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Special Issue

Off the Beaten Path? Frédéric Cailliaud's Bureaucratic Practice of Geological Fieldwork in the Lower Loire, 1836–1869

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Frédéric Cailliaud ran the Natural History Museum of Nantes from 1836 to 1869. An explorer, Egyptologist, geologist, and public political figure, Cailliaud's profile resists any attempt at categorization, yet a common denominator of his activities is the production of knowledge about nature. As an employee of the Nantes municipality, Cailliaud's activities, especially fieldwork, intersected with administrative demands. This did not make him the puppet of standardizing bureaucratic forces. Rather, the term bureaucracy is used in this article as an epistemic category to reassess the role of instrumental changes in scientific knowledge production as it was increasingly integrated into public administration.

Focusing on Cailliaud's papers (notes, manuscripts, publications) and the place of fieldwork in them, this article seeks to cast light on the material and relational dimensions of knowledge production in a nineteenth-century provincial museum. In doing so, I seek to reassess the place of bureaucratic work in the production of geological knowledge and argue that the field and the office were not "separate worlds." Instead, the exploration of their entanglements complexifies our understanding of knowledge production in the nineteenth century.

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Moles were "the geologist's best ally,"[1] Frédéric Cailliaud (1787–1869) once wrote. As the director of the Nantes Natural History Museum from 1836 to 1869 and a specialist of the local subsoil, Cailliaud seemed very appreciative of the contribution of these mammals. As burrowing animals, moles facilitated field geologists in observing what lay hidden below the surface. Cailliaud's comment, made in one of his manuscripts, gives us a glimpse into his negotiated encounter with natural elements as it appears in written form. Focusing on Cailliaud's writings to reassess the place of bureaucratic work in the production of geological knowledge, I will argue that the field and the office were not "separate worlds."[2] Instead, the exploration of their entanglements complexifies our understanding of knowledge production in the nineteenth century.

In the wake of Robert Kohler's influential work on field sciences, of John Pickstone or Christian Jacob's material approach to the history of science, nourished with critical studies such as Donna Haraway's "situated knowledges," this wide historiographical range has contributed to making matters of collecting and field experience crucial to historians of natural history in their effort to situate knowledge production about nature.[3] Emphasis on the material challenges and outcomes of field collecting has illuminated

[1] MHNN, 2R842, "Recherches géologiques et conchyliologiques dans le département de la Loire-Inférieure" [mss], unpaginated.
[2] Kohler, *Inside Science*.
[3] Haraway, "Situated Knowledges"; Kohler, *Landscapes & labscapes*; Pickstone, *Ways of Knowing*; Jacob, *Lieux de savoir*; Kohler, "Finders, Keepers."

how knowledge of nature was never limited to the product of intellectual work carried out in natural history cabinets, but largely hinged on negotiated operations conducted outdoors. By reversing the view of the field as an open space abound in encounters with nature, histories of naturalist travels, fieldwork instrumentation, specimen transportation, and conflicts with indigenous populations have revealed the complexity of the social interrelations and power relationships that constitute the field.[4]

The material turn in studies of natural history has, successfully and quite rightly, renewed the history of knowledge about colonial nature, that is, in areas represented as distant from European spaces.[5] For the moment, however, the classic history of subsoil knowledge in the provincial spaces in Europe is still confused for a metonymy of national narratives and has only been marginally reexamined.[6] The provincial space was important for the mining services and geological surveys in the nineteenth century. Rather than the geographical periphery of a country or the fringes of a capital city, the provinces were conceived, politically and scientifically, as resource areas for both the territorial construction of the state and for extractive projects and economic development.[7]

Historians of geology, beginning with Mott Greene, Roy Porter, Martin Rudwick, or Jim Secord, have strongly emphasized the role of fieldwork in shaping the discipline.[8] In terms of geological theorization, on-site exploration and the simultaneous development of stratigraphy spurred a deep reading of historical time, indexed on the history of the earth.[9] In terms of practice, because of geology's connections with public and private enterprises, geological surveys provide key insights into the nineteenth-century study of the subsoil.[10] These historiographical trends have, however, often approached geology as a well-defined scientific discipline, performed by a cohort of professionals, be it engineers or museum workers, who operated "hammer in hand" in the field.[11] As they evolved in what was often characterized as "state science," these earth specialists were seen to be struggling with contradictory impulses; the administrative norms of the science-blind state apparatus, and the aspiration to produce scientific findings on the other. Within this narrative, fieldwork appeared as a space of scientific freedom, away from office-produced guidelines.[12]

New examination of the traditional field vs. office divide is necessary to shed light on the meaning of "the field"; rather than simply an outdoor plot of land under study, I argue that the field is better described as a space that was recomposed on the museum director's desk. Following Dorinda Outram's study of the very Parisian figure of Cuvier and how his position at the Paris National Museum of Natural History redefined spaces of naturalist practice, Frédéric Cailliaud's archives offer rare and original insights precisely into the work of a provincial museum director and investigator of the local subsoil.[13] Cailliaud devoted much of his time to the mineralogy and geology of the *Loire-Inférieure département* (hereafter, Lower Loire). His numerous manuscripts, which are central to this study, were mostly recorded as his "scientific papers." They consist of several boxes of correspondence, manuscripts, and collection catalogues.[14] Concerning the study of the subsoil, one group of papers stands out; the unpublished manuscripts of "Études géologiques et paléontologiques dans le département de la Loire-Inférieure" and "Recherches géologiques et conchyliologiques" alongside dozens of related notes and paper slips.[15] This body of sources is complemented by institutional archives produced by Cailliaud.[16] Often overshadowed by the collected samples and published geological maps, these papers illuminates fieldwork as an everyday concern.

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[4] A sample of the now abundant historiography can be found in Curry et al., *Worlds of Natural History*. For the Francophone space, see Bourguet et al., *L'invention scientifique de la Méditerranée*; Juhé-Beaulaton and Leblan, *Le spécimen et le collecteur*. The topic of field collecting is further discussed in Dubald and Madruga, "Introduction. Situated Nature."

[5] On geology, see in particular Chakrabarti, *Inscriptions of Nature*.

[6] On "national metonymies," see White, "The Nationalization of Nature." Some recent studies on science at the margins include Dubald, "Capital Nature"; Lukić, "Serious Scholars"; Anthony, "Introduction."

[7] Troch, "Ne pas grever l'avenir."

[8] Porter, *The Making of Geology*; Secord, "Geological Survey of Great Britain"; Secord, *Controversy in Victorian Geology*; Greene, *Geology in the Nineteenth Century*; Rudwick, "Geological Travel and Theoretical Innovation."

[9] Gohau, *Histoire de la géologie*; Rudwick, *Bursting the Limits of Time*; Rudwick, *Earth's Deep History*.

[10] Laboulais, *La Maison des Mines*.

[11] ADLA, 1568S/1, Lorieux to the Prefect of Lower Loire, [1837].

[12] Laboulais, "Serving Science and the State."

[13] Outram, "New Spaces."

[14] MHNN, Fonds Frédéric Cailliaud.

[15] MHNN, 2R842, "Études géologiques et paléontologiques dans le département de la Loire-Inférieure" [mss]; "Recherches (…)," op.cit.

[16] AMN, 2R565.

