



What Is an Environmental Problem?

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Abstract

This paper advances two arguments about environmental problems. First, it interrogates the strength and limitations of empiricist accounts of problems and issues offered by actor-network theory. Drawing on the work of C.S. Peirce, it considers how emerging environmental problems often lead to abductive inferences about the existence of hidden causes that may or may not have caused the problem to emerge. The analysis of environmental problems should be empiricist in so far as it is sceptical of the claims of those who know in advance what the problem is, but it should also be alert to processes and things that are not readily traceable or perceived. Secondly, the paper's contention is that environmental problems almost invariably involve an encounter between unlike or disparate materials or processes. In such circumstances, the challenge is to develop a form of inquiry that is alert to both the specificity of such encounters and to the specificity of the political situations in which they come to matter.

Keywords

abduction, actor-network theory, environment, political situations, problems

Introduction

It is widely thought that scientific research leads to the solution of more or less well-defined problems, or at least the search for problems that can become well-defined and therefore could, in principle, be solved. Indeed, in *The Structure of Scientific Revolutions*, Thomas Kuhn defined a scientific paradigm in terms of the relation between problems and solutions. According to Kuhn, paradigms are 'universally recognized scientific achievements that for a time provide *model problems* and solutions to a community of practitioners' (1962: viii, emphasis added). In effect, the solutions to problems, in his account, derive from the routinized application of existing models. Paradigms are not theories or sets of ideas, as is often supposed, but learned and established models with which practitioners address problems. As Isabelle Stengers observes, 'the originality

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of Thomas Kuhn's concept of paradigm was to show us how members of a scientific discipline learn how to treat problems' (Stengers, 2010: 39). A problem is a construction in Stengers' account but, as she makes clear, it is not a discursive construction that can simply be projected on to or imposed on the object of research, but, rather, is constructed through technique or treatment. The existence of the object both precedes and is transformed and supplemented through this construction, potentially generating novel objects (Whitehead, 1985; Stengers, 2000).

I begin with Stengers' reading of Kuhn to highlight the continuing salience of one way of conceiving of problems in both the natural and social sciences. In this view, the problems of scientific research have to be set up in a way that enables them to be treated along the lines of the model. The treatment could be mathematical, of course, as is the case in some areas of physics and economics. Stengers herself dwells on the significance of mathematical models in both classical and quantum mechanics. But treatments can also be chemical or electromagnetic, and accomplished through well-established methods, such as mass spectrometry or X-ray crystallography, or they may be embodied in the operation of standardized pieces of laboratory equipment that can be readily obtained from suppliers. The challenge for the scientist in this context is to find a treatment that takes its inspiration from problems that have already been solved. This challenge is not trivial, for the treatment must both follow the model of the solved problem and be designed in a way that addresses the specificity of the particular problem and the obligations that this particularity generates (Stengers, 2010). General (or model) problems are certainly valuable, but only as long as they are not used in a generalized way (Barry, 2013: 142).

Nonetheless, despite its originality, Kuhn's approach to the treatment of problems is a negative and restrictive one. In his rendering, problems have to be made to resemble model problems. At the same time, problems are also understood as potential obstacles that, if they do not prove to be surmountable, may ultimately disrupt and destabilize the value of the generalized model. In effect, Kuhn assumed that the normal mode of scientific research led to the generation of singular solutions to given problems.

In this paper, I consider how this instrumental and essentially negative conception of the problem can be rethought. How can problems be understood positively in a way that directs us to consider not so much how they are obstacles to be overcome, but how problems can generate novel effects as well as multiple responses and solutions? Foucault's concept of problematization suggests the possibility of a positive account of the problem:

Problematization doesn't mean the representation of a pre-existent object, nor the creation through discourse of an object that doesn't

exist. It's the set of discursive or nondiscursive practices that makes something enter into the play of the true and false, and constitutes it as an object for thought. (Foucault, 1989: 296)

Problematization, for Foucault, does not lead to a solution on the basis of a given model, but the opening up of the field of possible solutions along with further questions: in his account, it is the 'transformation of a group of obstacles and difficulties into problems to which diverse solutions will attempt to produce a response' (Foucault, 1997: 118). The challenge, following Foucault's proposition, is to show how it is possible to reverse the vector of inquiry. Rather than consider how scientific research generates model problems and true solutions, the task is to show how research may generate multiple solutions and, indeed, further problems. Following Foucault, as Mariam Fraser observes, 'there is no true solution to a problem. ... [The best] that a solution can do is to develop a problem' (Fraser, 2010: 78). For Kuhn, problems can be made to conform to a model, on the basis of the commitments of a community of practitioners to that model. But what if the realization of a problem generates the potential for multiple lines of inquiry, and many solutions? How then are we to understand the generation of problems, particularly those problems that cannot so readily be made to replicate the model, whether in practice or in principle?

