

How science-society interactions design post-mining territories: transdisciplinary patterns in Cévennes, France

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Abstract In line with the European Union's guidelines, the context of a mining resurgence in metropolitan France plans the prospective opening or reopening of mines. In this general context, the politicization of the post-mining subsurface is sparked by this mining industry rebirth, linked to reminiscences of its mismanagements. Politically and socially, research advances on post-mining issues become strategic knowledge to legitimise such a position. We hypothesise that the knowledge produced in the research has a longer reach (a more robust social impact) when it is co-constructed with the inhabitants, thus leaving the confined field of science to fertilise concrete action on the territory. Based on three case studies in the Cévennes informed by a review of scientific literature and the media, semi-structured interviews with scientists and local inhabitants, and informal interactions, this paper argues that even though they were not designed as participatory, the research processes investigated have become so, *via* spontaneous interactions with local inhabitants. We analyse the circulation of knowledge during the research processes and its impacts on the learning of researchers and inhabitants involved and on the territory. A reflection concerning a typology of forms of transdisciplinarity ongoing, and their influence is outlined.

Keywords: citizen science, transdisciplinarity, knowledge, post-mining territory

1. Introduction

In line with the European Union's guidelines, the context of a mining resurgence in metropolitan France plans the prospective opening or reopening of mines. The grounds to support this approach include the ecological transition and national energy independence. In this context, the politicization of the post-mining subsurface is sparked by this mining industry rebirth, linked to reminiscences of its mismanagements (Balan, 2021). In the Cévennes (South of France) polymetallic mining operations have occurred since Gallo-Roman times. Due to competitive foreign mineral raw material supplies, the region's mines began to close gradually in the 1990s. The economic, social, sanitary, geotechnical, and environmental local consequences still affect the territory. In these global and national contexts, research advances on post-mining issues

(phytoremediation, containment of mine tailings etc) become politically and socially strategic knowledge to legitimise such a position. This reveals the entanglement of societal and scientific features that make the territory. We hypothesize that the knowledge produced in the research has a longer reach (*i.e.* a more robust social impact) when it is co-constructed with the inhabitants, thus leaving the confined field of science to fertilise concrete action on the territory. We will first discuss the circulation of knowledge in each project studied and then we will analyze their effects on the territory.

2. Methodology

2.1. Description of the territories and research projects studied

Three past research projects were investigated in three polymetallic post-mining territories in the Cévennes: Saint-Laurent-Le Minier (hereinafter Saint-Laurent), Saint-Sébastien-d'Aigrefeuille (Saint-Sébastien) and Saint-Félix-de-Pallières (Saint-Félix).

A significant lead-zinc deposit was located in Saint-Laurent, managed by Metaleurop during the last years of extraction. The ADEME (the French Agency for Ecological Transition) has taken responsibility for the site since 2009. A research project on phytostabilization (SyMetal) took place there and investigated the role of symbiotic mechanisms between a plant (*Anthyllis Vulneraria*) and its rhizobium zinc and cadmium resistant.

The former mining site in Saint-Sébastien was operated by the Peñarroya until 1963. Since 2010, it is in part managed by the ADEME. The research project was adjacent to the scientific monitoring center OSU OREME (Observatoire de REcherche Montpelliérain de l'Environnement). It was focused on an acid mine drainage, the main source of heavy metals and metalloid pollution in the territory. The spontaneous attenuation process was particularly investigated.

Saint-Félix was home to numerous mining sites ran by Umicore. The former operator now manages a small,

contaminated area, while the rest remains unmanaged. Several expertise works were undertaken by researchers, but very few formal research work was conducted.