Despite the growing institutionalization of museums in nineteenth-century France[17], there were no established guidelines regulating the missions and duties of museum directors. In fact, the profiles of this 1800–1870 generation of men in charge of natural history museum collections were quite diverse, as Cailliaud exemplifies.[18] Born to a Nantes family of master craftsmen, he was certainly trained in goldsmithery and gemology. He also presumably attended the public mineralogy courses offered at the Paris Natural History Museum.[19] He later joined several expeditions to Egypt between 1817 and 1823, from which he gained momentary fame and recognition.[20] Back in Nantes, he became the assistant to his predecessor, François Dubuisson (1761–1836). Cailliaud was officially appointed director in 1836. A member of the city's notabilities, Cailliaud was a member of learned societies of the Lower Loire, the Academic Society and Archeological Society, and served as city councilor towards the end of his life.

Cailliaud's profile resists any attempt at categorization. An explorer, Egyptologist, geologist, and public political figure, a common denominator of his activities is the production of knowledge about nature in various ways. From 1826 until his death, his practice was sustained by his position at the museum. In this context, the museum directorship was a breadwinning activity (from 1836 onwards) giving him a place of work distinct from his own home and making him a municipal agent *avant la lettre*.

Cailliaud's activities, especially his fieldwork, intersected with administrative demands. This did not make him the puppet of standardizing bureaucratic forces. Rather, the term bureaucracy is used in this article as an epistemic category to reassess the role of instrumental changes in scientific knowledge production as it was increasingly integrated into public administration.[21] Focusing on Cailliaud's papers and the place of fieldwork in them, this article seeks to cast light on the material and relational dimensions of knowledge production about subterranean nature in a nineteenth-century provincial museum.

The Administration of Fieldwork

Cailliaud's outdoor research and collecting was conducted within a normative framework attested by his production of administrative documents. The specific nature of these documents lies within their justificatory and obligatory value in support of the public administration, typically the Nantes municipality and occasionally the Lower Loire *préfecture*.[22] The ensuing statements of expenditure, annual budgets, and receipts substantiate how Cailliaud's fieldwork was largely planned and designed through a bureaucratic culture of using paper technologies within the office space provided by the state administration.

As an employee of the Nantes municipal administration, Cailliaud was expected to provide annual reports of his activities. Within these, the yearly statements of expenses and budgetary provisions attest, from 1836 to 1864, relatively stable outdoor activities which received supplementary financial support on three occasions. Whereas an annual operating budget was provided for museum maintenance and some acquisitions, the fieldwork expenses ranged from 100 to 400 francs of the overall 800-franc budget.[23] Cailliaud also received a monthly salary of 1,000 francs in 1852[24], enabling him to cover his traveling expenses, which were otherwise only partially reimbursed. In 1851 and 1852, a supplementary subsidy of 300 francs was granted by the Lower Loire *préfecture*; and in 1862, that subsidy was increased to 600 francs "for the completion of the geological map."[25] These three occurrences are the only clear mentions of the *préfecture*'s specific funding of the geological study of the Lower Loire, although Cailliaud had worked on it well before 1851 and later in 1863 and 1864.[26]

The drawing up of the annual budget was supported by requests for continued credits that document the administrative context surrounding museum-led fieldwork. The 1844 issue is typical of this annual practice (Figure 1).[27] Although handwritten on plain paper without a letterhead, the request followed a formalized

[17] Pomian, *Le musée*; Poulot, *Des musées de France*.
[18] Dubald, "Capital Nature," 105–19.
[19] Rétif, "Les cartes géologiques," 82.
[20] Cailliaud, *Voyage à Méroé*; Mainterot, *Aux origines de l'égyptologie*.
[21] Felten and von Oertzen, "Bureaucracy as Knowledge"; Gardey, *Écrire, calculer, classer*.
[22] *Préfectures* were overseen by prefects (*préfets*). They were tasked with the administration of *départements*, the key territorial division of the French state.
[23] AMN, 2R565.
[24] Ibid., 23 June 1852.
[25] AMN, 2R565, Statement of Expenses in 1851 and Budgetary Proposal for 1853, 23 June 1852; State of Expenses in 1860, [1861].
[26] AMN, 2R565, Statement of Expenses, 20 December 1862; Statement of Expenses in 1863, August 1864; Budgetary Proposal for 1865, [August 1864].
[27] AMN, 2R565, Budgetary Proposal for 1844, 25 March 1843.

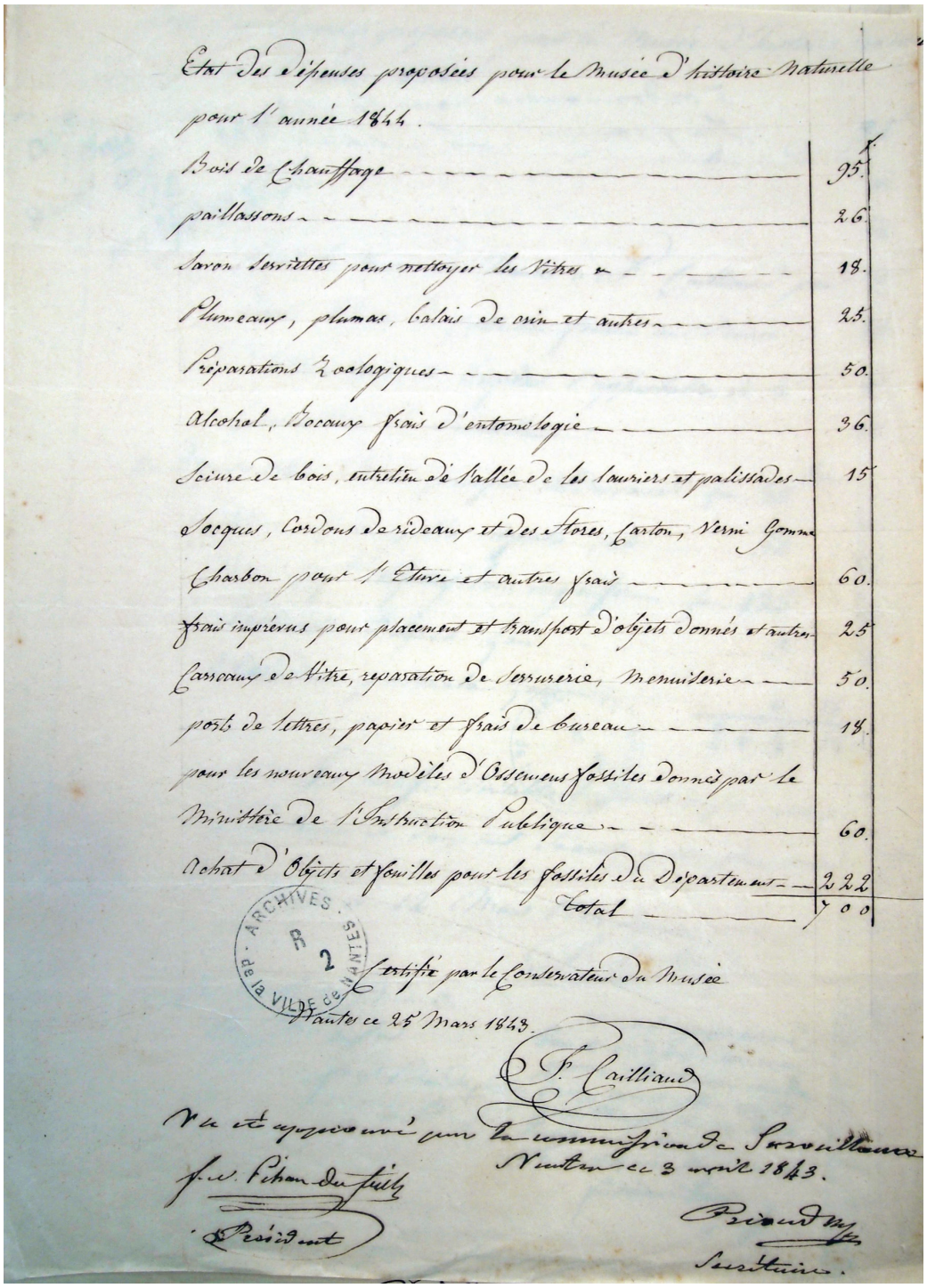

Figure 1: "Statement of proposed expenses for the Natural History Museum in 1844." AMN, 2R565, 25 March 1843.

