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Outposts of science

Placing science bubbles at the margins of (post)colonial French territories

David Dumoulin Kervran, Jérôme Lamy, Jan Verlin

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Since the 1970s social sciences have analyzed science as an historically and geographically situated social practice, an approach that has undoubtedly transformed our view of scientific production. However, empirical studies were mostly carried out in industrialized countries and focused on major globalized cities (in the North and progressively in the South). Whenever historians of science were looking beyond these urbanized spaces, they were instead favouring science production in “expedition-exploration mode” (Heggie, 2014) or field work and “collecting science” (Kohler, 2007). Permanent scientific places “elsewhere”, in remote territories were not yet considered. Hence, this paper sheds light on scientific places at the extreme margins of the French overseas territories inherited from the colonial empire. It contributes to the literature that explores how much the power of world metropolises and their modes of governability are often rooted in remote (post)colonial experiments, especially through science production. Our major objective is to explore scientific outposts, beyond the multitude of scientific disciplines and world regions, to show how the power of global hegemonic nations is *indirectly* boosted by remote scientific activities, and conversely, how the localisation and production of major scientific disciplines are discreetly shaped by postcolonial local frictions. To investigate this twofold process, we analyse the very places where scientific research is done.

For this reason, we propose the concept of “scientific outpost” as one possible development for lab-studies considering their specific localization, in order to characterize scientific places that are neither calculation centers nor field work sites. These places are defined by four different criteria: 1) Their materiality: Outposts are permanent places with building for continuous “occupation” and scientific work, 2) Their geography: These places are situated in remote territories of former colonies with difficult access and set apart from local settlement, 3) Their politics: Scientists working in outposts built their careers in former or current metropolitan cities and they have very limited or conflictive relations with local societies, 4) Their epistemology: These place-based practices exclude local knowledge and produce exclusive universal knowledge destined for calculation centers in a different manner than do field sciences.

The concept of scientific outposts is the result of comparing research on three different French scientific infrastructures located in the hinterland of regions overseas: a rocket launch base in Algeria desert, a volcanological observatory in Martinique island mountains and a biology station in French Guyana rainforests. Beyond countries and scientific disciplines, we realized how much our cases had in common, and we forged the term “scientific outpost” in order to capture these shared distinctive features. While the Hammaguir case is based on archive investigations (the centre was closed in 1967), the

Martinican observatory and the Guianese station were scrutinised by means of mixed qualitative methods including direct long observation and semi-directive interviews (N=28 for Guyana and N=88 for Martinique).

In order to demonstrate the fruitfulness of the “scientific outpost” concept, we proceed in four steps. First, we dig in STS literature to show how we build the conceptual analytical framework by bridging the so-called “spatial turn” in the history of science, with emerging postcolonial STS trend. The following parts are devoted to the comparison of the three case-studies, each one focusing on one transversal dimension of scientific outposts. The second presents the socio-historical context of election and fixing for the right place in each case. The third explores the institutionalization of the infrastructure through his relations with the faraway metropolitan center. The last part highlights some common features of the relations with local societies.

1. Outposts - building blocks in literature

From scientific places to placing practices

The “spatial turn” in social studies of sciences, first identified thirty years ago, experienced various sequences¹. It turned out to be a powerful way of questioning the universality of scientific rationality and exploring the situatedness of scientific practices. Nevertheless, this grand theory approach needs some “middle-range” conceptualization, since “space” is a fuzzy concept and “place” could be understood in very different ways (Agnew 1987). We conceptualized “scientific outposts” by building on four different approaches: *Place* as a scientific institution, *spatializing vs localizing* places of knowledge production, and finally *placing* as an encompassing issue to be investigated and as a process to be documented. Each existing approach brings a specific building block for the definition of scientific outposts.

First, we rely on a body of scientific literature that insists that science is produced in specific “places” - as institutions, characterized by their enclosure and by a concrete social and material design, inspiring authority and trust. Gieryn contributes to this debate in showing how scientists routinely produce science by engaging in “boundary work” with non-scientific practices and knowledge (1983, 1999) and in proposing that these specific places have to be considered as “truth spots” (2002). All enduring scientific places - including “outposts”- are carved out this way. First studies focused on the “Laboratory” with its infrastructure developed for experiments, a very special “place” supposed to be outside any geography localization, hence providing a “view from nowhere” (Shapin, 1998). Inspired by the modelization of the “Laboratory” studied in industrialized territories (Latour 1983, Schaffer

¹ The first sequence began with Ophir & Shapin’s (1991) use of the term and subsequent analyses by Shapin (1995), Livingstone (1995), Turnbull (1997) and Smith & Agar (1998). A second sequence is characterized by the publication of large syntheses (in history, Livingstone, 2003, Powel, 2007 or sociology, Gieryn, 2002) A third sequence can be identified when this geographical perspective in science history permeates the whole field of STS studies and when science studies gave more importance to non-professional scientists and to places that are not officially places for science.

and Shapin 1985) other scholars added further "places", considered as social institutions, to a growing list of scientific places: Museums and lecture halls (Naylor, 2002), collections (naturalist Alberti, 2002 or blood, or molecular Gisler, 2010), hospitals (Galison and Thompson, 1999), observatories (Aubin, 2015) or biological stations (Raf de Bont, 2015); . or even look outside the more elitist social world of professional scientists, (Secord, 1994). A trend of historian studies has been produced on practices of "field-sciences" (from Kuklick and Kohler 1996 to Kohler 2011) even if defined mainly in opposition to lab-spaces (Kohler, 2002), a duality that "scientific outposts" could contribute to better assess. However, very few analyses rely on case studies from non-industrialized countries and even less are interested in scientific "places" that are neither in an urban context² nor pure field practices designed to collect data . Some exciting studies on scientific bubbles in remote territories do begin to emerge (Redfield 2000, Soto Laveaga 2009, Geissler, Kelly and Sismondo, 2016; Raby 2017) but without transversal conceptual work. For this reason we introduce "scientific outposts" as a new and specific type of scientific "place", due to their position in remote areas and their relation towards the centers of science production.

A second perspective relevant for our approach could be called "geopolitics of science production". It focuses on "spatializing" the production of science, by inquiring the diffusion and circulation of knowledge (Latour 1987 ; Shapin 1998; Secord 2004), models, instruments as well as scientists on a global scale (Schott, 1993). Main studies however focused on the global north and inner global north cooperation dynamics. The scientific integration of other countries has been studied through a centre-periphery lense (even if refined, see Kreimer 2019), on centering on (under)development of science communities in southern countries (Gaillard et al. 1997). However, globalization of STS studies tends to reproduce the internal hierarchy of science's field itself and fails to recognize the importance of scientific research done in the periphery of these countries (Dumoulin et al 2018). Only recently the spatial margins marked by colonial conquest have been reconsidered as crucial to understand the internationalization of scientific practices (Lachenal 2016, Raby 2017). Thus, our objective is to study geopolitics of science production, focusing on extreme long distance circulations, and by prioritizing scientific infrastructure built directly by hegemonic countries in the "empty" margins of our globalized world.

A third promising direction in the spatial turn for analysing scientific outposts, is to explore how scientific "places" are not only conceptualized by transnational circulations and "spatialization", but as much by "localization" (Schaffer 1991, p. 190; Dumoulin Kervran, 2018). This last approach takes a more embodied, material and historicized approach to "situate" knowledge and to the geographical distribution of "scientific places". When investigating localization processes in the Algerian desert, Martinique mountains and French Guyana rainforests, we will use the terms "territory" to point to an assemblage of humans, non humans and topography, and "local society" to refer more precisely to human populations living in this territory.

² Major cities in the global south do have now their lab studies (Kreimer, 2019). These territories, represented as "remote", "empty" or simply "unknown" places, are successors of 19th century remote locations within industrialized countries (their previous inner margins), for instance as high mountains where scientific observatories were built or wild coastal areas where first marine biological stations emerged in Europe.