2.2. Data collection

There were three stages in the data collection:

- 1) a review of scientific literature and the media (respectively 84 and 221 articles about post-mining challenges on these territories)
- 2) semi-structured interviews with scientists who worked on these territories, and local inhabitants committed to the issue, most of the time also visible in the media, (respectively 5 and 14) were recorded, fully transcribed and qualitatively analyzed *via* the software Sonal
- 3) informal interactions during field trips, which have proven to be essential to our data collection as several people refused to be recorded

3. Results and discussion

3.1. Participative or not participative?

None of the projects was thought of as participative. Yet, the interactions between scientists and local actors were not scarce. Following Gibbons et al. (2010), we propose to use the "Mode 1", and "Mode 2" production of knowledge distinction to comprehend the knowledge linkages at play in each case study. The Mode 1 of knowledge production takes place in academic and disciplinary contexts, is homogenous and autonomous (Hessels & van Lente, 2008), whereas the Mode 2 is described as "socially distributed, application-oriented, transdisciplinary, and subject to numerous accountabilities" (Nowotny et al., 2003, p. 79). We acknowledge the limits of this distinction pointed out by the literature, in particular its blurry contour and its failure to be applied to real cases (see Hessels & van Lente, 2008), but we believe these categories are heuristically useful.

In Saint-Laurent, the research process about soil contamination began when a farmer, worried about seeing abnormal losses in his livestock welcomed researchers specialized in contaminated soils to uplift the uncertainty and potentially take adequate measures, on the advice of a researcher. The researchers spotted plants resistant to heavy metal pollution, which aroused the interest of additional researchers. This alert (Chateauraynaud, 2020) and the following research showed the land wasn't suitable for agricultural or housing purposes. It also resulted in various research projects, including SyMetal on phytostabilization. The farmer developed a trusting relationship with the scientists during the research project, through offers of assistance in moving the equipment as well as taking care of the experimental plantations in the absence of researchers. The researchers explained they

acknowledged his input and encouraged him to participate in the study. The farmer seemed at ease, aware of the added value of his participation in the study. His involvement in a field trip with agronomy engineering students, where he holds a preeminent place, suggests that the relationship was quite horizontal. Thus, we consider this situation to be an example of co-construction of knowledge and falls under the "mode 2" knowledge production category.

The most recent effort on acid mine drainage in Saint-Sébastien was partially inspired by the then-mayor in the hope that it may help address the pollution problem. The scientific literature review shows a specialization of the numerous articles published on this specific acid mine drainage, from fundamental to more applied aspects. A researcher, the project coordinator, explained this shift: "*Being confronted with residents, their concerns, needs, expectations, and anxieties concerning the acid mine drainage convinced us to shift the research questions as observing pollution without doing anything about it was a bit embarrassing, precisely given our relations with the residents*"¹.

This consideration of local needs fits in the "mode 2" category, although the relationship is not as thorough as in Saint-Laurent. Downstream the project, the researcher's participation in the science festival was a means to disseminate the results to the local actors, which is closer to mode 1 than mode 2 as the knowledge is *in fine* still generated by scientists and then communicated to —rather than produced with — inhabitants. This difficulty in classifying this research illustrates this distinction's limits (Hessels & van Lente, 2008).

In Saint-Félix, there has not been any significant past research project. Nevertheless, the media analysis and interviews showed numerous linkages between science and society: some scholars act in this territory *via* expertise missions. For instance, ecotoxicologists and toxicologists led a study at the request of locals, thanks to collaborative funding. They released a report in 2013², in which they concluded there were significant environmental and health concerns and condemned "*several fundamental failings by the State and its decentralized administrations*" (Le Figaro, 2016). In fine, Saint-Félix also falls under a mixed knowledge production mode. The fact local needs is the basis of the scientific work, and that the inhabitants provide crucial contextual information fits in the Mode 2, but the knowledge is still mainly produced by the scientists.

These examples share several features commonly found in transdisciplinary literature but also have features fitting in the Mode 1 category. The main aspect of transdisciplinarity is the fact that scientific questions were oriented by the inhabitants who also gave crucial contextual elements (history of the site, location of the perceived pollution etc), which is described as positively

¹ In the following, all verbatims are indicated in italics. They come from interviews conducted during the survey campaigns

with scientists and local actors and have been translated from French by the authors.

influencing the problem relevance (Lux et al., 2019). Thus, different degrees of relationships between scientists and local inhabitants spontaneously occurred in these research projects, although the relationships may be different at each stage of the process.