layout that is visible in the document; the wording of the subject "Proposed state of expenses for the Nantes Natural History Museum in 1844"; a list of items, followed by a word of certification, a date (25 March 1843) and a signature. Further down, the president and secretary of the museum board's endorsement appeared in different ink and bore a slightly later date (5 April 1843). In this type of document, fieldwork appeared in between the lines, through indirect references, such as mentions of "excursions" or "excavations" ("*fouilles*") alongside the costs of transport of "harvested objects" ("*objets récoltés*").[28] These mentions usually appeared at the bottom of the list of supplies and consumables, making fieldwork an activity seemingly funded with

[28] AMN, 2R565, Statement of Expenses, 29 October 1845; Statement of Expenses, 20 December 1862.

the remainder of the available budget. But fieldwork also appeared as the result of gestures inscribed in the rhythm of the museum office, punctuated by various stages of formalizing requests, anticipating them in the spring for the year to come, collecting the necessary endorsements and having it finally validated by the Nantes city council.

Cailliaud's museum-led fieldwork and interest in the subsoil was linked, at least thematically, to the geological survey. Referring to this program to categorize his work would, however, fail to grasp its complexity. Instead, Cailliaud's case reveals the little-known history of provincial museum directors producing geological knowledge in France, where this task was normally assigned to mining engineers exclusively.

The French geological survey was systematized in the early nineteenth century.[29] This program chiefly leaned on the corps of mining engineers specially created in the late eighteenth century. Initially coordinated from Paris, the survey was deployed at the provincial level with the 30 August 1835 memorandum ("*circulaire*") sent to the *préfectures*, making them responsible for funding and overseeing the geological maps of *départements*.[30] In the Lower Loire, this created a peculiar situation where two geological study programs ran in parallel. The engineers' approach, however, offers a very different perspective on fieldwork.

The work of mining engineers regarding the geological survey was guided by instructions circulated in the *départements*. The 1836 "Program for the execution of departmental geological maps" was issued by the Ministry of public works.[31] This set of instructions in particular specified the adequate base map (the Cassini map) and the way the data should be represented (sections one and four). It also encouraged fieldwork as an opportunity for direct, on-site observation, rather than relying on second-hand sources which could cause errors (sections two and three). A substantial part of the instructions, finally, pertained to deliverables, like the map minutes. Engineers were requested to leave a copy of the minutes in their office, allowing for the monitoring of the project and ensuring that the proceedings remained confidential (section four). Next to the minutes, the annual submission of tour logs ("*journal de tournée*") was requested. This was a crucial document, to the point that it was the subject of additional instructions in May 1837 specifying that the logs could by no means consist of abbreviated field notes but had to be a daily account in full text of reported "observations."[32]

Executing these instructions was more complicated than it looked on paper. Despite the insistence on tour logs being submitted, none can be found in the archives of the service. Perhaps they were disposed of, but this seems unlikely. These diaries were conceivably never provided, as the additional instructions requested. The repeated complaints of engineers regarding lack of time to conduct the survey reinforces this hypothesis. In 1843 for instance, engineer Joseph Durocher declared an increased number of excursions but conceded they made up to "only fifteen days" of surveying fieldwork, and in 1852 an even "[smaller] number of days."[33] Slow progress caused concern with the prefect whose reaction was to request even more reports, namely one per trimester in 1845.[34] The scarcity of the reports allows for lingering doubt on the efficiency of such measures and suggests that the precedence of surveying over other tasks was relative.

The geological survey and mapping of the Lower Loire were plagued with problems arising from the high turnover of engineers. From the 1830s to the 1860s, the survey was first entrusted to Théodore Lorieux (1800–1866) who was assigned with *Ille-et-Vilaine* département (hereafter, Ille and Vilaine) neighboring the Lower Loire. Lorieux was soon called to other duties and replaced by Jean-Eugène Sentis (1814–1865) in 1838. Due to Sentis's workload, the supervision of the survey was returned to Lorieux shortly thereafter, before it was eventually entrusted to Joseph Durocher (1812–1861) in 1842.[35] Again, Durocher was busy; a professor at the Faculty of Science in Rennes, he was then also in charge of the survey of both Lower Loire and Ille and Vilaine. Additionally, he spent considerable time on long-distance expeditions and his career was cut short by his death in 1861.[36]

[29] Laboulais, "Aux origines."

[30] BPM, Fonds Beaumont, dossier 1, fol. 53, "Le Conseil général des mines annonce l'établissement de cartes géologiques départementales aux Conseils généraux des départements." 30 November 1835. https://patrimoine.mines-paristech.fr/document/Beaumont_01_053.

[31] ADLA, 1568S/1, "Programme relatif à l'exécution des cartes géologiques départementales," 22 March 1836.

[32] ADLA, 1568S/1, "Note additionnelle," 1 May 1837.

[33] ADLA, 1568S/1, the Undersecretary of state for public works to the Prefect of Lower Loire, 19 April 1843; "Rapport de l'ingénieur des Mines [Durocher] sur l'exécution de la carte géologique," 7 July 1853.

[34] ADLA, 1568S/1, the Prefect of Lower Loire to the Ministry of Public Works, 16 July 1845.

[35] ADLA, 1568S/1, the Undersecretary of state for public works to the Prefect of Lower Loire, 4 February 1842.

[36] Malaguti, *Éloge du professeur Durocher.*

The implementation of ministerial and prefectoral instructions was therefore confronted with the contingencies of the engineers' working conditions slowing down progress. It was the bureaucratic nature of the work, however, which made a relative sense of continuity possible. The actors of the *département* administration had to constantly negotiate to obtain the engineers' papers (or copies of) to create an accessible documentary base. The mining service, an actual office space, was central in the accumulation of reports, minutes, and correspondence produced alongside fieldwork. These bureaucratic tools turned particulars of individual field experiences into a collectively used logistics of geological knowledge.[37]

These bureaucratic connections were decisive in ensuring the continuity of work despite the numerous disruptions to the program, as shown by the context in which the geological map was entrusted to Cailliaud.[38] At the time of Durocher's premature death, nearly twenty-five years after the initial 1835 decree, the geological map was still not completed. While the appointment of Cailliaud to finish off the work is never explicitly mentioned in the archives, the *préfecture* was obviously aware of his competence. Cailliaud was known to oversee the Museum's Lower Loire geological collection, to conduct research on its subsoil and perhaps even to be working on his own geological map.[39] He had also been an assistant to Dubuisson, the author of the earlier 1831 mineralogical map.[40] His role as a member of the Academic Society confirmed, if needed, his scholarly credentials to the *préfecture*.

The bureaucratic culture captured in the everyday work of standardized paper production illuminates the role of administrative norms in designing fieldwork. The regulatory framework issued by administrative authorities offered means of adapting to contingencies. Administrative norms were also not inflexible obstacles in that they were appropriated in plural ways. Intuitively, the work of engineers seemed much more standardized, but their own norms were subject to adjustments when used outside their corps. Cailliaud, for instance, responded to the prefectoral demand of delivering a geological map based on national guidelines. His description of the map, however, was only a dozen pages long, compared with the hundreds of pages of descriptions by the engineers.[41] Not only did his geological activities belong to another administrative framework and culture, but his research developed well beyond the national survey.