Other writers have written extensively on the history of the concept of problematization in French philosophy (e.g. Maniglier, 1997, 2012; Osborne, 2003; Bowden and Kelly, 2018; Ross, 2018), and I do not intend to dwell on this history here. Nor do I consider those domains of scientific knowledge, such as quantum mechanics and relativity theory, that address the kind of well-defined mathematical and model problems that preoccupied Kuhn; nor, again, do I address the sciences of complexity and thermodynamics that powerfully inform Stengers' account of what she termed cosmopolitics, as well as her opposition to the hierarchical relation that exists between physics and chemistry (Stengers, 2010; Barry, 2015). Instead, I intend to venture outside mathematics and beyond the world of the laboratory and its standardized and well-defined procedures, and to consider instead the significance of local environmental problems for which the relevance of models is sometimes far from clear. In environmental research, the researcher is likely to have to be alert to the specificity of the situation and the obligations that it generates. Moreover, environmental problems are often associated with a wide range of forms of, in Foucault's terms, 'moral reflection, scientific knowledge, [and] political analysis' (Foucault, 1989: 264), including the work of lay publics and 'counter-experts' (Callon et al., 2001). My suggestion is that the question of the problem has been dominated by thinking about the closed spaces of the laboratory and the clinic as opposed to the relatively unbounded spaces of, for example, the depleted forest, the

polluted city street, the contaminated mine, or the flood plain (Pickering, 2013).

In light of the above, I develop my argument in three stages, suggesting that reflecting on environmental problems points to three positive understandings of problems. The first follows from the work of Callon himself who, in an early contribution to what he then called the 'sociology of translation', examined the 'struggles to determine what is problematic and what is not' – a theme he pursued a few years later in what became a canonical account of actor-network theory (Callon, 1986). The notion of problematization, which was central to this earliest formulation of actor-network theory, led on to the idea that problems can be equated with matters of concern, or what the social theorist Noortje Marres later termed issues (Marres, 2007). Problems, in this account, are unlikely to be solved by reference to models. Rather, issues generate demands for democratic engagement; they pose problems for publics. In these circumstances the challenge for the analyst is to give appropriate credit to the issues as well as due attention to the democratic practices that might be required to address them.

In the second stage of the paper I turn from actor-network theory to the work of C.S. Peirce, and his formulation of the idea of abduction. My contention, following Peirce, is that an awareness of an emerging or potential environmental problem can lead to abductive inferences that direct witnesses to agencies and processes that, rightly or wrongly, have caused the problem to emerge. Peirce's original conception of the logic of abduction therefore points to some of the limitations of the actor-network theoretical conception of the problem. For whereas actor-network theorists are determined to avoid making assumptions about hidden causes and processes, emergent environmental problems frequently generate abductive inferences about hidden causes, including references to unacknowledged injustices and inequalities in power and to history. In these ways, environmental controversies revolve not only or primarily around explicit issues but crystallize and grow in relation to a diverse range of inferences about what might lie beyond or behind apparent transformations. For the analyst, informants' accounts make it possible to trace some of the geohistorical and political movements that pre-exist the formation of environmental problems.

One of the characteristics of environmental problems, I will propose below, is that they almost invariably involve a relation or an encounter between unlike or disparate materials or processes that are often, although not necessarily, in proximity with one another. More specifically, this encounter is assumed to occur between an industrial practice or manufactured material or chemical ('a pollutant') and a natural environment or milieu in relation to which this industrial, artificial or manufactured substance comes to exist. This is accompanied by a generalized concern with the assessment of the environmental impacts of industrial

activity and the progressive regulation of what are deemed to be artificial materials. In such circumstances the challenge is to develop forms of inquiry into ‘how, in what degree, and in what manner, things come to matter within specific situations’ (Savransky, 2016: 41). In the third stage of my argument, I observe that one of the limitations of analyses of both issues and abduction is that they dwell on processes of political mediation but have little to say both about the materiality of the things that existed prior to or beyond their mediation as ‘impacts’, and about the encounters between these things that constitute environmental problems. Such encounters take situationally specific forms, establishing a vast range of sites at which problems are taken to emerge and may come to emerge in the future.