3.2. Impacts of the interaction between researchers and people on the territory

In this part, we will consider the “impacts” (Walter et al., 2007) of these interactions. We chose not to focus on the materialization of the research through substantial remediation work (“output”) as it seems intuitively more political than linked to the local research itself in these three case studies. However, we acknowledge that mediatic attention, scientific and expertise results may influence the decision of undertaking such a significant remediation work. The “impacts” of the research projects on people were diverse. The literature divides them in “scientific” and “societal impacts” (Walter et al., 2007).

3.2.1. Scientific impacts (of and on scientists)

Scientists underlined the scientific added value of interactions, for example in Saint-Laurent:

“They (local actors) also generate questions. And that, well, the fact of having a question that comes out of the field, raised by people who have looked and thought about it, is interesting for us. Because we are rarely in the field.”

According to the scientist, local actors can offer a perspective rooted in the real world and generates pertinent scientific queries that wouldn't arise otherwise. This result is in line with the literature (e.g Scholz & Steiner, 2015). On a more reflexive level, being solicited by local actors pushed the researchers to question their role and moral values. In Carnoulès, changing the research questions was linked with the awareness people had expectations regarding scientific work. Then, they had to decide either fulfilling their pure scientific interest or being in line with societal demands. A researcher working in Saint-Félix conceptualized his mission as *“to reassure them (the local inhabitants). Because in fact, some were convinced that their whole water was contaminated. (...)”*. He linked his transparency with his duty as a researcher in a public institution to have a social utility. Finally, several researchers explained they enjoyed on a personal level the social shift their mission took as they were able to connect with people, and sometimes even forming friendships.

3.2.2. Societal impacts

On the local inhabitants' side, the most obvious effect was psychological: having research work on their territory helped to “reassure” (see above) and calm them down. In Saint-Félix, not having research on the site was correlated either to anxiety or nonchalance. It was underlined by some inhabitants the psychological dimension was very important: being listened to, seeing people paying attention to the issues was already easing a bit the burden. The “successful” outcomes of research in similar territories (e.g Saint-Laurent) allow the inhabitants to hope solutions will be found, or adequate measures will be taken.

In line with the literature, changes in behaviour occurred with the increase of information available (e.g Di Iacovo

et al., 2016; Walter et al., 2007). The behaviour went from passive to active when the people became actors of their safety and health: some stopped growing vegetables in their garden or used containers, moved their hens to a less polluted area, started taking off their shoes in their houses and monitoring their impregnation with pollutants by regular blood tests. This is a matter of system knowledge (about their personal situation) and to some extent transformation knowledge (Walter et al., 2007).

However, each inhabitant balances these constraints with their cost of implementation (economic and in terms of effort). Sometimes, they judge the gain doesn't worth the effort. Concerning the displaced hens, their owner said *“Yes, there is a high content in the soil, but there is... It's not crazy. So, we leave them there. And then it seems to be going well”*. In other words, they valued eating the eggs they produced over the uncertainty concerning their impregnation, as they have not tested the eggs afterwards. Finally, the hope triggered by ongoing research enabled some inhabitants to imagine a new future for the territory. This theme particularly stood out in Saint-Sébastien, a territory where important remediation work has been carried out. A member of a local association explained:

“We want Saint-Sébastien to be recognised as a clean site. And this is fundamental if we want this town to develop while remaining what it is. (...) Either we decide to remove all this nature and then we build real estate, we install companies (...) Or we say, we have a magnificently preserved valley ten minutes from Alès (city nearby) and we have tremendous tourist potential.”

This quote reveals the attempts of changing and controlling the narrative in post-mining territory in a process of “repurposing” (Keenan & Holcombe, 2021). This new narrative may be in tension with the actual situation and leads to apparently inconsistent behaviour. The same inhabitant who was campaigning for revegetation work said:

“When the ARS (French health agency) says we should put signs everywhere saying don't sit on the ground because the soil is polluted, we say but, it's not good for the (interpretation) path (designed by the organisation to make the territory attractive).”