Finally, “placing” will be a very useful and encompassing concept for this purpose if we follow a more pragmatic stance proposed by Meyer & Molineux-Hodgson (2016). The word “placing” has been used metaphorically by most prominent authors in STS. In this sense the term only shows how an author is analytically positioning an activity or a concept in a broader context, whether it be a sector of activity or more conceptual fields (see Shapin 1998, Leith & Vanclay 2017). In our perspective, *placing* is the main object of study, as a set of social practices that researchers would be able to describe and analyze. Following a large array of STS studies on place and scientific practices (Latour, 1987; Shapin, 1988; Livingstone, 2003; Secord, 2004), *placing* points to a twofold process: how a place is chosen and continuously fitted out by building and maintaining “access” to these territories (Ribot & Peluso, 2003), and how this place is connected with other places through circulations and distant social interactions. We follow Meyer & Molineux-Hodgson when they consider the *placing* as strategic, spatially and timely deployed, socially productive, creating new communities of expectations and new connections between previously segmented social fields. Nevertheless, specific features of “outpost” lead us to insist on two other dimensions of the *placing* process. First, each of us focuses on place-making itself - on the production of a unique place. That means that we pay attention to non scientific local interactions, possible conflicts and peculiarities of each territory, both material and imaginary (Kneas 2020). Second, we insist on spatial asymmetries and how long history made them, as long as we consider together placing process, and postcolonial dynamics in science. All these specific understandings of “placing” are encapsulated within our following presentation of the “scientific outposts” concept.

Postcolonial placing

An important feature of our “scientific outpost” is that they stand at the margins of former “empires”. They are scientific infrastructures located in (post)colonial territories, so called because the modalities of colonial representation do not stop abruptly with independence and leave deep traces in the sociopolitical order of the formerly colonized countries. . Historians of colonialism have largely transformed the importance we must attribute to scientists and scientific knowledge for colonial government. More broadly they described how scientific modernity itself and industrialized European societies have been deeply innervated by colonial experiences and related knowledge productions (Saïd 1993, Mc Leold 2000, Bonneuil, 1991). As written by Drayton (1999, p. 251), mother nations of imperial projects have turned daughters of them.

The world of outposts, with its reference to Conradian Congo at the end of XIX° and beginning to XX° points to colonial “frontier culture” based on scattered colonial presence and exploitation. Our conceptualization of “ scientific outposts” relies more on studies on exploration and extraction “regimes” (Schiebinger & Swan 2004, Frost 1996), than on “colonial science” approaches as presented in the literature on “science and empire” (for French colonialism: Petijean et al. 1992; Osborne 2005; Bret et al, 2019). These approaches rely on how science has shaped direct exploitation of the whole territories and the control of populations in the context of plantation and settlement colonies - as agronomy or medicine - that established permanent infrastructure near population centers. Outposts sciences share with the *exploration and extraction mode* of science practices of collection, inventory with a / mandatory transfer resources to “calculation centers” to gain scientific authority (Latour

1987), as well as indirect economic power. They are also shaped by the institutional legacy of the French centralized “colonial machinery” (McClellan, Regourd 2000) and echo the quest for prestige of pre-republican times (see McClellan III and Regourd, 2000, 48-49) as the competition of colonial powers perpetuates through cultural national hegemony (rooted in scientific authority).

Thus, another inspiration are studies in *Postcolonial STS*, because they show the importance of observing remote interactions and practices of scientists in order to understand how science is produced in central laboratories and global cities. Influence on European natural sciences is extensively documented (Schiebinger, 2005), as well as the impact of the emergence of quantified ecology in Africa during the 1920s on French scientists (Lachenal, 2016) - or in the Caribbean for North American Scientists (Raby, 2018). Building on postcolonial STS means that we pay attention to how techno-scientific resources are translated between sociocultural space and how they reconfigure local societies and forge new cultures (Anderson 2002; Chambers, Gillespie, 2001). However, outposts maintain distance to local societies and we also partially adopt a “metropolitan perspective” (McLeod 2000, p. 11) by following the scientists themselves living in “bubbles”. Interactions with “locals” are documented but we insist on social and epistemic exclusion. This approach enables us to measure the strength of (post)colonial policies on the ground level, from faraway places, often considered problematic for scholarly practice.

Measured by the distance from political centers in the metropole and the alteration of their location, these scientific places are isolated in three ways: one, as overseas postcolonial territories in “tropical regions;” two, as outbacks or hinterlands within former colonial territories; three, as locations with difficult access and exclusive membership. These overseas (post)colonial territories are part of what we can call “sparsely populated regions” (Le Tourneau, 2020), characterised by “low overall population density, incomplete control by central states, remoteness and the existence of specific life-styles and societies.” Our three case studies are located in desert or tropical natural spaces, perceived as frontier zone, “elsewhere,” exotic, remote, and mostly empty. In Martinique, the volcanological observatory stands on “mornes” (hills), which were permanently settled after 1848 by former slaves, whereas the coast is home to planters, as well as colonial and state institutions. In Algeria, major urban centres and colonial offices are situated on the coast, far from the Hammaguir rocket launch base, constructed in the desert. Similarly, biological stations in French Guiana were established in the tropical forest that covers the hinterland, some distance from the urban centres on the coastline where most of the population is concentrated. This distance is also reproduced by the different types of boundary work (Gieryn, 1983) engaged in by residents of these outposts. Their access is exclusive thanks to the logistical challenges inherent to reaching them and the continuous social reproduction of distance by means of epistemic and social boundary work. Local residents are largely excluded from these places: Nomadic Berbers in Hammaguir, small farmers in Martinique, Maroons or illegal gold diggers in French Guyana. The access of local elites is also restricted or used strategically to maintain boundaries between these outposts and urban centres. As a consequence of this distance and enclosure productions: scientific outposts have very low visibility for local populations and elites and thus their contestation is weak.

Our analysis of this postcolonial placing of “French science” aims to identify the characteristics of these “scientific outposts,” despite the substantial differences between their location, historical trajectory, and scientific disciplines. What we call outpost “placing” is

analysed through a comparative method as a three-dimensional process: 1. building a (remote scientific) place = the colonial dynamic that led to the choice of a distant and “underdeveloped” location at the margins, 2. spatialising = the experience and management of profoundly unequal overseas connections between these “outposts” and the “centre” (through metropolitan laboratories and institutions), 3. localising = the frictions between local communities and daily scientific production.

2. Building scientific places in remote postcolonial territories (Far away politics)

In this first part we are inquiring how specific (post)colonial appropriation practices are molding the choice of where to build scientific infrastructure. We argue here that scientific outposts are situated in colonial “frontier territories”, imagined by colonial powers as remote, sparsely populated areas. Scientific infrastructure is anchored in these spaces by three interdependent colonial processes. First, for each case-study, we show how scientific infrastructures are embedded in economic extraction processes. Scientific data production both mimics and accompanies economic exploitation in colonial “frontier territory”. Second, since the areas of anchorage are both imagined as hostile and subject to conquest, military presence is enabling the emergence of scientific outposts. Third, while slowly gaining autonomy from the former processes, outposts are relying on mobile and temporary scientific missions and explorations that only slowly stabilize to permanent local anchorage. As scientific frontier infrastructure, they depend on larger investment of the French state, sometimes from competition with rivaling colonial empires, and have to withstand collapse and abandonment.