Problem and Issue

In the early development of actor-network theory the idea of the problem had a remarkable importance. For Michel Callon, in particular, scientists were engaged not in the technical solution of problems but in what he called ‘struggles to determine what is problematic and what is not’ (Callon, 1981). In effect, the sciences were just as much concerned with the generation of problems, through technique, as with their resolution. Indeed, in what became one of the canonical contributions to ANT, Callon affirmed that

researchers sought to become indispensable to other actors in the drama by defining the nature and the problems of the latter and then suggesting that these would be resolved if the actors negotiated the ‘obligatory passage point’ of the researchers’ programme of investigation. (Callon, 1986: 196)

For Callon, a problem did not pre-exist its problematization but, by whatever means, had to become a problem, which could therefore become amenable to solution. In this analysis, the sciences were means of translating the problems of others into an abstracted form from which a solution could be derived. Problems should not be understood as representations of objects but as (re)constructions of the relations between research and its objects.

The key insight of this early actor-network theory (the ‘sociology of translation’) was, however, not that the sciences were fundamentally practices of problematization as opposed to representation, but that problematization necessarily entailed the translation or reconfiguration of relations between actors. The predicate, as is well known, was that such an analysis of problematization does not assume a priori distinctions either between social and natural actors, or between subjects and objects. At the same time, it rejects the idea that there are real social and

economic interests they lie behind claims to natural scientific knowledge. As Steven Shapin observed, ‘interests and other “social” factors cannot be used as causal items because they are consequences of negotiation and the effects of the settlement of disputes’ (Shapin, 1988: 543; see also Amsterdamska, 1990: 495–504). This flat ontology of actants, meshed together, went along with a fierce empiricism. This was an empiricism that consistently resisted efforts to posit the existence of unobservable processes or structures but insisted on the need to render visible what Latour called the ‘observable traces’ of agency (Latour, 2005: 53). Reflecting this empiricist commitment, research inspired by actor-network theory came to be alert to the production and circulation of documents and traces while being equally sceptical of the existence of forces and flows of both interest and affect that are not manifest or recorded in the form of observable traces.

In subsequent work, ANT’s early concerns were reformulated, and explicit reference to problems disappeared. But traces of it nonetheless remained. In *The Politics of Nature*, for example, Bruno Latour offered the concept of ‘matters of concern’, which were conceived of not in the terms of given problems, or representations or matters of fact, but as problems that were uncertain, partially-known, entangled, contested and in process (Latour, 2004). Subsequently, and extending Latour, Noortje Marres reformulated the actor-network theoretical account of problems through the concept of the issue. She gave two justifications for this move.

First, influenced by my work (Barry, 2001), as well as that of Emilie Gomart and Maarten Hajer (2003), Marres noted that while early actor-network theory interrogated science in action, it had failed to carry out the same form of inquiry into the practice and apparatus of politics (Marres, 2007: 764). In reformulating ANT to take account of politics in action, as Brice Laurent has argued, her account of ‘problematization describes the continuous work needed to transform new issues into public problems’ (Laurent, 2017: 22). In short, issues do not just generate the possibility of multiple solutions; they also lead to the formation of new publics. It is necessary to ‘talk of an issue when the available codes, irrespective of what they are, fail to answer the questions raised by the issue’, generating the production of new publics or ‘concerned groups’ (Callon, 2009, quoted in Laurent, 2017: 21).

