collect additional data to address questions raised or refined by the processes we analyzed. Thus we may revisit early participants or engage new ones. For example, we might need to probe related domains beyond those about which we have data (paleontologists and geologists conducting mapping research). How different are their archiving needs from those of scientists in cognate domains? In the end, our Grounded Theory process remains, as it should, open-ended and embracing diversity and multiplicity.
But to meet the daunting challenges underscored in this study, geologists and archivists must learn more about each other and then collaborate to improve the accessibility of field notebooks, namely by exploring both informal and formal ways that geologists search for information. Archival scholars may be well-suited for the task, having accrued nearly three decades of literature on archival users and use. More specifically, these scholars and practicing archivists must educate geologists on basic archival principles endemic to the quotidian needs of academic and professional geologists. This information may be leveraged to create teaching tools; traditionally, archival principles and practices are not taught to geologists (and vice versa). Thus collaborative learning and collaborative creation of finding aids may be the best solution to this impasse. For their part, archivists must focus not only on artifacts birthed by digital technologies (the future may see born-digital field notebooks, for instance), but also on so-called “traditional” materials such as handwritten field notebooks. These notebooks contain evidence whose evidential value must not be squandered.

**Exemplary participant quotation:**

“I would keep any of the geo, any of the paleontology notebooks I came upon because I don’t want to put myself in a judgmental position ... that is a lot of responsibility to say this is not good enough or not enough data. ... It’s just too much responsibility.”

In general archival scholars and geologists must focus more broadly on moving archival processes upstream. First, they must focus on explaining to geologists the vital importance of appraisal and of establishing and retaining intellectual and physical control of geological materials such as field notebooks. Similarly, geologists must learn about standard practices of arrangement and description, access and availability. Third, archivists must imbue geologists as both creators and users of archives with an appreciation of the role of original order, respect des fonds, and provenance and in turn, how these principles ensure the trustworthiness and authenticity of a notebook’s content. Fourth, working together archivists and geologists must determine that enough and appropriate context remains available to all users and reusers. Finally, archivists must engage in more concentrated outreach toward the geological community. More specifically, archivists and geologists must sell the importance of their respective professional work to each other. Only with a cross-pollination of archival and geological knowledge can geologists and historians optimize the use and reuse of such valuable evidential artifacts as field notebooks.

**Reflective Theory Development**

Over the course of more than four decades, Grounded Theory has become a “hotly contested” methodology. As Ian Dey observes, “There is an irony—perhaps a paradox—here: that a methodology that is based on ‘interpretation’ should itself prove so hard to interpret.” Researchers continue to differ over proper execution of Grounded Theory methods as well as what constitutes “finished” Grounded Theory. J.W. Creswell insists that conclusions reached through Grounded Theory remain only “suggestive, incomplete, and inconclusive.”

According to Jaccard and Jacoby, theories “are essentially conceptual systems designed to be useful in identifying, organizing, and…explaining or predicting some defined portion of the
Positivist theory represents “a statement of relationships between abstract concepts that cover a wide range of empirical observations”; it “seeks causes, favors deterministic explanations, and emphasizes generality and universality.”65 Positivist theory also lends itself to an objectivist perspective. Objectivism minimizes the importance of the social context that envelops the data, the researcher’s influence, and the quotidian interactions between the researcher and her participant(s). Comfortable with her own authority and objectivity, the researcher “becomes more of a conduit for the research process rather than a creator of it.”66

On the other hand, interpretive theory presupposes “emergent, multiple realities; indeterminacy; facts and values as inextricably linked; truth as provisional; and social life as processual.”67 Its goals include conceptualizing the given phenomenon to render it comprehensible abstractly, propagating theoretical claims vis-à-vis scope, depth, power, and relevance, recognizing one’s subjectivity in theorizing, and putting forth an imaginative interpretation. Self-characterized as “unabashedly interpretive,” Charmaz deems theorizing a practice and argues that interpretive theorizing allows a researcher to transcend the individual and micro levels.68

A social constructivist perspective flows naturally from interpretive theory. It pivots around a reflexive approach toward both processes and products. Constructivism maintains that reality—and thus meaning—is a construction of the human mind rooted in a particular time and place; thus “reality” changes along with its social context.70 Charmaz argues that constructivist Grounded Theory “places priority on the phenomena of study and sees both data and analysis as created from shared experiences and relationships with participants and other sources of data.”71 Constructivist Grounded Theory reveals differences among persons and thus uncovers hierarchies of power and communication that otherwise might remain implicit. But even constructivist Grounded Theory is no panacea in qualitative research: in the end, “Theory generation continues to be the unfilled promise and potential of grounded theory.”72

Nonetheless, Grounded Theory offers no mean return on investment. The lengthy and arduous process and the concomitant iterative interrogation of the data imbues the researcher with more confidence in her results, especially when she juxtaposes Grounded Theory with less rigorous methods such as conducting only a survey or only a series of interviews. Grounded Theory can bolster a constructivist study’s credibility, resonance, originality, and usefulness. More specifically, the sampling process in Grounded Theory ipso facto ensures flexibility. In other words, no longer must a researcher close a study prematurely for intellectual reasons. Conversely, Grounded Theory demands many resources; to say the least, it requires a researcher to balance planning and creative work.

The difficulty of maintaining such a balance perhaps culminates even before developing theory. Bluntly put, the coding process is the most difficult—even agonizing—part of Grounded Theory. The researcher immerses herself in the data with but the vaguest of notions of what might come of her work. Ideally, the iterative process of Grounded Theory work helps the researcher to find common threads in her interviews and observations. But as Kathy Charmaz reminds us, “The more unproblematic—that is, routine, familiar, and ordinary—observed events seem to you, the more problematic creating an original conceptual analysis of them will be.”73 Geologists and archivists both guard against insignificant results, whether contradictory or confirmatory. However, confusion and indeed failure may be as instructive as significant confirmation,
especially in mid-range theory-building. As such, Grounded Theory represents an analytical tool not to be neglected. In this case, its use serves geologists and archivists both.

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