| Martinique | Political chronology | | Scientific chronology |
|-------------------|--|---------|---|
| 1502 | - First contact with Europeans | 17th c. | - First scientific expeditions |
| 1653 | - First colony | 1803 | - Botanical garden |
| 1670 | - Extermination, assimilation and displacement of indigenous populations, - Installation of plantation economy and slavery | 1902 | - Meteorological and volcanic observation post : a place for data transmission; |
| 17th - 19th c. | - Colonial wars | 1935-36 | - Service of the physics of the Globe of Martinique, first concrete building: <i>a laboratory</i> |
| 1848 | - Abolition of slavery - Overseas department | 1946 | - Volcanic observatory joins the Institute of the Physics of the Globe |

| | | | |
|------------------|--|-----------|--|
| 1946 | - Overseas department & region | | of Paris: place of data transmission |
| 1983 | - General strike | 1970 | - University of the French Antilles & Guiana |
| 2009 | - Single regional government | 1976-2019 | - Ambivalent status between laboratory and data transmission |
| | | 2019 | - New building with laboratory facilities |
| Algeria | Political chronology | | Scientific chronology |
| 1830-1848 | - Colonial conquest | 1840-42 | - Jean-Baptiste Bory de Saint-Vincent's Algerian scientific expedition |
| 1900 | - Installation of a general governor | 1881 | - Congress of the French Association for the Advancement of Sciences (AFAS) in Alger and Oran (1988) |
| 1902 | - Creation of Alger, Oran and Constantine départements, Military administration for the southern territories | 1894 | - Foundation of the Pasteur Institut Pasteur in Alger |
| 1944-1946 | - Provisional government of the French Republic | 1947 | - Scientific and military base |
| | - War for Independence | 1950 | - Launch of a first rocket "Véronique " |
| 1954-1963 | - Independence | 1954 | - Autonomy of civil sciences |
| 1962 | | 1965 | - Launch of satellite A1 on a «Diamant » rocket. |
| | | 1967 | - Transfer to southwest France and then to Kourou in Guiana |
| Fr.Guiana | Political chronology | | Scientific chronology |
| 17th c. | - Official colonisation | XVII°-X | - Scientific expeditions from Métropole |
| 1848 | - Abolition of slavery and creation of penal colony model | XI° | - Botanical Garden in Cayenne |
| 1946 | - End of penal colony and overseas department | 1872 | - Scientific French Institutes in Cayenne (Pasteur and the futur Office for Scientific Research in Overseas Territories) |
| 1962 | - Overseas region | 1940-54 | - Kourou Space center & Forestal Paracou station |
| 1995 | - Creation of the Nouragues Reserve | 1967 | - 1st "Muséum" camp / Arataye River |
| 2007 | - Creation of the "Amazonian Parc" | 1978 | - Creation of "Les Nouragues" Station with Strong investment of CNRS* |
| 2010 | - Single regional government | 1987 | - Internationalisation, Growth of |
| | | 2000-10 | |

| | | | |
|--|--|---------|---|
| | | 2011-21 | Model Ecology & local scientific infrastructure - Growth of Financial support & of Cayenne's Administrative office |
|--|--|---------|---|

Table 1 : comparative chronology

Volcanic observatory of Morne des Cadets, Martinique

The “old” French colony Martinique in the lesser Antilles was already during the second half of the 17th century a popular field for naturalists and missionaries publishing on the natural history of the lesser Antilles. These first scientific investments overlapped with the extermination, assimilation and displacement of the indigenous population as well as the gradual installation of the plantation economy and transatlantic slave trade. Whereas the first naturalist accounts of the Antilles are directly embedded in colonial expeditions, the French Academy of science allowed for autonomous scientific endeavors after its foundation in 1666. However, Martinique’s position close to other colonial insular territories made the expedition mode of colonial conquest also suitable for the scientific accumulation of taxonomic knowledge. Expeditions notably served the economic needs of a plantation economy identifying medicinal or agricultural plants for the mainland and other French colonies and for the collections of emerging metropolitan museums of natural history.

A first demand of the local intendant for a permanent scientific place, a trial garden, was still rejected by Louis XVI in 1787. A botanical garden only opened in 1802 with a naturalist as its director as an initiative of the local colonial prefect to celebrate Martinique’s return to France after the British occupation of the island. Apart from this representative function, the garden naturalized crops from other colonial territories and supplied the metropolitan botanical gardens with tropical plants from the French Caribbean as did the naturalist expeditions before. In 1886 an agricultural laboratory was attached to the garden further highlighting the transition of Martinique from field to laboratory pushing the scientific frontier further inland.

From 1878 onwards a professor of natural history was also present in Martinique due to the foundation of the Schoelcher college, funded by local authorities, again after the initial resistance of the central colonial power. Still, the lack of local experts became apparent when in 1851 and in 1902 scientific commissions examined the Mount Pelee volcano after signs of activity. The first commission consisting of military pharmacists and doctors underlined in their report their lack of necessary competences. The composition of the second commission of 1902, formed by two professors of natural history of the Schoelcher college alongside a military engineer, a military pharmacist and a lieutenant-colonel of the colonial troops, shows the scarcity of local scientists and the availability of colonial military expertise.

The botanical garden and the Schoelcher college were eventually destroyed during the May 8, 1902 volcanic eruption and so the colonial state relied again on scientific expeditions. The Minister of the Colonies mandated a mineralogist, a Navy engineer and a doctor of science to make a short stay in Martinique. When on August 30, 1902 the town of Morne Rouge partially disappeared after another eruption, Alfred Lacroix, the mineralogist from the first mission, was sent back to the island. In a military logic, he decided to install two

observational outposts on inland mountaintops for observing the “enemy”, the active volcano. One was quickly abandoned while the other was maintained with the help of the colonial troops. Equipped with a boat, Lacroix abandons the observation post regularly for small expeditions. When in 1903, Lacroix returned to Paris, the Governor delegated observation activities at the observation post entirely to the local military battalion. When its commanding officer left Martinique in 1905 for a new assignment, only two adjutants continued observations. Five years later the General council of the colony questioned the Observatory's existence by criticizing the incompetence of its military personnel. Eventually, the remaining soldiers were relieved from their observation duties and the governor assigned the outpost to the professor of natural history of the reconstructed Schoelcher college. Hence, the military-scientific collaboration remains limited in the Martinique case to the crisis situation where a once territorially stable colonial power had to retreat from half of the island.

The first observational huts appear in Martinique because of the absence of population in the area at risk. Lacroix relies on interviews with survivors to gather data on the volcano's activities. The first outposts replaced in that sense the observations of local populations that fled and made it also possible to reaffirm the presence of the colonial State in an abandoned territory. The colonial power questioned by its inability to manage the eruption of 1902 (no evacuation, the governor perishes in the eruption) thus prepares the reconquest of this space to reintegrate it into the settlement colony. Once the crisis was over, the outpost lost its strategic position and military involvement decreased to a bare minimum. It is however noteworthy that its observation logs focused on meteorological observation after the end of the eruption cycle, observations that colonial troops made since the 18th century to anticipate storms and assure the maritime connection and therefore the export of goods.

A second eruptive cycle between 1929 and 1932 triggers the construction of a concrete building on a neighbouring mountain top next to the original observation huts and in 2019, a new bigger building displaces the observatory again to another neighbouring hill, abandoning again the former infrastructure. Over a century a territorial “placing” allowed to fix the observatories on top of “mornes”, volcanic peaks between the ruins of former plantations, abandoned industrial infrastructures from rum production and small farms of former slaves.

The case of the volcanological observatory anchored in Martinique shows how the late scientific investment of the colonial authorities gave place to outposts in absence of other scientific institutions.