The Relational Nature of the Lower Loire

Unlike engineers' tour logs or naturalists' signature notebooks, Cailliaud elaborated his study of the Lower Loire's subsoil on dozens of unbound paper slips.[42] This body of documents, the likes of which have rarely been preserved, reflected his attention to both the geomorphological and social features of the Lower Loire. This contrasts with contemporary representations of the natural space which were first informed by the essentialist approach of revolutionary theorists of the French territorial division as natural units.[43] More generally, thinkers of the time painted a picture of the purity of natural space that rested upon the denial of its relational fabric.[44] At the end of the twentieth century, efforts to characterize the field against lab work made it a resource for modern biology. This further substantiated narratives on a natural space ready to be sampled.[45] In Cailliaud's papers, however, this essentializing narrative on natural fields gives way to a space of hybridity produced by a relational fabric of societies and environments.[46]

From his notes, one can easily imagine Cailliaud walking along roads, paths, crossing fields and scampering over rocks along the coast, his naturalist's gaze resting on the horizontal expanse of the earth's crust, browsing, and pausing by some geomorphological detail. The Lower Loire is not a region with marked relief, nevertheless, Cailliaud liked to use the occasional escarpment as a chance to gain height and broaden his gaze.[47] At other times, he would fixate on a specific detail of some bedrock, looking closely at the orientation of the slate foliation at a quarry hinting at subterranean layers.[48]

[37] Denis and Lacour, "La logistique des savoirs."
[38] Cailliaud, "Carte géologique," (1860).
[39] ADLA, 1568S/1, "Comparaison de la carte géologique de M. l'Ingénieur Durocher avec celle de F. Cailliaud," n/d.
[40] Dubuisson, "Carte géognostique."
[41] Cailliaud, "Carte géologique." Other examples may include: Fourcy, *Carte géologique du Finistère*, 172; De Boucheporn, *Du département du Tarn*, 114; Guillebot, *Du département de la Côte-d'Or*, 71; Lory, *Description géologique du Dauphiné*, 751. See also Dubald, "Capital Nature," 154–58.
[42] On notebooks, see Bourguet, "A Portable World."
[43] Ozouf-Marignier, *La formation des départements*; Bourguet, *Déchiffrer la France*.
[44] White, "Wilderness to Hybrid Landscapes."
[45] Kohler, *Landscapes & labscapes*. These findings have since been nuanced in Kohler, *Inside Science*.
[46] Lefebvre, *The Production of Space*.
[47] MHNN, 2R842, note, unpaginated.
[48] Ibid.

This narrative of trudging and observing nature should not make us overlook the context in which Cailliaud explored the Lower Loire. He was not a neutral figure; he came with a reputation and social credit, being an embodiment of the knowledgeable scholar and having the status of a director doing his "job."[49] As a result, his fieldwork can be mapped through the study of his list of travels and destinations of choice. Setting out for the Lower Loire's outdoors usually meant traveling for a few days, but rarely more than a week at a time. On one occasion, in 1845, Cailliaud took a leave of six weeks; he usually traveled a few times a year, and up to eight excursions were recorded in 1850.[50] Although fieldwork was part of his duties, it was always time away from museum affairs and as such required justification. When he traveled, Cailliaud used public coach services. From the center of Nantes, on Quai de Turenne (south of Ile Feydeau) or across the arm of the Loire, from the Auberge de la Boule d'Or, he could easily reach most localities.[51] At times, when exploring the coastal area, maritime transport was also helpful.[52] Because only his personal and transport expenses and those pertaining to the samples shipped back to the museum were defrayed, little is known about his choices of accommodation, aside from occasional stays in hotels, for instance in Nozay. The hotel served as a base for exploration.[53] Vacationing was also a great opportunity to explore the coastal area, as shown by Cailliaud's recording of his observations from the "bathing lawns" of his coastal residence at Saint-Nazaire.[54]

Upon reaching a locality, Cailliaud would set out to explore. His itinerary was significantly influenced by the administrative organization of the French territory into *communes*. His fieldwork kit did not seem to have included maps, either for purposes of orientation or to record routes and on-site findings. He favored written textual descriptions in the form of itineraries that listed sites, distances, and identified deposits and minerals. This mapping technique used *communes* as departure points with directions or distances to indicate which side of the road the observation was made. When necessary, small drawings accompanied the notes (Figure 2).[55] Cailliaud thus elaborated a textual cartography of the Lower Loire composed of names of *communes*, hamlets, and roads connecting those localities.

With limited resources and time, and generally traveling alone, Cailliaud used his scientific reputation, professional authority, and considerable experience to make social connections that would facilitate his observation, sampling, and data collection work.

Information gathering and contact with local inhabitants were organized before the trip. The mayor of Nantes introduced Cailliaud to his colleagues, who were kindly requested to offer their guidance.[56] When he prepared to survey a new destination, Cailliaud gathered names of local individuals and recorded them in lists as he received the information. In Bouaye, for instance, a locality in the southern countryside of Nantes and on the banks of the Lake of Grand-Lieu, Cailliaud initially got in touch with Monsieur le Marquis de Juigné, the owner of the lake. The aristocrat referred Cailliaud to his guards for assistance. Later, Monsieur Fruneau, a Bouaye court clerk, sent him a servant and one of his farmworkers to dig at Petit-Bois, a nearby hamlet.[57] In Sainte-Lumine-de-Clisson, Cailliaud was assisted by a member of the clergy, the parish priest, Monsieur Guillet.[58] Because Cailliaud often visited quarries and mines, he regularly used the opportunity to hire nearby dayworkers to perform excavations under his supervision.

The names of high-profile individuals were recorded, for later expressions of gratitude and as a token of respect for local hierarchies dominated by a powerful aristocracy and bourgeoisie. At the other end of the social spectrum, those who sold their physical strength for this hard, strenuous work remained anonymous and were merely items on a list, mentioned as "day laborers" or only in the context of human "transport of objects."[59] The survey of the Lower Loire depended on a web of informants across the social spectrum, and Cailliaud's skills did not only lie in the quality of his observations, but also in his ability to mediate social hierarchies in order to be granted permission to access sites of interest in a complex space of social barriers and gated areas.

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[49] Shapin, *The Scientific Life*, 22–46.

[50] AMN, 2R565, statement of expenses in 1845, dated 29 October 1845; statement of expenses in 1850, 24 August 1850, 16 October 1850, 28 December 1850.

[51] MHNN, 2R842, note, unpaginated.

[52] AMN, 2R565, statement of expenses in 1851, 28 December 1851.

[53] MHNN, 2R842, note, unpaginated.

[54] MHNN, 2R841, "Notes diverses sur les pholades," n/d.

[55] MHNN, 2R842, note, unpaginated.

[56] Ibid; ADLA, 1568S/1, Desvaux to the prefect of Lower Loire, 20 March 1843.

[57] MHNN, 2R842, note, unpaginated.

[58] MHNN, 2R842, "Recherches," op.cit., unpaginated.

[59] See for instance AMN, 2R565, statement of expenses in 1851, 28 December 1851.