Marres’ second contention was that the work of John Dewey and Walter Lippmann demonstrated why and how publics should have a role in the definition and resolution of problems. As she observed, Dewey and Lippmann were not just concerned with the challenges that the development of science and technology presented to democracy, but alert to the limitations of a narrowly human-centred approach to the definition of problems and the objects with which such problems were linked. As Marres reminds us, ‘a distinctive feature of the pragmatists’

accounts of public involvement in politics is that *the particular characteristics of the contested objects* are taken into consideration' (Marres, 2007: 772, emphasis added). Moreover, public involvement in the politics of science and technology should be valued, she insisted, not merely because it enlarges the space of democracy, but because it both draws on and addresses the 'particular characteristics' of contested objects. As against a form of political analysis that focuses relentlessly on subjects and/or discourse, Marres followed actor-network theory in turning attention towards the characteristics of the objects involved in the issues that animate political life and controversy.

In effect, the concept of the issue, in Marres' account, turned the question of the problem inside out. Problems are not to be solved through the application of a technique, as Kuhn imagined; rather, problems generate the demand for forms of democratic debate and engagement that will invariably come to transcend given institutional and procedural settings (Marres, 2007: 775). Moreover, while Marres' democratic commitment distanced her from the Machiavellian vision of problematization associated with early actor-network theory (Haraway, 1997), she also widened ANT's commitment to empiricism, calling for analysts to 'attend to a broad range of events in which issues are articulated as objects of potentially widespread concern' (Marres, 2007: 776; cf. Lukes, 1974). Indeed, she went further, arguing that the public articulation of issues generates contestation, and that such contestations were increasingly traceable through web-based methods (Marres, 2015). Yet at the same time, Marres' analytics of issues retained a strict focus on observable public problems through what she termed an 'empiricist approach' to controversy analysis (Marres, 2015), thereby reproducing early actor-network theory's commitment to a particular interpretation of empiricism. I return shortly to consider the limitations of analysing problems only through the study of readily observable traces and texts.

The contention that it is necessary to attend to the 'particular characteristics' of objects that are the focus of an issue, however uncertain and contested these characteristics may be, is a clear strength of actor-network theoretical approaches to the study of problems. From this perspective, problems are not just discursive constructs, or vehicles for existing interests. Problems, conceived of as issues, *generate* political consequences. Moreover, problems force calls for greater democracy and, through the mobilization of concerned groups, create the possibility for new problems to emerge. Problems and publics are co-constituted. Yet at the same time, the specific kind of empiricism espoused by actor-network theory raises questions as to which problems are not articulated as objects of concern, as well as which voices may be excluded in the process of problematization.

Political Situation and Abduction

The actor-network theoretical approach to problems and issues directs researchers to trace the process of problematization beyond the confines of the scientific laboratory or community. In this way science and technology studies, in the guise of ANT, took further a concern with problems inherited from both Bachelard and Kuhn, reinflected by Marres through Dewey and Lippmann, yet went far beyond the scope of their enquiries. In effect, ANT associated problematization not just with the practical work of the laboratory or field scientist but also with the work of non-scientists and concerned groups, thereby reconfiguring and undermining the boundaries of what counts as science (Laurent, 2017).

When applied to the study of environmental problems, however, certain limitations become evident. The ANT approach tends arguably to remain focused on problems themselves and, as a consequence, is not adequately attuned to the way that environmental problems are invariably caught up in a nexus of relations with other political and economic concerns and grievances, as well as cultural movements (although see Callon et al., 2001). In other words, environmental problems tend to be not only contested – even in their very definition as a problem – but multiple. Consider, for example, the debate over the problem of the environmental impact of Genetically Modified Organisms (GMOs) in agriculture in the EU, the introduction of which was widely opposed by environmentalists across Europe. In practice, an environmental activist group may resist the use of GMOs, but although the group's opposition is framed in terms of the negative environmental impact of GMOs, this opposition may also express a mistrust of government or of the arrogance of some scientists, or a critique of the power of multinational corporations; indeed, it may simply reflect a wider sense of the need to defend the purity of the natural environment against contamination. In short, the problem of whether GMOs are safe or not is not just posed by GMOs, is difficult to circumscribe, and does not lend itself to a singular solution. In this vein, reflecting on the irresolvability and multiplicity of the GMO problem, Stengers described the controversy that arose around it not as an issue but as an event:

What made for an event in this epoch that is ours, suspended between two histories, what enabled the European movement of resistance to GMO, to make the possibility of acting rather than undergoing felt, was the discrepancy that was created between the position of those who were producing more and more concrete, more and more significant knowledges, and the position of those responsible for public order. (Stengers, 2015: 36)