Space launch site Hammaguir, Algérie

The colonization of Algeria by the French began in the 1830s and continued in a violent process of wealth capture and military domination of the territories throughout the 19th century. Long before the installation of the space base in Hammaguir, the Algerian colonial space was invested for scientific activities: cartography (Blais, 2007, 2014) and astrometric surveys (Soulu, 2016: 422) participated in creating a grid directly serving the worldwide colonial domination. Similarly, the geological exploration of the Algerian subsoil aimed at capturing coal (Pervinquière, 1908), copper and lead (Gaultier, 1905). This scientific investment was used by the French political authorities to divide the colonized space via administrative divisions: the Territories of Southern Algeria (where the Hammaguir launch

base was positioned) were created ex-nihilo as a regional entity. The Algerian hinterland is considered by the colonizers as a desert space and contrasts with the coastline, more populated and commercially more developed. From the beginning of the colonization, the coastal strip was caught in a dynamic of extraction and agricultural development.

This work of the colonial division of the desert space accompanies and nourishes two parallel processes. On the one hand, this territory is considered void of inhabitants. The Tuareg populations that crisscross the tracks are ignored, neglected or fought against (Naegelen, 1952: 48). The very name Hammaguir points to the violence of an occupation that denies the presence of the local populations and their occupation of the place by artificially creating a local name combining two indigenous terms, a rocky plateau (Hammada) and a *wadi* (the Guir). On the other hand, since the indigenous presence is invisible, the colonial power strives to configure the dominated territory according to its views. From the 1930s onwards, the desert was notably imagined as a tourist area for the French metropolitan population with the construction of roads, the establishment of dedicated infrastructures (hotels), and the advertising of the "automobile cruise in the Sahara" (de Foucaucourt, 1932). Rail transport constituted the ultimate shaping of the colonized desert space. The construction of a railway line linking the Mediterranean to Niger, passing through Colomb-Béchar (Archinard, 1924, Deschamps, 1931) is supported by the French military. The aim was to provide a robust infrastructure for the transport of troops as well as for the circulation of goods.

The establishment of the French space activities in Hammaguir is thus based on this generalized exploitation of the desert space. Since the 1940s, attempts to launch rockets on the metropolitan soil failed and, immediately after the end of the war, the French authorities designated an area in the desert as a military firing range. The area of Colomb-Béchar (the nearest town) is chosen because of its proximity to the desert, its good visibility and the presence of a railroad. Quickly this first firing range is insufficient and so in 1948 the military started to test rockets 120 km from Colomb-Béchar, in the area artificially named Hammaguir. About ten years later, further south in the desert, the French army established two military bases for nuclear testing (Reggane and In Eker). These new infrastructures are, in a way, the margin of a margin, that is, an area of nuclear testing and where the transportation infrastructure also serves the miners. The Algerian aerospace center consists of two distinct places: Colomb Bechar, a place of exclusivity for Interarmy center and in Hammaguir a place of experimentation for scientists and soldiers (launching rockets, checking their trajectory, measuring in the atmosphere, testing on animals)

This military stabilization of colonial domination preceded and accompanied the work of French scientists who began to explore the spatial domain. The Hammaguir outpost is based on an ancient colonial presence, an invisibilization of the local populations and a reconfiguration of the place (associating an urban center [Colomb-Béchar] and a launching base [Hammaguir]).

“Les Nouragues” biological station, Guyane

Guiana is a territory that has remained demographically, economically and scientifically marginal for a very long time, even centuries after first French settlement in 1503 and foundation of Cayenne in 1643. The French State whose authority has been locally

challenged for a long time, has devoted very little attention to it, not investing neither in a settlement nor a production colony. After the abolition of slavery in 1852, this ultra-periphery has been first used by the French government to create a network of famous prisons in 1852. The creation of the Guiana Space Center in 1965 is a major investment of the French state in French Guiana. Nevertheless, since the 17th century then throughout the 20th -and 21th- centuries, scientific naturalist expeditions had famous achievements in Guiana (Lezy 2000, Allorge et al. 2001). Major research organizations with headquarters in Paris only settled during the second part of the XX century in the capital Cayenne. An independent "University of French Guiana" was only developed in 2014. The creation of perennial scientific infrastructures in ecology, the discipline producing most of scientific publications on Guiana today, has been each time the secondary result of the few major economic development projects of the central state: Kourou space center between 1965 and 1968, biomass "Green Plan" in 1975-76, and creation construction of the Petit-Saut Dam in 1989-1994 which provides almost half of Guiana's electricity. The current map of scientific institutions overlaps with Guianese development. It focused on the capital, Cayenne, then the space center in Kourou, and finally the coastal strip where the vast majority of guyanese population lives, as illustrated by the road network which still exists only on the latter.

The creation of the Nouragues station by biologists in 1987 embodies the penetration of national scientific institutions - in particular the French National Research Council CNRS, in the Guianese interior through the growth of the tropical forest ecology. It went along with the new preoccupation of the central State to conserve tropical forests and manage those territories by creating natural reserves. The goal is notably to control the advance of a new wave of illegal mining activities that appeared in the 1980s and accelerated from the year 2000 onwards. The station is thus included in the Nature Reserve of Nouragues (the largest in France) created in 1995, when the entire interior territory was declared a National Park (the project of the Amazonian Park of Guyana was launched in 1992 and created by decree in 2007). The scientists of the station, focusing on basic rainforest research, are by and large not in direct contact with the military. However, the isolation of the zone has favored cooperation: the scientist J.-M. Thiollay discovered the area in 1987 thanks to helicopter flights with the military while the same year a plot of land for the drop zone was cleared by military allowing for the construction of the station and delivered the first fridge. Moreover, soldiers and researchers have a similar global trajectory, arriving in French Guiana in the 1970s from former French colonies after their independence. Then, police and military operations based on a new doctrine of controlling the Guiana interior take place in parallel to new scientific installation. The goal of pushing back illegal gold mining leads to some onward collaboration between scientific and militaries from 2007.

The creation of the Nouragues station occurred in a zone that remains very isolated from Cayenne until today: access is done either by helicopter, or by car and then 6 hours by canoe. This region, upstream of the Approuague River and then of the Arataï River, embodies, seen from France or even from Cayenne, an empty territory (no population nor roads), a margin of the margin, an unknown, dangerous and mysterious Guyanese deep forest. The region and the site of the station were chosen by scientists precisely for this "emptiness". The main argument was that it was an un hunted, non-anthropized primary forest, even though. The region could actually be better described as frontier territory, as it has experienced various waves of extraction for the last 150 years and since 1999, illegal gold miners has become very present again all around the station. The exact location of the

station was the result of a long process based conducted by a small group of scientists belonging to several research organizations headquartered in Paris, but relying on various field camps in the forest. It was not until 1987 that the present location was fixed on an “Inselberg” site.

The colonial authorities built these three scientific outposts at the margin of the French empire. This remoteness justified as a colonial category the need for military and scientific intervention to exploit rare scientific resources. This marginality has two dimensions. These territories are defined by remoteness from the colonial center and in contrast to the densely populated and developed coastal areas. This gaze from the outside without prior knowledge produced these territories as empty and dangerous. Whereas it is the erupting volcano that creates a “hostile” and “empty” space in the case of Martinique, the Sahara Desert and the tropical rainforest serve the same purpose in the case of Algeria and Guyana. The pyroclastic flows of Mount Pelee, an unknown scientific phenomenon, the sparsely populated Algerian desert for dangerous experiments and the specific quality of the Guyana tropical ecosystem with an “Inselberg” and tropical forest at different altitudes constitute resources that localize scientific research in these spaces. However accessibility is crucial for maintaining an outpost. Presence of some transportation infrastructure orient the choice of a specific place (road, river, railroad or air strip) but scarcity of infrastructure in spite of all is a common feature.

This first step of scientific placing has to be understood within a broader dynamic of extending the colonial state linked to economic exploitation and military control. However, scientific outposts gained autonomy from these processes by their progressive socialization within emerging scientific fields. The postcolonial condition explains some central features of scientific outposts, not just in the process of choosing a place and building a permanent infrastructure, but also in the management and institutionalization of these scientific places, as we will see.