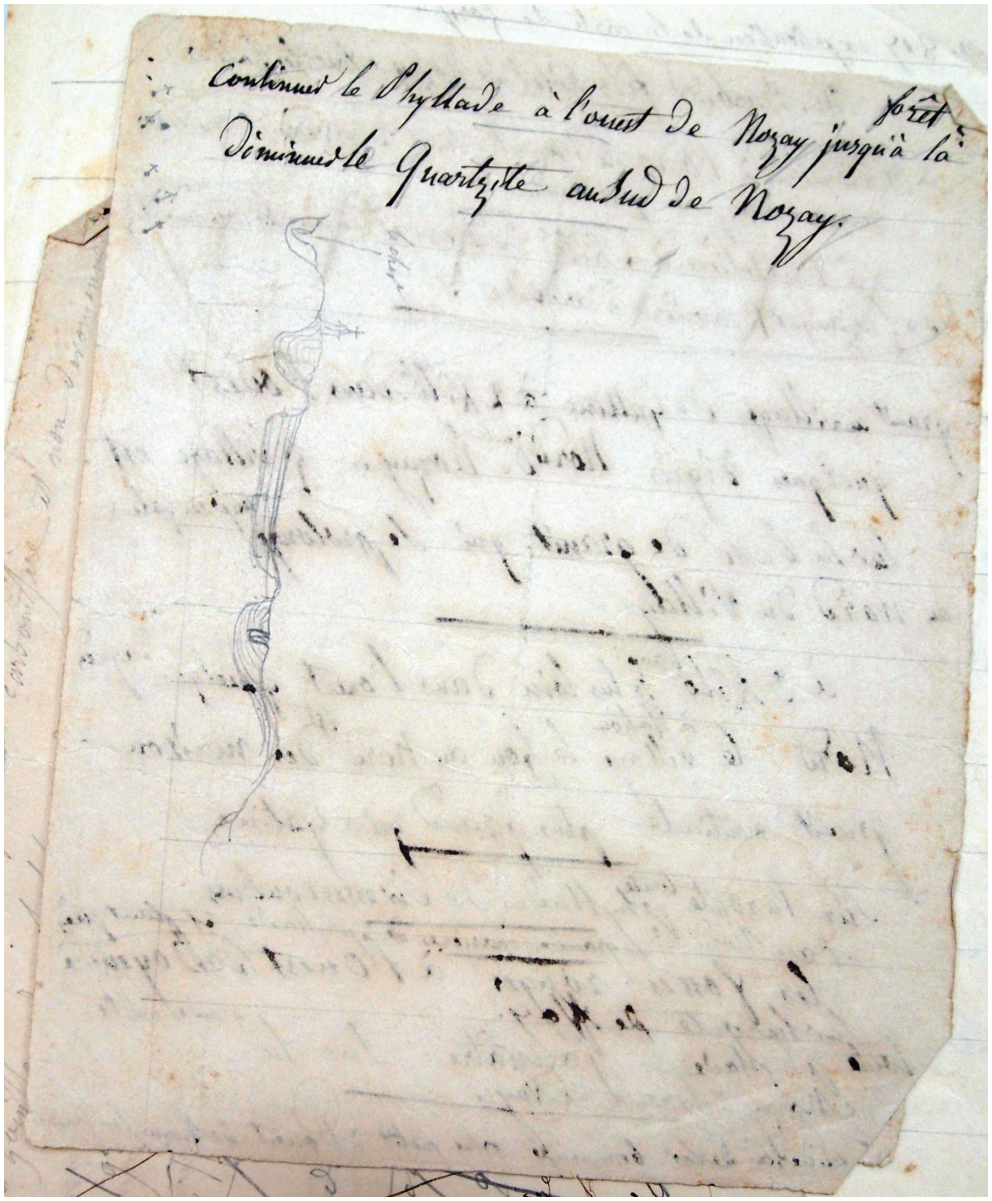

Figure 2: Textual and figurative representations of phyllites near Nozay. MNHH, 2R842, undated, unpaginated.

The morphology of social dynamics and human activity was indeed crucial in the shaping of the geological knowledge of Lower Loire, and official guidelines underlined the importance of observing them. In practice, it made trenches caused by worksites or railroads prized spots of observation.[60] Kilns, quarries, and mines, i.e., sites of extraction and transformation of mineral substances, were prominent targets of the survey, too. These sites of human exploitation of mineral resources provided convenient openings in the earth, where bedrock "cleared of [their] vegetal cover" lay bare, facilitating the exploration of the subsoil to identify "useful" minerals or "substances."[61] Also, workers were available on site.[62] The quarry work and extractive industry indeed conditioned the overall geological inquiry. For his exploration of the Silurian fauna, for instance, Cailliaud was particularly interested in the lime quarries of Erbray and Saint-Julien-de-Vouvantes.[63] While his 1835 exploration had suffered from many setbacks, he later noted that the development of the quarry sustained the progress of his research: he returned with "fruitful" results in the 1850s, after the exploitation had substantially expanded.[64]

[60] MHNN, 2R842, note, unpaginated.
[61] Cailliaud, "Carte géologique," (1861).
[62] ADLA, 1568S/1, Lorieux to the prefect of the Lower Loire, [1837]. See for instance MHNN, 2R842, note, unpaginated.
[63] Cailliaud, "troisième faune silurienne."
[64] MHNN, 2R842, "Sur l'existence de la faune troisième silurienne dans le Département de la Loire-Inférieure" [mss].

Cailliaud recorded the presence and location of mineral samples, and simultaneously documented their quality based on their uses and on his practical knowledge of specific substances. He would for instance consider the use of granite for architecture or millstones, both in view of its future economic utility, but also as a source of information.[65] The practice among quarry workers of wearing glasses for protection against flying shards was also lay, practical knowledge used by Cailliaud in the process of building a corpus on the geology of the area.[66] Knowledge from ancient civilizations, too, could be useful; he once came across archeological remains of "Roman" extraction of lime in the Saint-Gildas marshes, which was taken as a clue for the presence and quality of lime there.[67] Ancient knowledge converged with contemporary uses in agricultural developments, too. On one visit, Cailliaud's attention was caught by the activities of a school farm. The school was an excellent opportunity for fieldwork due to its plowing and agronomy classes, both used to access knowledge about the subsoil.[68] Plowing could uncover samples and fossils, but the presence of the school and therefore of specialists in agronomy enabled Cailliaud to interview soil experts, both on agricultural development and on activities on the surface of the earth and below.

Lastly, knowledge of the subsoil also depended on its exploration by contractors. In the locality of Crossac, Monsieur Martin, an entrepreneur, had stumbled on an outcrop of sulfured lead in 1822. The man was initially working to drain the marshlands through the construction of a system of canals and sluiceways. In 1823, Martin continued his search for lead seams. A few kilometers from the initial point, he identified a lead vein five meters below the surface. This vein was located under a thick layer of peat which had to be cleared and six exploration trenches were dug out, all of them seventy-eight meters long, with six forty-meter shafts and twelve boreholes adding up to 240 meters. However, the work was interrupted because the nearby river threatened to flood the site. Martin continued his drilling in 1829, with disappointing results. According to Cailliaud, his investment of 1,000 francs was too small, notably in comparison with the research of a Piriac tin deposit which had required an expenditure of 500,000 francs. This, to Cailliaud, explained the unsuccessful outcome, despite the three months spent on the site.[69]

Cailliaud did not seem preoccupied by the impact of such heavy transformations of the landscape on the field. Rather, his account of Martin's story was used in his "Recherches" to argue about the superior financial capacity of the extractive industry in the exploration of subterranean nature. The naturalist depended on entrepreneurs, as much as the mining business relied on the survey to expand. Fieldwork supplied common grounds of discussion in the Nantes scientific and political venues or high-profile dinners. Geological practice and knowledge were neither the preserve of mining engineers nor of the museum director, they were shared.