What is apparent here is that the problem of the environmental impact of GMOs intensified conflict over a series of further questions, in this

way producing multiple vectors of contestation. The singularity of the problem of GMOs therefore derived not just from the particular characteristics of GMOs, but also from the nexus of related issues that came to be contained in the GMO event. In previous work I introduced the term political situation, rather than event, to convey the ways in which debates such as those around the problem of GMOs, safety tend to draw together many different ongoing historical currents, grievances and concerns, some of which may appear not to have any necessary relation to one another. Political situations, I suggest, contain multiple lines of contestation, each with their own historical trajectory, that come to be gathered together as a single event. Conceived in this way, environmental problems – rather than inviting singular solutions – open up a range of future, and contestable, possibilities (Barry, 2013). The political situations generated by the multiplicity of environmental problems, and their association with a series of further concerns, is one reason why it is generally difficult to arrive at a solution to any singular environmental problem from a general model. Paradoxically, one might say, it is the multiplicity of environmental problems – evident in the political situations they generate – that constitutes their singularity.

A further observation follows. It is that the singularity of environmental problems leads to the prevalence of what C.S. Peirce termed abductive arguments in environmental politics (Barry, 2013: 84). Through abduction, as Peirce makes clear, it may be possible to arrive at an account of the causes of particular problems or what he calls ‘surprising facts’ – whether it be the occurrence of an accident, the proposal to roll out a new technological system (such as GMOs) without having carried out sufficient research, or the decision to build a major new infrastructure that may prove to be environmentally damaging. Following Peirce, if a problem is recognized as surprising, then it may be possible abductively to infer that something else (A) must have happened that would account for this surprising fact (C). As Peirce put it, ‘If A (the cause) were true, C would be as a matter of course’ (Peirce, 1934: 117).

In environmental politics and governance, my contention is that abductive inferences are remarkably commonplace in relation to perceived problems. The surprising and singular problem may well take a dramatic form – for example, an incident of pollution, a catastrophic storm, or the decision to locate a mine, a pipeline, or a power plant in a natural park or a marine protected area, or in the immediate vicinity of a town or city. Yet such a problem may not necessarily be instantaneous, but rather an indicator of a long-term shift – as in Rachel Carson’s famous observation about the long-term decline in the bird population (Carson, 1962). It is the surprising occurrence of these kinds of problems, whether they are instantaneous or develop progressively over time, that fuels the demand for abductive explanations of their causes. However, the abductive inferences generated by such problems can often be

contradictory or at least in tension, they can be apparently unrelated, and they can be resistant to any integration, and it is this property that leads to the existence of contentious political situations that contain multiple public controversies (Barry and Gambino, 2019).

Of course, the inferences generated through abduction may be based on spurious assumptions. Indeed, at their worst, they may amount to no more than conspiracy theories. Journalists and political activists, as is well known, are all too prone to accounting for surprising problems as expressions of the power of particular individuals or companies, or of hidden forces. It is common enough to arrive at the plausible conclusion that something (A) must have occurred for C to happen, and, thus, that whoever is responsible for A is also therefore responsible for C. Yet, as Peirce observed, plausibility ‘proves nothing but the ingenuity with which the hypothesis has been adapted to the facts of the case’ (Peirce, 1958a: 67; Forster, 2011: 135). Indeed, even social scientists may be susceptible to explaining away particular environmental problems as the products of such generalized forces as neoliberalism, or commercial economic interest, or capitalism in general, on the basis of limited empirical research. It is against this background that, rejecting such a tendency to move abductively from problems to causes with insufficient care, one of the explicit justifications for the empiricism of early actor-network theory was its insistence on the importance of detecting observable traces of agency, allied to its resistance to totalizing analyses of social structure or formations of capital. Thus, while actor-network theory was centrally concerned with problematization, as I have suggested, this was bound up with an opposition to any idea that the emergence of specific problems can be understood as a product of social forces or economic interests that pre-exist the process of problematization (Latour, 1999: 152, cited in Fraser, 2010: 65).