3. Spatializing: the ambivalence of center - periphery relations

The post-colonial logic of scientific investment involves regulating the relationship between the metropolitan center and the periphery. While it is clear that these were the material and symbolic advantages that France, as a (post-)colonial power, could gain from its scientific outposts, it must be borne in mind that the distance is also a challenge. Maintaining infrastructure in an area that is difficult to access, sometimes dangerous or hostile, presupposes constant work to solidify scientific interventions and everything connected with them.

Each case study will first inquire about the maintenance of outpost infrastructure and the solidification of scholarly spaces attached to it. First, maintaining infrastructure in an area that is difficult to access or sometimes dangerous requires continuous investments from the center. Thus, scientific outposts are the result of permanent stabilization of spaces of

intervention, which also entails the management of human resources. In all three cases: science is done by scientists coming for limited period of time from the “metropolis”, whereas permanent data collection and scientific infrastructure maintenance is done by technicians, military personnel () and some locals for non-scientific or parascientific tasks. Second, each outpost infrastructure brings into play the properties of embedding, practical conventions and the incorporation of norms from the center (Star, Ruhleder, 1996: 118-119), and we can follow the tensions and ambivalences generated by a scientific activity that is far away but dependent, at all times, from the pulsations of the centre. Third, we trace for each case study the ambiguous legitimacy within the world of science, between prestigious large scientific infrastructures [“Grand équipement scientifique”] and “peripheral sciences” considered only as place of data collection or applied sciences too dependent from the specificities of the place to contribute to the advances of science.

Volcanic observatory of Morne des Cadets, Martinique

In Martinique, the problem of maintaining scientific infrastructure built for mitigating a crisis, appears as a problem of scientific legitimacy of the outpost rythmed by pulsations from the centre. After the necessity of maintaining an observatory in Martinique was questioned several times by local authorities after the 1902 eruption, the transformation of the first simple huts to a volcanic observatory out of concrete is again linked to an intervention from the center after a second eruption cycle of the Mount Pelee volcano from 1929 to 1932.

Although without casualties, the eruptions of 1929 caused damages to the island's infrastructure and revived the spectre of the 1902 eruption. Since the seismographs of the observation post had recorded no warning signs, a national scientific commission at the Ministry of Colonies suggested the construction of a modernized volcanological observatory on the site of the former observation post as well as a meteorological observatory at a military Fort in Fort-de-France. Subsequently, the French government allocated a vital part of the national contribution for the reconstruction of Martinique to volcanic monitoring. The new Volcanological Observatory building, constructed as a local laboratory and only the second concrete building of the island, was inaugurated in 1934. To appease local resistance, a new local laboratory, the "Colonial Globe Physics Department" replaced the former outpost for data collection. It allowed for a local scientific advisory committee, but its “scientific organization and the general control of the operation shall be regulated later by the central power.” (Colonial Office, 1931). Already in 1936, at the end of the eruptive crisis, the General Council of Martinique gave up financing the Observatory when its disaster mitigation mission disappeared. Lacroix noted in 1938, that "in Fort-de-France its usefulness is discussed; its subordinate staff is reduced or threatened, its credits if not its existence is threatened." (cited after Henry, 2008).

The Observatory remained a colonial institution until 1946, when the Institut de Physique du Globe de Paris (IPGP) took over its management, even though the local General Council remained the owner of the building. The attribution of the Observatory to the IPGP corresponds to the restructuring and differentiation of the French earth sciences with the foundation of the National Meteorological Office in 1945, which in turn took over the meteorological observatory of Martinique. For the scientific outposts, decolonization in the

form of departmentalization was, in fact, a centralization, in the sense that the two Martinique observatories became branches of Parisian institutions. Correspondence between the director of the IPGP and the head of the Observatory shows how the details of the Observatory's daily organization were managed remotely. On the other hand, some aspects of this institutional change, such as the attachment of the Observatory's employees to national educational bodies and salary issues, did not materialize for the Volcano Observatory until 1959 after the death of its director. He committed suicide in the isolation of the Observatory.

Following this incident IPGP always maintained two researchers in place with the help of local technicians, but even though researchers stayed in Martinique for years, they saw their assignment as a temporary mission. Still in 1964, one of the researchers imagined an automatic data collection with the responsibility of the Observatory in the hands of a local technician. Complaints about the lack of comfort in housing and about the lack of recognition for the work in difficult conditions are common issues in the correspondence from this time period. From 1970 onwards, the post of Director was finally assigned to a metropolitan engineer, who was responsible for data production and would be joined by a researcher with a temporary assignment. Technical advances in remote sensing allowed continuous instrumentation of the volcano. During the 1990s and 2000s, researchers were again given the direction of the Martinique observatory assisted by postdoctoral fellows. Still the distance to the central laboratories and the high work load in monitoring activities and risk communication to the local population make the position unattractive in the long run. Notably, it is rarely possible for the local scientific staff to analyze observational data and publish on it. Researchers either remain for a short period of time or they are obliged to remain for years in absence of suitable replacement. Scientific missions compensate regularly for the lack of staff on site.

Nevertheless, in 2019 a prestigious new observatory opened. This second most cost-intensive building on the island is co-financed by the local government and the European Union, whereas the central IPGP is responsible for equipment and staff. The new building is equipped as a laboratory, but the observatory's staff is not sufficiently well equipped for analyzing data locally. After having oscillated between a place for data transmission and a laboratory, the observatory remains in between places.

Space launch site Hammaguir, Algérie

Hammaguir is a friable space: the living conditions in the desert are known to be difficult. The first installations in 1947 were precarious. The first soldiers to settle there lived in tents and only benefited later from permanent infrastructures. The equipment essential to military and civilian activities on the firing ranges required masonry constructions. Notably, the cinetheodolites, instruments that allow to follow the trajectory of fired missiles, require concrete shelters. In the same way, the "Central Firing Range Station" is a solid building that is essential for the proper functioning of the base, since all firing sequences are organized within it. The construction of the shooting range and all the infrastructure of the base exploits local material resources, but the contractors regularly solicited by the engineering services belong to the economic universe of the colonists. For example, the construction of the

Central Station of Champ de Tir is entrusted to the company *Travaux & Constructions dans le Sud*, directed by Barthélémy Pessione.³

Since the infrastructures were used both for the tests of the military rockets as for those of the civil rockets, the scientific autonomisation is a complex and slow process in Algeria (1948-1967). The cinetheodolites, are for instance manipulated by the military to assist scientific work. For a long time the engineers and physicists were only missionaries who came to use military infrastructures for their research. The most important scientific decisions were taken in France (in Paris for the National Centre for Space Studies (CNES), in Verrière-le-Buisson for the Aeronomy Service): it was there that the research carried out at Hammaguir was programmed. When it comes to building and operating heavy and costly infrastructures (such as a military and space base) the administrative procedures are very centralized in France. Hammaguir is thus, for the most part, controlled from the political and scientific centers of the French metropolis. The science practiced at Hammaguir is different from what is implemented, for example, within the Aeronomy Service at Verrière-le-Buisson. In Hammaguir researchers spend a few weeks in the desert and then return to Paris to analyze the results and publish articles.

It is not only researchers who circulate between Hammaguir and Paris. Data also circulated. On site, the military personnel of the base helped with the implementation of the experimental devices. However, Hammaguir is a real colonial "bubble" in Algeria, even after decolonization: the place has its own means of supply from the metropolis, its infrastructure of daily life (from the bakery to the open-air cinema).