Contrasting with romantic narratives about scholarly men faced with the incommensurable greatness of nature, Cailliaud's papers are not only documents that tell us about the complexities of fieldwork, this paper trail containing geological, social, environmental, and economic information weaves together aspects of Cailliaud's field experience and reflects that the field itself was in fact a collective and relational experience.

Recollecting the Multiple Temporalities of the Lower Loire

> "Searches on the islet were grueling. First, sea crossings are often troubled by storms, especially during the spring tide, which one is advised to choose. The ground is uneven, covered with sharp jagged ridges and excavations where the sea has stayed. The ground everywhere is covered and concealed by slippery kelp. (…)
>
> These searches occasioned many stays at the lighthouse. One, amongst others, was longer than we would have hoped: during the equinox of November 18, we were forced to retreat into the tower for 14 days of stormy weather. (…). Quite fortunately, we had biscuits, potatoes, and sand containing foraminifera with us, and we did not run out of biscuits and potatoes."[70]

Cailliaud's recollection of the trying episode of searching the Atlantic coast of Lower Loire emphasizes the importance of the natural phenomena of tides or equinoxes, the long, suspended moments of waiting, the risks inherent in the morphology of the relief, where rugged boulders and slippery vegetal species made

[65] MHNN, 2R242, "Recherches," op. cit., 51–52.
[66] See for instance MHNN, 2R842, note, unpaginated.
[67] MHNN, 2R842, "Recherches," op. cit., unpaginated.
[68] MHNN, 2R842, note, unpaginated.
[69] MHNN, 2R242, "Recherches," op. cit., 39.
[70] MHNN, 2R842, "Études," op.cit.

it challenging for humans to not topple over. Fieldworkers had to deal with food and sleep deprivation. Inserted between two pages of his unpublished "Études géologiques et paléontologiques," this anecdote reflects the lingering presence of the terrain in ensuing publications. This sensory and emotional experience of fear finds a place in Cailliaud's scientific writing, against a stereotyped posture of detachment or from standards of "de-situated" science.[71] The separation between field and office work is further questioned here through the persistence of fieldwork in Cailliaud's publications. Rather than scientific accounts reaching for neutralized narratives devoid of any mention of the conditions of inquiry, Cailliaud mixed his geological writings with anecdotal material rooted in the multiple temporalities of his life, of contemporary societies, of antiquity, and of deep nature.[72]

Cailliaud's writings underline his interest in the geology and subsoil of the Lower Loire, at the intersection between animal species and mineral environments. His work made geology and conchology intersect, an interdisciplinary approach visible in his publications on *pholadidea* (piddocks), a marine mollusk that drills the rock to create tubular burrows.[73] This had an impact on Cailliaud's more general approach to geological knowledge. Geology was often described as a puzzle-solving activity of making what was hidden below eventually intelligible and commensurable.[74] While the historiography has mainly focused on European-built—perhaps even European-capital-city-built - and bible-centered narratives,[75] Cailliaud's challenge lay in the piecing together of complex human, animal, and environmental data using his experience of fieldwork, not as a theoretical backdrop, but as a way to make subterranean nature intelligible.

Putting the geology of the Lower Loire into written form required a long exercise of reorganizing the collected data. These notes were often taken on used papers, for example the back of a page of Arabic lexical helpers during Egyptian trips, or a list of iron ore mining sites on the flip side of the death notice of his colleague Charles Lory's son.[76] Where pencil seemed to be used for a primary inscription, ink indicated validation; when he wrote over the pencil note, Cailliaud either flagged information or confirmed the importance of that data. Most importantly, this process recast the experience in an effort to make it fit into categories, particularly temporal geological ones. The outcome of this rearrangement process took the form of lists, for instance on "middle tertiary terrains"[77] (Figure 3). In order to make this list, Cailliaud assembled various related field notes; in the same set of paper slips, we find for example a note on the Erouches marshes, on the Auré pond (Figure 4), and a list of contacts living around Bouaye (Figure 5).[78] Thus, data garnered along the way, such as descriptions of sites and informants, was backed up by other, cross-sectional lists. Some of the data on informants disappeared, but not entirely; on a different list of limestones, Cailliaud mentioned a limestone deposit "at the Sainte Lumines marshes (...) near the house of the priest who gave me the shark teeth."[79] Using it as a memory aid and organizational instrument, this system was an attempt to embrace the entirety of the data retrieved from fieldwork.

His attention to detail encompassed both scientific data and other information. The geological descriptions would be nested in stories and anecdotes, with the intention of walking the reader through the process, by re-creating particulars and practicalities of fieldwork in the texts. The geological description drew on movement verbs that evoked Cailliaud's journey and took the reader along with him as he prepared to "leave the coast," or "before leaving the crystallized terrains," or "moving to another terrain at Saffié."[80] Otherwise, the many mentions of "finding" or "coming across" a substance, or of "encountering" minerals or strata was a narrative style which offered a vivid rendition of the on-site exploration.

His use of anecdotes served to give his scientific discourse a sense of place and substance. In his "Études," one-paragraph stories effectively described overheard conversations or discussions with informants. Cailliaud humorously related the story of Musset, the parish priest of Touvois, who had been looking for water near his garden shed. The dayworkers hired by Musset soon came across bedrock instead of water.

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[71] The question of emotional detachment has been primarily studied by social scientists; see for instance Davies and Spencer, *Emotions in the Field*, 4; De La Soudière, "L'inconfort du terrain." See also Kohler, *Inside Science*.

[72] Chakrabarti, *Inscriptions of Nature*.

[73] MHNN, 2R842, "Études," op.cit.; "Recherches," op. cit.; Cailliaud, "Note sur un nouveau"; Cailliaud, "Procédé employé par les pholades."

[74] Greene, "Geology."

[75] Chakrabarti, *Inscriptions of Nature*.

[76] MHNN, 2R842, note, unpaginated.

[77] Ibid.

[78] Ibid.

[79] Ibid.

[80] In order of quotations: MHNN, 2R842, Cailliaud, "Études," op. cit., [46b]; "Notice du la carte géologique du département de la Loire-Inférieure," [5]; Cailliaud, "Études," op. cit., 156.