This shows the internal tension that can occur. Behind the desire to move forward appearing in narratives, the legitimacy of certain uses is at stake.

3.3. Discussion and implications concerning a about a typology of transdisciplinarity

Several “outputs” and “impacts” on scientific and societal levels were identified in these case studies in line with the literature about transdisciplinarity, particularly in terms of knowledge, which partly supports our hypothesis.

Concerning the impacts, our findings are in line with the literature on transdisciplinarity: “most authors agree on the lack of clear causal relationships between the research process, its results and the effects” (Lux et al., 2019, p. 184). The potential impacts of the research processes and transdisciplinarity found in our analysis were partly in line with the literature, in particular the learning process and

capacity building and improvement of the situation (Lux et al., 2019).

However, other features present in the literature did not explicitly appear in our case studies as a result of the research processes. For example, network building, a common effect of transdisciplinarity according to the literature, appeared in our case studies, but independently of the research processes. Community identification did not emerge from the interviews. This may be linked to the low number of people involved in each project, which we assume is a collateral effect of spontaneous transdisciplinarity. The post-mining situation may also explain this lack of community building as this topic is divisive: a part of the inhabitants advocated for a better management, another was reluctant to acknowledge the contamination and the last part had an intermediate position. Consequently, only the people already active in these issues were interested in the research projects.

The research and the communication around the results seem to influence the inhabitants' behavior as they have more information available. However, uncertainties remain. The case of Saint-Laurent, our most thorough example of co-construction, was limited to only one person, which limits the societal impact. Moreover, his behavioral adaptation was largely comparable to the ones of inhabitants in Saint-Félix where there were expertise works only. Therefore, other factors than cross-fertilization of knowledge might be at play for an increased social impact. The literature notes that the sharing of both explicit and tacit knowledge should be considered (Di Iacovo et al., 2016) and that communication processes adjacent to the research projects, situational factors also play a role (Lux et al., 2019). Further research would be necessary to evaluate the influence of components: the sociological and political context, the potential instrumentalization of the research, the initial knowledge asymmetry, the different temporalities of researchers and inhabitants for instance.

The originality of our research is to point out the beneficial psychological impacts of a research process or expertise that is adapted to the inhabitants' needs, open and transparent. Even if the research does not always result in concrete remediation work, it is comforting: the problem is recognized, hope is allowed, and the inhabitants have a clearer view of the situation. They can start looking ahead to the future and moving from a passive to active attitude. In this sense, the scientific research seems to give an impulse for people to reclaim their territory, although this statement is highly dependent on each individuals' nature. This pre-eminence of psychological factor is maybe linked to the specificity of a post-mining territory, particularly anxiety-provoking, but it also stresses the importance of upstream interactions with the researchers. Finally, this part highlighted that changes in behaviour are two-way: by interacting, both inhabitants and researchers reciprocally influenced each other's behaviour. However, this is rarely mentioned in transdisciplinary literature as the focus appears to be mainly on societal changes.

Establishing a typology of spontaneous transdisciplinarity is not straightforward. The projects were not designed as transdisciplinary, which implicates the roles of each person was never formalized. This results in an increased momentum in the inclusion of inhabitants observed, depending on the stage. Likewise, the potential impacts were partially in line with the literature. However, we would recommend adding the psychological effect to the existing categories as it seems to be a preponderant feature.

4. Conclusion

Thus, this study showed the transdisciplinary processes and relationships that can occur in research not perceived as transdisciplinary: it produces change both in the individual relationship to the pollution problem and in its management. However, these changes may seem limited compared to real transdisciplinary research. The results were mainly in line with the literature, but the psychological benefits of the research were revealed. The relevance of performing anthropological and sociological studies on transdisciplinarity must then be underlined. Such study requires to build a certain trust, which can be achieved in interviews more than in surveys and quantitative analysis.

The limitations of this study lie mainly in the material collected. The research projects were already over, and our data came essentially from a *posteriori* discourse with people involved. Moreover, as transdisciplinarity was not a goal, no written documents could inform us about relationships at a given time. Finally, further interviews could reinforce the robustness of these initial results.

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