For enabling pulsations from the center, the maintenance of a direct air connection between central France and the Colomb-Béchar-Hammaguir complex was essential. The challenge was to transport personnel and large quantities of material (notably fuel, rockets...). Two airfields were opened, the first one, Béchar-Ville, was for commercial traffic, the second one, Béchar-Léger, was reserved for military transport. These strict rules were relaxed with the arrival of scientists in 1957. Physicists from the Aeronomy Service (SA), engineers from the Ballistic and Aerodynamic Research Laboratory (LRBA), from the National Office for Aerospace Studies and Research (ONERA) and from the Center for Teaching and Research in Aeronautical Medicine (CERMA) do not live permanently in Hammaguir. They came at regular intervals to participate in launches and to conduct experiments. All of the aforementioned laboratories are based in metropolitan France (Verrière-le-Buisson, Vernon, Palaiseau and Paris respectively). Military personnel maintain the infrastructure: they occupy the site permanently and help with the handling of instruments and rockets on site. The center (metropolitan France)/periphery (colony) dependency worked in both ways. On the one hand, the military on site did everything to get supplies in France and to bypass the local supplies; on the other hand, the scientists obtained permission to continue to exploit the launch base for five years. Here comes postcolonial science with a high interest of metropolitan political authority. The legitimacy of scientific practices in Hammaguir is, in a way, backed by the military interests of the state which develops missiles for military purposes.

³ ASHD, GR 1H 3382, Barthélémy Pessione, 9 juillet 1963.

“Les Nouragues” biological station, Guyane

Spatializing “Les Nouragues” main practices highlights how, since the creation of the station in the 1980s this remote patch of tropical forest is only connected with scientists from metropolitan France, even though circulation slightly grew with Cayenne during the last 15 years. The station’s trajectory has been shaped by the importance attributed to it at the very far CNRS headquarters in Paris and by the decisions taken there: investment, appointment, or budget cuts affecting the daily life of the small team. Locally, the still fragile institutionalization of the station is shown by the construction of various buildings, the creation of the Nouragues Reserve and a second infrastructure, the Pararé camp near to the Inselberg (1995). Furthermore, the installation of a system of paths and forest monitoring plots or the expensive construction of the COPAS (Canopy Operating Permanent Access System, 2014) further shows the increasing infrastructure of the station. It is also consolidated in administrative terms with a small team of permanent staff and funding, integrated into CNRS management models (scientific infrastructure network, CEIBA laboratory of excellence, etc.). In addition, international calls for projects and grants to access the site with helicopters since 2007 has enabled an increase in the number of international residents and enhanced the international scientific fame of the station.

However, the scientific authority of the station as a place of research remains ambivalent. On the one hand, tropical biologists are often familiar with the station and keep alive its aura of a mythical and exceptional place for fieldwork and for the quality of its flora and fauna. On the other hand, this recognition is exclusively based on specific scientific networks from metropolitan France. The station remains unknown or exotic for scientists from other disciplines or for biologists working purely in the laboratory (molecular biology, genomics, etc.). tainted both by the stigma of fieldwork and by the isolation of the site - the distance from the large laboratories and major conferences of scientific elites. Until 2000, fauna analysis was privileged (systematics, physiology, ethology), then the study of the forest dynamics in specific plots gained visibility through modeled ecology. It has been hybridized during the last decade with the tools of meta-barcoding and environmental DNA, as well as research on climate change and the monitoring of gas exchanges. This turn towards big data has thus transformed the culture of field biology and the instruments have allowed the station to enter the management category of “Big Science” and the networks in which these infrastructures are inserted around the world. The scientific legitimacy gained by this science of the ultra-periphery is thus linked to the political recognition of biodiversity sciences, and climate change debate with a turn towards experimentation and quantification, but also strongly linked to internationalization and to the “size” of instruments and budgets. For institutional, scientific as well as reasons of prestige, the CNRS sometimes describes the station as its “jewel in the crown”.

Biological stations, and even more so those of tropical biology, rely on short research stays. At Nouragues, the periods of intense activity are those of university vacations in France or in other countries of the North from which come the “regulars” as well as those who come only for a specific project or for a week scientific seminar. The visit by helicopter of journalists or political personalities may not exceed a few hours. With the exception of a few doctoral students, the scientists are only present for a few weeks or even a few days. They arrive at the international airport (a few live in Guiana but also only visit the station for short research stays), go directly to the station, and leave with their data.

The station has a small permanent team that "lives" in Cayenne and has consolidated over the years. The management and logistics of the station is handled from Cayenne, by dedicated employees, with an expatriate profile moving from between other French overseas territories. Nevertheless, the maintenance of the station and its data collection infrastructure, and especially, the continuation of certain scientific protocols over the long term as well as the organisation of researcher stays, require a presence on site. The employment contracts became more and more detailed and the periods of living in total isolation in the station more and more supervised putting at a distance the "adventurer culture" of the beginnings.

Spatializing scientific outposts highlights their dependence from metropolitan France's, creating "bubble spaces" of the metropolitan society. However, the tension between norms of exceptionality linked to the particularities of the territories and national-metropolitan standardization as well the tension between structural fragility of these interstitial places and institutionalization⁴, further highlight the ambivalence of the center periphery relations. Still, their fragility is not just due to evolving priorities of the center. These places are also closed or requalified by negotiating their boundaries with local societies as we will show in the following part.

4. Localizing Outposts in Postcolonial Territories: Frictions with Local Societies?

In order to understand the complexity of the historical pattern, it is necessary to detail how the interactions between scientists working in distant dominated places and local actors are organized : "mornes" and post-abolition small farmers in Martinique, desert and Touarègues in Algeria, and uninhabited tropical forests with illegal goldseekers and previous indian occupation in French Guiana.

Localizing outposts requires understanding of how, in this "bubble-place" , daily scientific production is shaped by post-colonial relations with localities. As proposed by Tsing (2004) these frictions with local societies are not limited to exclusion or domination, but are producing some cultural change, particularly in the local society. We observe particularly four aspects of these relations: - land ownership and property aspect of scientific infrastructure, - labor relations in science production: Interstitial and invisible relationships with certain "residents" and local scientists, - negotiating access with regional governments and elites: these relations can not always be bypassed and are finally caught up by the negotiations around (de)colonial issues, - patrimonialization processes and local and regional appropriations.

⁴ Martinique observatory is plagued by succession of upgrades and abandonment; The Hammaguir base was ruled by a strong military enforced prohibition but it provided a French bakery and an olympic pool in the middle of the desert, and life in the Nouragues station is split between strict CNRS security norms, a celebration of of French cuisine in the "jungle" and displays of "adventurer" culture disregarding common conventions.

Volcanic observatory of Morne des Cadets, Martinique

The case of the volcanic observatory shows an outpost anchored locally. Techniciens and maintenance staff come from the neighbouring communities of Saint-Pierre and Fond Saint-Denis. They remain however limited to this status, since the academic titles necessary for a promotion to engineer can only be obtained in metropolitan France demanding resources and abandoning families. However, as sole permanent staff, their knowledge of the access routes to observation stations and their relations with the landowners giving their land to install those stations is indispensable for the observatory. To ensure its accessibility, the observatory's scientific staff intervened several times during the 20th century to ensure road reparation and maintenance for the mountain village of Fond Saint-Denis and on the volcano. For this neighboring village, the observatory is also a vital employer. When the terrain chosen for the newly built observatory falls slightly outside the village's borders, its mayor insists for instance that the postal address of the observatory remains on village grounds.

Present in Martinique for over a century, the observatory is represented by the local authorities as a central part of the local heritage and is for instance integrated in Martinique's application to the status of UNESCO World Heritage for its Mount Pelee reserve, a flagship project for the local independentist government. The historic buildings as well as a prestigious new complex is owned by this local government as part of the 1945 "departmentalization" reform. The outpost remains also partly a bubble space, since its scientists, all from Paris, do not interact with the local university. However, local tourists and school classes visit the site regularly and its director makes frequent appearances in local media, where the observatory is depicted as a local institution. This current local appropriation echoes the Observatories past as part of the service of the physics of the globe of the colonies from 1934 to 1946, pride of the local political elites.