Despite ANT’s criticisms of the tendency of social scientists to be insufficiently empirical (Latour, 2004), and Latour’s insistent defence of a certain form of empiricism, the empirical study of environmental problems leads to a different conclusion. The analysis of contested environmental problems, I want to suggest, requires us to stretch beyond the limits of what is readily observable in order to elucidate both what is systematically absent (Hibou, 2011), akin to what has been called the constitutive outside (Butler, 1993), and what is at the limits of the discernible (Whitehead, 1920: 49–52). Three ethnographic vignettes drawn from my fieldwork in Georgia on disputes that erupted over the environmental and social impacts of a transnational oil pipeline construction project, the Baku Tbilisi Ceyhan (BTC) pipeline, help to illustrate and expand upon this point:¹

1. An informant, working for an oil company, handed me a CD containing a file of a scientific report that had been commissioned by the company from private contractors about the relation between the construction of the pipeline

and landslide risk. While the content of the report was informative in itself, the informant also wrote ‘This is not a public document’ with a marker pen on the CD itself, and later reminded me that I could not quote from it in any publications that resulted from my research.

2. A community liaison officer, working for an oil company, introduced me to a villager who had managed to stop the movement of pipeline construction vehicles near her mountain village in the lesser Caucasus. The construction of the pipeline, she told us in conversation, would prevent her moving livestock between two areas of pastureland. Her protest, which was the first she had ever been involved in, was not recorded in any official or public documents.
3. At the end of a workshop of geoscientists, a Georgian geophysicist told me about his research on the isotopic composition of water in the Borjomi region of Western Georgia. His conclusion was that his research demonstrated that a leak in the pipeline, whether due to landslides or sabotage, could lead to a contamination of a valuable mineral source in the lesser Caucasus (Barry, 2016). His research was not published until after the decision to route the pipeline through the Borjomi region was made and was rendered relatively marginal in the political situation that developed around the construction during its key phase (Barry, 2013: 43–9).

My analysis of the political situation that included the BTC pipeline came to rely on a vast archive of documents made public by BP, numerous reports produced by international NGOs and financial institutions, over one hundred interviews, and my own fieldwork along the pipeline route (Barry, 2013). These vignettes from fieldwork were thus only minor fragments of a much more extensive body of research; nonetheless, they were all highly significant. None of these encounters came as answers to questions that I had posed my informants in advance; all three were unanticipated. As François Chateauraynaud has observed:

In the course of empirical research, tensions, bifurcations, surprises, impasses and revisions intervene continuously, so that the researchers are hardly ever in a position to master the elements they will have to describe, analyze and, if necessary, also explain. Metatheoretical reasoning does not take into account the *pragmata* – the various ways in which objects emerge and impose themselves on the researcher during research. (Chateauraynaud, forthcoming: 4)

The three vignettes all conform to Chateauraynaud’s ‘revisions’. They were all what one might call ‘research events’, irruptions that were contingent on particular circumstances. And yet they imposed themselves on me, revealing and generating ‘surprising facts’ about the construction of the pipeline. As Peirce’s account of abduction would suggest, they prompted me to carry out the further research that was necessary if

the abductive inferences that I drew from these events were to prove insightful, and be more than merely speculative or ‘plausible’. For example, my informant’s performative and telling inscription in the first story, ‘this is not a public document’, pointed to the salience of the distinction between the voluminous archives that are made public on the internet about many major infrastructure projects and the vast range of documents, including this particular report, that – for whatever reason – are not. Specifically, regarding the first vignette: when analysing the environmental problem of the pipeline construction, it was essential to take into account the contents of the ‘not public’ scientific report. For this report indicated both the extent of the scientific research commissioned by the oil company on the problem of landslide risk and, crucially, the limits to which this research could be made public, while the latter pointed in turn to the complexity of the relations between the oil company and the Georgian government – relations that were never publicly aired and insight into which could be discerned only through diverse, indirect vantage points like the existence of this ‘not public’ document.

In the second vignette, my conversation with the villager pointed to the importance of a localized problem, the impact of the pipeline on her livelihood and that of other villagers, and her consequent direct action, none of which was ever recorded or made public. This was one of many small, fragmentary indicators that alerted me to the prevalence and significance of direct action by villagers across Georgia in the period of pipeline construction, actions that were generally not accorded significance by or recorded in published documents, and that were certainly not traceable on the internet (cf Jazeel 2019: 179).² At the same time, the mediation of the Georgian company liaison officer who introduced me to the villager was one indicator of the complexity of the relations between the local population, the oil company, and the company’s sub-contractors (Barry, 2013: chs 6 & 8).