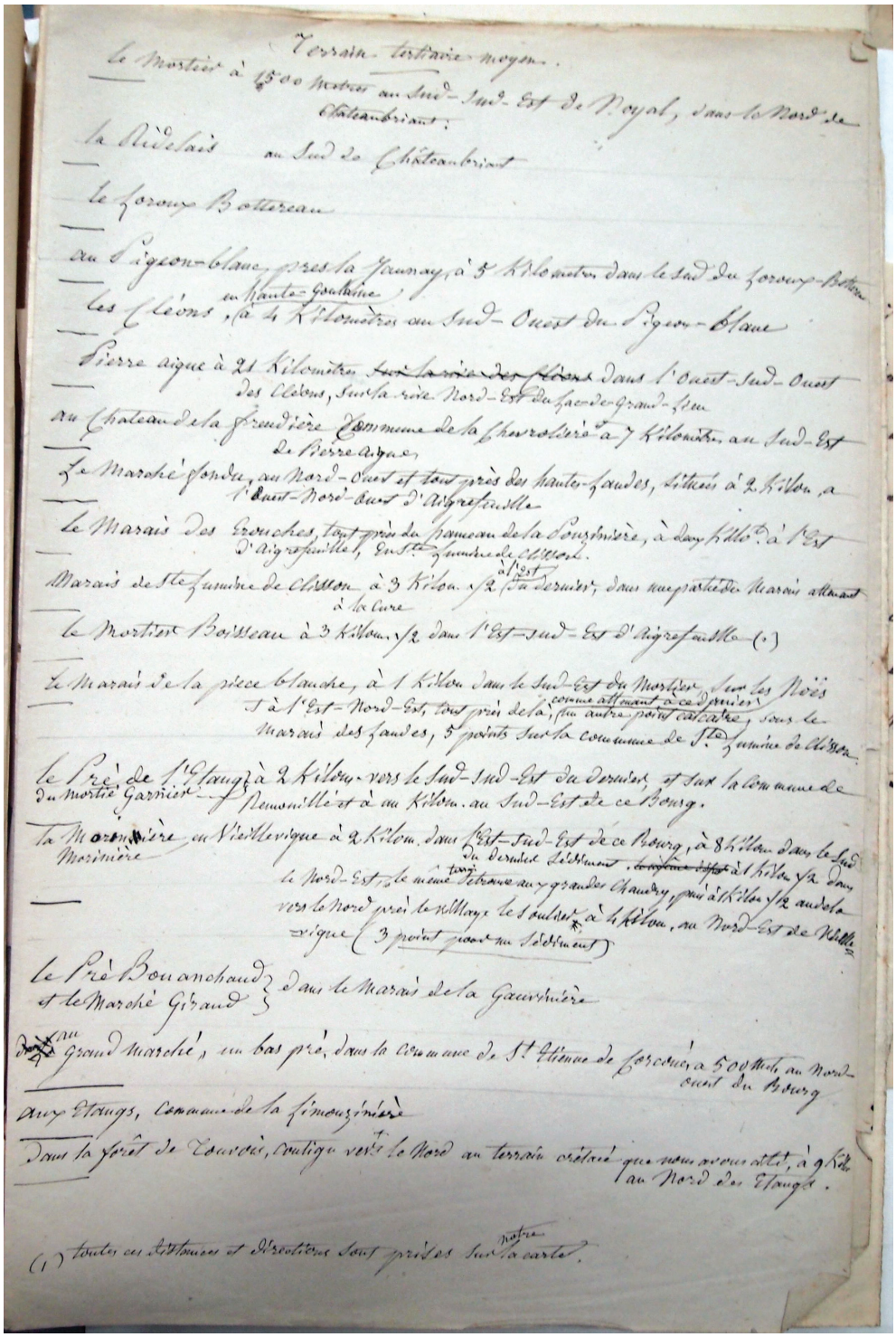

Figure 3: List of "Medium tertiary terrains." MHNN, 2R842, undated, unpaginated.

Never mind, Cailliaud jested, as this was taken as "a sign of providence" because the good find promised future extractions of lime and fossils.[81] Staying within the temporality of his society, his descriptions of certain rocks, for instance granites, were complemented with concrete descriptions of how those minerals were used in monumental urban works such as the granite used for the statue of Cambronne on the central square of Cours Napoléon in Nantes.[82] These stories helped readers envision the possible applications of fieldwork, reflected authentic direct observations, and anchored descriptions into everyday narratives.

[81] MHNN, 2R842, "Études," op. cit., 108.
[82] Ibid., "Notice," op. cit., [4].

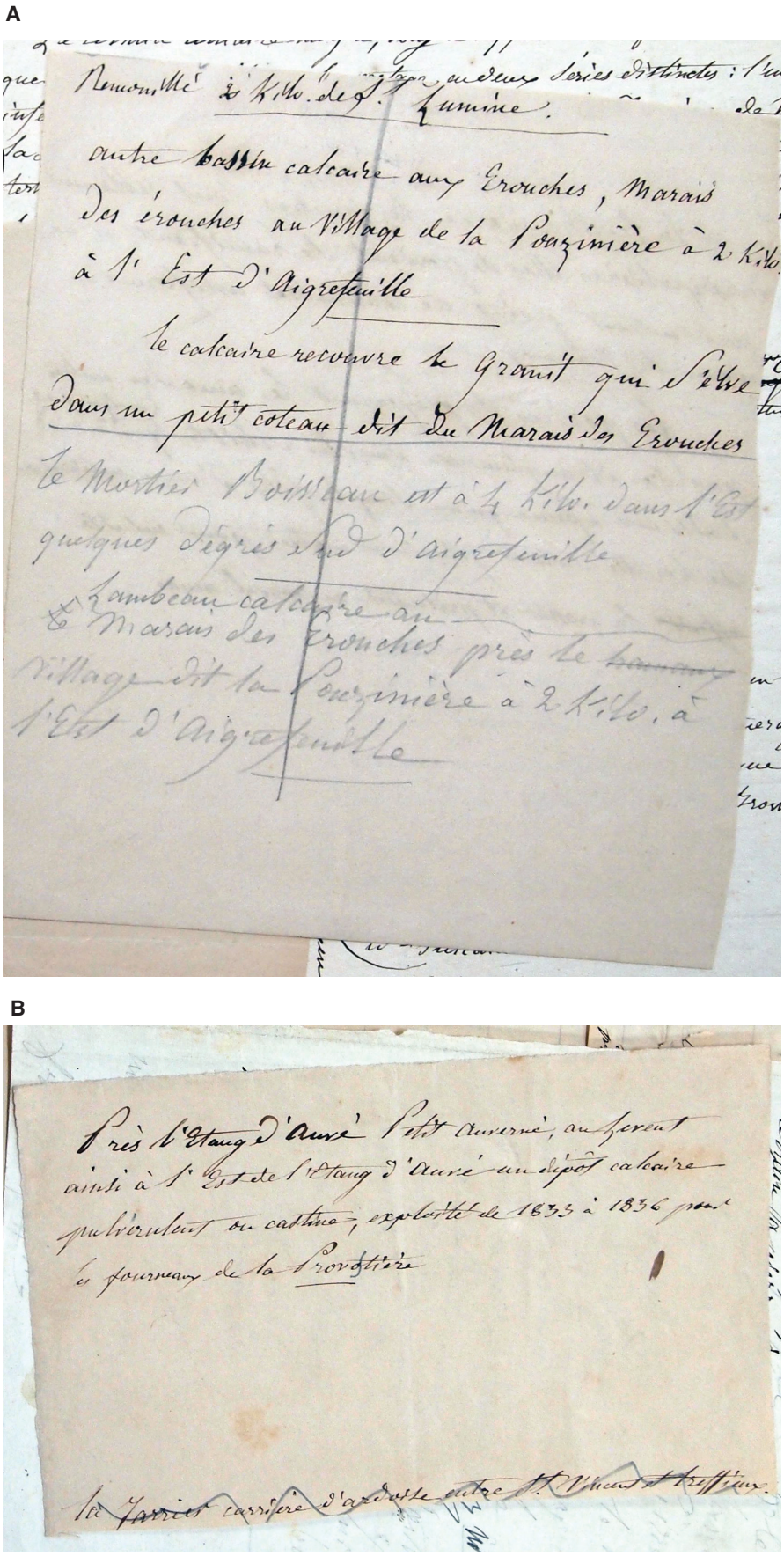

Figure 4: Examples of collected data on paper slips: Erouche marshes (A) and Auré pond (B). MHNN, 2R842, undated, unpaginated.