At the same time, the Observatory has no legal personality of its own and it is partly under remote control from IPGP. Weekly video conferences replace the former weekly correspondance with Paris. The hybrid status and the dependence from pulsations from the centre became again visible when Mount Pelee is considered reactivated in 2020. The scientific advisory board, led by the observatory, oscillated between completely excluding local scientists and integrating them. Thus, the observatory is a scientific place that is deeply rooted locally without losing its strong dependency from the center.

Space launch site Hammaguir, Algérie

The very powerful isolation of Hammaguir is coupled with a process of invisibilization of the surrounding territory and the populations living there. Local frictions are reduced to a minimum. The nomadic tribes of the Doui Ménia, who cross the Hamamguir area, were prevented from circulating after the construction of the launch pad (Gorman, 2009: 136). The invisibility of Hamamguir is also noticeable in the way the scientists refer to their place of experimentation.. It is remarkable that the researchers, in their reports of observation, make the colonial space disappear. First research reports mention Hammaguir (Blamont, 1959),

but in the course of the experiments from 1960 to 1963, the SA researchers increasingly no longer mention Hammaguir except in passing.

The case of Colomb-Béchar is particular: if the military camp is also a form of colonial extraterritoriality (the base has a swimming pool), the encounters with the local population are more common. But Colomb-Béchar is located upstream from the outpost; the city is the administrative and political fulcrum of colonial domination. Farther away, Hammaguir provides metropolitan life reconstituted in the middle of the desert. The local supply of food was deemed insufficient by the inhabitants of the base, who developed a parallel system with metropolitan France. The officers on site tolerated this "autonomous supply system", which isolated Hammaguir even more⁵.

Colonial oppression is also present in the region of Colomb-Béchar. The Vichy government set up prison camps with very harsh conditions in the region around Bechar during the Second World War (notably in Abadla). In the 1950s, the French government reused this model of "regrouping camps" for isolating the independence fighters from the population. The actions of Algerian fighters engaged in the struggle for independence from the 1950s onwards only concerned Hammaguir from a distance: however, some actions were carried out on the Colomb-Béchar-Ain Sefra railroad line⁶ (Bourdieu, Sayad, 1964).

Generally speaking, the whole intellectual and scientific elites (implanted, for the most part, in the coastal cities of Algeria) are ignored by the space program of Hammaguir. The University of Algiers is, at no time, concerned by the experiments in Hammaguir. The attitude of the Algerian political elites after the Evian agreements of 1962 is ambiguous concerning the Hammaguir base that the French military occupied until 1967. Even though the independence leader Ahmed Ben Bella opted for greater Algerian firmness against this perpetuation of the French occupation, "the Algerian government" was caught between the lines: "either it is satisfied with formal protest" and loses credibility or it affirms "its reprobation" and undermines a possible "cooperation". The space base thus constitutes an ambivalent colonial point even in the process of decolonization.

Hammaguir is above all a military base, closed on itself. The principle of colonial "localization" is pushed to its maximum here: the indigenous populations are ignored, as if absent from the landscape. Only Colomb-Béchar allows for some local "frictions", but most of the scientific work is carried out in an almost hermetic bubble.

“Les Nouragues” observation station, Guyane

The Nouragues station embodies the bubble-place where everything comes from elsewhere and everything that is locally produced goes elsewhere. This elsewhere is generally the former colonial calculation centers in metropolitan France, more than 7 000 km away across the Atlantic Ocean. For most of the scientists who come to the station, French Guiana is only the deep forest that surrounds the station. In 1986, the station's plot of land was very easily carved up and negotiated between two entities of the French central state at its Paris

⁵ AVSHD, GR 9R 961-2, Ministère des Armées, Rapport du contrôleur des Armées Le Sage, 30 mars 1967., p. 3.

⁶ AVSHD, GR 8T 213 AFN 122, Compte rendu de reconnaissance d'une destruction opérée par les rebelles sur la ligne Colomb-Béchar - Ain Sefra, 17 août 1956.

headquarters: the “Office National des Forêts” - which owned and managed almost all of the Guianese territory as a “state forest”⁷, and the CNRS - which funded the station. Thereafter, the issue of land ownership is almost invisible (no indigenous claims), as the land on which the station is constructed merges with the vastness of the Guiana forest entirely owned by the French State. Even temporary forestry or mining concessions are absent, given the status as a nature reserve created in the region in 1995. Thus, neighboring relationships are limited to a minimum. The intensification of illegal gold extraction in the vicinity of the station has instituted a regime of cohabitation made up of hostility and avoidance, punctuated by furtive crossings when traveling by canoe, by readings of traces in the forest (clearing or pollution) or by hearing distant sounds.

With the rise of the independence movement since the 1970s, the strengthening of regional authority since 1974 and then the creation of a single territorial government (2010), the legitimacy of a proper Guyanese political polity has gained importance. Calls for relocalizing *Guianese* decision-making and production have gradually taken their place in the political agenda. Central government officials are considered as merely passing through *Guiana*, while their interests and their social, cultural and racial identities are far removed from those of the Guianese population, which is perceived as creole and multicultural (and mainly uneducated) by national elites. This criticism has not spared the large elitist research organizations based in metropolitan France. Moreover, there is a specific opposition between a Creole identity perceived as turning its back on the forest and thus opposing the new metropolitan projects in favor of the interior’s forest space and its biodiversity. Scientific issues are secondary in this politicization dynamic (and even in the demands for “decolonization”), but the station has been criticized in French Guiana over the past decade, as a place closed to Guianese and producing science that is far removed from their concerns.

In order to fight this image of insularity, the CNRS has developed communication campaigns focused on the Guianese population, and partnerships developed with the Guianese authorities. The scientific station remains a place officially “closed to the public”, even if ecotourism has been attempted but remained extremely limited. Counting with very few resources, Nouragues Reserve has been unable to control the station. Nevertheless, recently, some collaborations have been set up, and some constraints have been imposed to the scientifics - such as new regulations for infrastructure and circulation, or wastewater treatment systems. It is also thanks to this collaboration that projects were developed with some inhabitants of Regina, the small town downstream of the Approuague River (6 hours by canoe): micro-projects like short food supply chain for some products, or science exhibitions in a local museum room and rare class visits at the station. These visits, even if they remain exceptional, mark an inflection in the life of the station, as it is perceived in Guiana as a closed and very exclusive place. Even biologists from metropolitan France (and even scientific expatriates in Guiana) have to apply with a solid scientific project to have the privilege of staying there. The station’s employees are only a handful and most are

⁷ Today, 96% of Guyana's 8.4 million ha. are covered by public forests, but land tenure status has diversified, with almost half included in the Guiana Amazon Park and 350,000 ha. of coastal strip.

considered "metros"⁸. The general population of French Guiana are not aware of the existence of the station, or perceive it as an inaccessible place.

In this last part we examined the relationship between daily scientific production and post-colonial relations with the localities in which scientific outposts are anchored. We showed how local political authorities are often bypassed or perceived as obstacles, and that those scientific places are actively excluded from macro political conflicts between (post)colonial margins and the metropolitan center in the name of scientific universality or some other exceptionality. However, those places are still caught up in the localized micro negotiations over (post)colonial issues. As "bubbles", they have privileged relations with their surrounding non-human entities but reduced relations with local societies from whom they are physically and symbolically separated. Scientific outposts have for a long time achieved some kind of invisibility in their region and this could explain the enduring weakness of critics. However, recently scientific outposts have experienced more pressure to connect with local societies and urban elites pushed for more appropriation, insisting on the universal knowledge produced by these places and their local cultural heritage.

Conclusion: Another extractive place

By relying on the trajectories of three different scientific outposts, this article analyzes scientific infrastructure as a post-colonial government of margins. We argued that colonial history produces "scientific outposts", as places connecting the margins with the metropolitan center. This threefold exposition of postcolonial placing connected the empirical description of our case studies with the more conceptual exposition of what we call "scientific outposts". This enabled us to explore their material, geographic, political and epistemic⁹ specificities, the four criteria of the definition we exposed in the introduction of this paper.

Another place for science: historical perspectives

By understanding scientific outposts as postcolonial institutions we unveil two processes which are usually kept invisible. First, we can contribute to question the role of scientific practices in the construction and reproduction of post-colonial global hegemony. We argue that scientific isolationism, materialized in scientific outposts, perpetuates science and its institutions as dominant resources. Outposts symbolize the exclusion and non-recognition of postcolonial territories and their societies and the unequal access to scientific resources.

⁸ Two Saramakas, maroon people from Guiana, work continuously on the station (even though they are actually born and raised in other parts of Guyana) and the official canoe of the station lives in Régina, the coastal town downstream of the river (but is from Brazilian origin). Four other technicians, most of whom arrived in French Guiana to take up this position, relay each other between work periods at the station and rest and recovery in Cayenne (and pass vacations in France!). There is one management position in the Cayenne's CNRS office, but the scientific directorate is in Paris.

⁹ Our epistemological definition of the "scientific outpost" follows our theoretical and methodological choice to focus on places themselves, but the epistemological features of outposts require further analysis.

Second, by focusing on outposts as scientific institutions localized “overseas” we propose to measure the importance of postcolonialism in western research programs by inquiring how knowledge and practices “circle back” to central laboratories.

Scientific outposts must be seen as a new “scientific place” between laboratory and field work where scientific practices aim more at basic science than applied science. Basically, with the laboratory, outposts share the construction of a perennial infrastructure, intense boundary work to create an exclusive place, fundamental high level science production and the enduring dependence on bureaucracy. With fieldwork, outposts share the scientific importance given to specific non-human surrounding, very remote location from “global cities” which make long travels necessities, intensity of these short stays for scientists (as intimate experiment as well as socialization process¹⁰), and difficulties to maintain these ideals of isolation. In order to better qualify outposts, it is useful to compare them more systematically with the definition of laboratory model. We define “scientific outpost ” as a kind of remote distorted translation of the laboratory model with different forms of boundary work and closure.

The historical comparison of the three cases allowed us to show that scientific outposts share many characteristics. Many social practices have proven to be comon beyond scientific disciplines, regions of the globe, historical moments and heterogeneous political contexts. It was also essential to show the constitution of this post-colonial situation: colonial history is always essential to understand the choice of places enmeshed in the dynamics of circulation and global dependence. The history of the Martinique Volcanological Observatory crosses the history of the transformation of a colony into an overseas department. The Hammaguir space base is above all colonial but its purely scientific activities take place in the years following Algeria's independence before being abandoned after the departure of the French. While the biological station in French Guiana was created forty years after the departmentalization. The historical approach also shows how these "scientific outposts" illustrate the dynamics of frontiers: they are places that experienced waves of extraction a century before and left few traces, scientific places that illustrate the passage from expeditions and field camps to permanent infrastructures, but also places whose "permanence" remains fragile, shaped by their bureaucratic dependence on distant metropolitan France. The role of these scientific outposts in the history of postcolonial modes of government is marked in the 1960s by the independence processes of the former colonies, but also more recently by the growing importance of European funding in Martinique or Guyana, reclassified by the new European status of "ultra-peripheral regions".

If we look rather at the influence of the post-colonial context on scientific practices, the historical approach of the three cases highlights how scientific practices have become autonomous from military activities still central to the colonial dynamic (this very strong

¹⁰ Outposts are characterized by small, closed social worlds marked by the laborious atmosphere and the porosity of private and professional life (cf. monasteries and "total institutions' '), by the importance of the processes of socialization and transmission of the values of this scientific field, by the importance of the affective and imaginary charge that scientists project onto this place. (For the way how daily practices shape identity, values and research careers, see *Traweek 1988: 162*). A gendered gaze on the life in the outspos will be very fruitful: they mainly masculine worlds and colonial and postcolonial are strongly oriented in this sense (Londa SCHIEBINGER (dir.), *Colonial Science, Isis*, 96, 2005-1) but the historical comparison we proposed here highlight how the world of biological stations have been transformed in this regard.

relationship weakens in the case of Hammaguir, disappears progressively in the case of Martinique, while it is very indirect and weak in the case of the Guiana station). This comparison of historical trajectories shows that these scientific outposts have stronger social and epistemic boundaries with respect to local societies than the mode of expeditions that preceded it, but also how they have recently gained in local visibility and that their inaccessibility is increasingly questioned by local political elites who are trying at the time to reappropriate their legitimacy¹¹. We also observe a strong evolution of practices increasingly marked by remote monitoring and the automatic transmission of data by capture technologies, which leads to the importance of local practices of maintenance of these scientific instruments.

Generalize Scientific outposts placing in science and beyond : a program

We base our conceptual proposition on French outposts. This is more a methodological and practical choice than one justified for analysing the specificity of the French case. We aim to explore how these outposts give us a better understanding of the broader postcolonial science mode of production. The fact that the outposts studied here are all at the French imperial margins make the comparison even relevant beyond very different historical, political and disciplinary case studies. Moreover, scientific outposts are part of a shared territory for (post)colonial science production objectified by the circulation of scientists and of scientific infrastructure between these margins. We argue that both outpost models and scientific actors circulated intensely in between French post-colonial territories, and we assume that the same dynamic could be identified within other national configurations, and even more in between them. With our conceptualization of scientific outpost, we push towards a broader comparison on similar scientific postcolonial places in other national and imperial spaces, that call for future studies¹².

Our case studies show that scientific outposts are very far from being a fossil of the ancient colonial past. Scientific bubbles in remote territories have been boosted by some technical innovations (i.e. internet or solar supplied computers) and even by postcolonial evolutions since sixty years. As long as there is no need to dominate and manage the whole country to build an outpost (nor belief in a civilizing mission which “had fallen into spectacular disfavour by the last quarter of the twentieth century” (Seth, 2009, p. 374), scientific outposts remain a very important component of the contemporary global regime of science production. High mountains scientific stations, astronomical observatories, polar stations, tropical biology stations, sea-labs and marine stations in abyssal seafloor, space centers, or even the International space station: all these very expensive scientific infrastructures are actually fundamental in contemporary science production. Scientific outposts are thus very useful to describe scientific practices, far beyond the three scientific domains we briefly presented in this article.

¹¹ Nevertheless, these trends obscure the fact that highly specialized and high-tech contemporary science could be a lot more epistemically exclusive and excluding than XIX^e or XX^e century science.

¹² Characterizing some specific features of French post-colonial science production go beyond the purpose of this paper. French institutions and historical trajectory show obviously some specific features, i.e. the french bureaucratic “machine”, with specific centralization path dependency, and only further comparative investigation could better identified the generalization’s potential of our definition of scientific outposts.

Moreover, we think that the Scientific outposts could be also fruitful for a more transversal analysis of current globalisation and modes of capital accumulation in relation to the localisation of scientific practices. Attention to localizing processes by STS scholars could be a very promising point of discussion for focusing on transnational exploitation, prospection and research strategies of global corporations. Even if this logic is not new, scientific outposts must be considered as a new kind of the government of margins by extractive enclave used by hegemonic powers (see Ferguson & Gupta, 2002; Ferguson 2005) and the model of worksite “fly in - fly out” spread all over the world in remote territories for oil and mining extraction industries since the 70’s (Storey 2010). This inclusion of scientific outposts in a broader comparison with the economic enclave model - and global extractive economy - could be another line for further inquiry on scientific outposts.

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