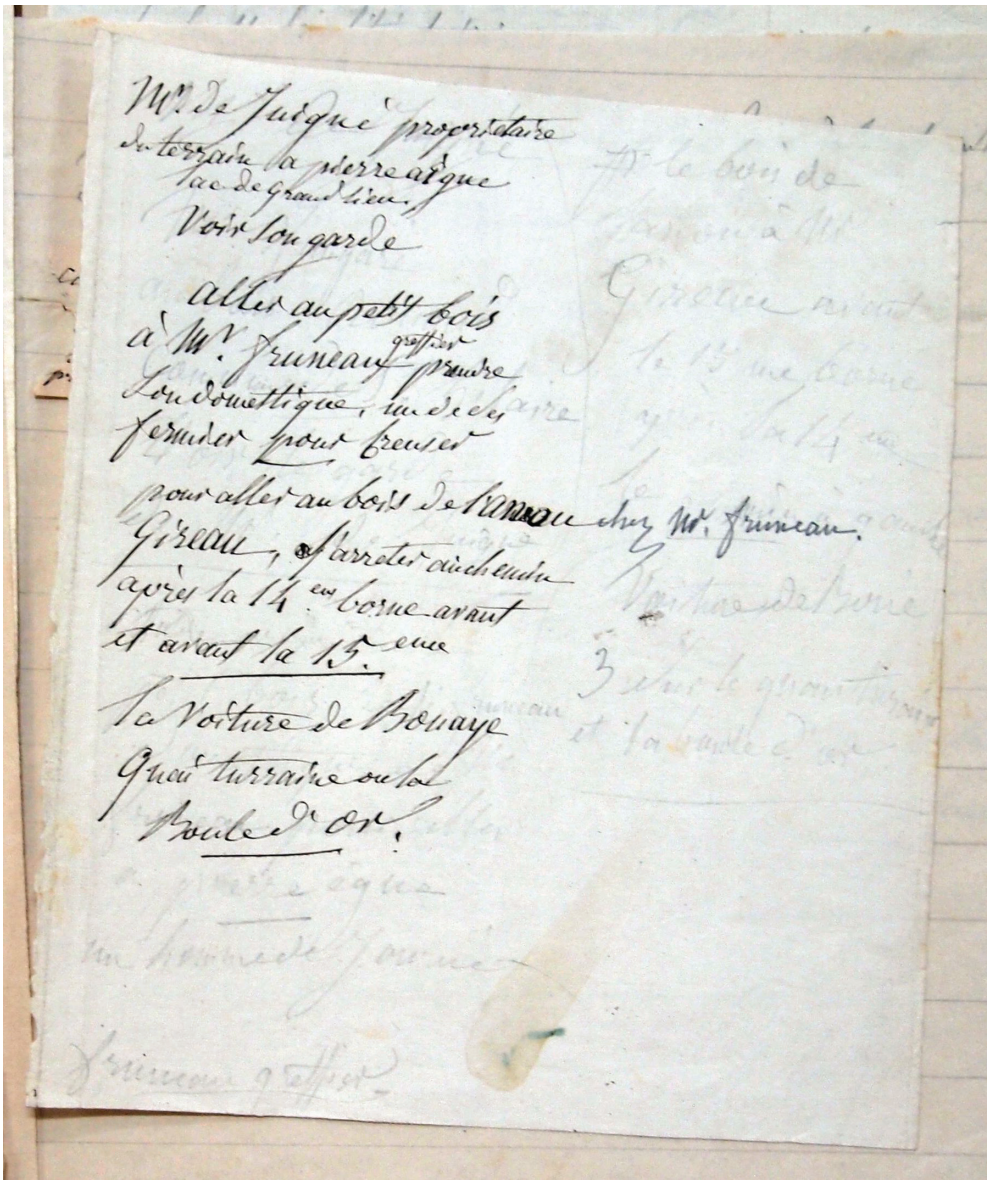

Figure 5: List of contacts near Bouaye. MHNN, 2R842, undated, unpaginated.

Cailliaud also brought up antiquity by referring to his past fieldwork. The "Études" connect the Lower Loire to the Egyptian field, through mentions of, for instance, how he "often had reason to be struck with astonishment by the numerous instances of tears in the rocks," a phenomenon observed in the plateaus of Upper Egypt. Elsewhere, he recalled that in Upper Nubia, he had "observed" long suites of sandstone plateaus.[83] These Egyptian references allowed him to epitomize the symbols of authority of, respectively, the knowledgeable scholars trained in the field and whose travels gave him valuable scientific capital, and the orientalist-laden aura of ancient Egyptian civilization.

Cailliaud did not stop at antiquity; he also projected the explored Lower Loire into prehistorical landscapes. His texts played with the reader's imagination to suggest how a familiar place could result from geological events such as how "ancient perturbations produced the erection of igneous rock which suddenly emerged [from the subsoil] as the gneissic and granitic hillsides of the departmental land ruffled their peaks"; or the description of immemorial times when extinct species had "lived in the region."[84] To support his narrative, Cailliaud occasionally played with the idea of a mysterious earth, portraying an underground world shaped by dramatic natural forces greater than any human agency. Cailliaud indulged in lyrical comments on the

[83] MHNN, 2R842, "Études," op. cit., 19–20.
[84] MHNN, 2R842, "Notice," op. cit., [5].

subsoil in footnotes and transition sections, mentioning how "springs surge[d] from the immensity of the earth's depths" and how "dark [a] science" its study was.[85] Beyond the lyricism, these formulations exude a sense of mystery in the knowledge of subterranean nature as something one can only see through a set of clues, a place that is also one of darkness, perhaps even filth or evil.[86]

Nineteenth-century scholarly work is usually described as increasingly scientific, evidenced by neutralized accounts of observations. Nevertheless, Cailliaud fused the experience and contingencies of fieldwork with scholarly knowledge in his scientific writings. In making room for contextual elements and stories,[87] he drew on the everyday practice of research to enhance the quality of his work and give it further credit. As he juggled with the earth's multiple temporalities, Cailliaud used his own experience to historicize the Lower Loire. Perhaps he tried to legitimize the place of this provincial land on the list of significant scientific places for the deep history of the earth. Most certainly at least, his written fieldwork reports, by meshing the scientific, environmental, and social worlds, did convey the multiple agencies at work in the making of the Lower Loire.

Conclusion

Field and office work were not separate worlds. Instead, as exemplified by the case examined here, bureaucratic practice was intrinsic to a nineteenth-century museum director's study of subterranean nature. Even if fieldwork occupied a crucial place in the cultures of natural history, here it existed within the framework of public administration in the context of its development as much as it offered a space of negotiated opportunities, economic and domestic stability, and public recognition.

Cailliaud's fieldwork, as it was woven together in his writings, resulted from direct observation of socially produced environments subsequently assembled in paper form on his desk. Cailliaud's narrative was not about great encounters with nature; it was about everyday operations, including timelines, workloads, and other contingencies.

Cailliaud's geological practice, rather than a finely delineated scientific discipline, was a "hybrid enterprise"[88]; it developed both inside and outside of his office, across the lines of science and administration, even across administrative scales, in hybrid spaces of human-produced environments. There, in his negotiated field, sometimes off the beaten path and sometimes not, Cailliaud wrote the story of his own life as a scientist.[89] In doing so, he also produced an original provincial case that illuminates the minute of knowledge production. This, in turn, sheds light on the complex agencies that shaped the Lower Loire and calls for pursuing a contextualization of natural science practices beyond national metonymies of the local and beyond pre-existing categories that fail to do justice to the complexities of knowledge production.

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Competing Interests

The author has no competing interests to declare.

[85] MHNN, 2R842, Cailliaud, "Études," op. cit., 3.
[86] Williams, *Notes on the Underground*.
[87] Kohler, *Inside Science*.
[88] Chakrabarti, *Inscriptions of Nature*, 19.
[89] The expression was borrowed from Shapin, *The Scientific Life*.

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