Regarding the third vignette, the geophysicist’s independent research demonstrated the limits to the corporately-commissioned scientific research that had been made public about the problem of the pipeline’s environmental impact at the time the decision to construct the pipeline was given the green light, as well as the relative marginality and low status of Georgian scientists in the public debate about the construction of the pipeline at the time.

These examples therefore direct our attention not only to the process of problematization, but also to the limits of the public articulation and contestation of environmental problems, the existence of inequalities and other differences between actors that affect what may or may not be made public, and the demarcation of those problems that are readily traceable from those that are not so easy to trace. In other words, the three vignettes issue a demand that we investigate the relation between published documents, accounts and interpretations and those that are

not published, not written, not yet written, or could never be made public (Hibou, 2011). In short, they direct us to the importance of including in the analysis of the political situations engendered by environmental problems those elements that never become or have not yet been actualized as public problems. More generally, in pointing to what is not readily observable about the constitution of environmental problems, the examples above direct us to become attuned to those problems that remain localized or marginalized, manifest in their lack of elevation into public discourse.

Political sociologists have, of course, long recognized the importance of secrecy in political life. One should not expect that every government or commercial document will become public, nor would it be desirable or feasible for this to occur (Simmel, 1950). Yet with the exception of the first story, the three vignettes do not turn on secrecy or the withholding of information that could be made public. Instead, they direct us to consider the question of the relation between what is made public about problems and what is not, what is readily traceable and what is difficult to trace, and who is or is not in a position to crystallize what is a problem; they point, then, to ‘effects of power that do not necessarily show themselves’ (Chateauraynaud, 2015: 9).

The analytics of the political situation that I have outlined therefore goes further than the frameworks of problematization and issues developed by actor-network theory. Certainly, the actor-network theoretical accounts of problematization and issues are empirical; but at the same time, as I have indicated, they are too restricted in their empiricism. In particular, they remain overly focused on the existence and the generation of published documents and texts – including those that can be traced on the internet (Marres, 2007; cf. Whatmore, 2009). In this context, my informants – who introduced me to documents that had not been published, to concerns that had not been heard or recorded, and to potential accidents and the controversies such problems would generate, even if neither had (yet) taken place – performed what we might call, following Deleuze and Guattari, minor political gestures (Deleuze and Guattari, 1986; Barry, 2017). My informants – who were villagers and farmers, corporate employees and scientists – did not articulate an anti-corporate politics. Rather, they alerted me to the contours of the boundary between those processes that could and those that could not be readily traced, and between those processes that, at particular times, could or could not be posed, or barely discerned, as environmental problems. This methodological point takes on heightened and ironic salience, of course, in a period in which the principle of transparency is used as a device for determining the extent to which problems are or are not rendered public.

The three vignettes, and the commentary I have provided on them, require that we consider anew the limits of what is traceable and observable, and in this way they point to the need to rethink the particular

commitment to empiricism manifest in ANT. As noted earlier, ANT has been critical of those social scientists who too rapidly generate abductive inferences and, in doing so, explain away particular surprising facts by reference to totalizing social forces or a wider social context. In opposition to this tendency, ANT has advocated an empiricism that focuses on ‘observable traces’. But my fieldwork vignettes direct us to the possibility of a renewed critical empiricism that entails a subtle form of abductive inference attuned to those aspects of the political situation that are marginalized or systematically absent from public discourse, or that cannot be directly perceived, but are discernable nonetheless (cf. Peirce, 1934: 123). In this way, the analysis of political situations demands and proffers an empiricism that is intended to expand and reconfigure what the problem is, as well as what and who influences what it might become in the future.

But the vignettes also tell us something more general about environmental problems. For in their focus on the problem of environmental impact, they are all concerned with the relation between two broad sets of materials and processes: a pipeline, and the physical and social environment through which it is expected to pass. The unpublished corporate scientific report (vignette 1) examined the geomorphology of an area and came to the conclusion that the construction of the pipeline would not generate additional risks of landslides; while the geophysicist (vignette 3) traced the potential future relation between oil flowing from a leak in the pipeline and the supply of Georgia’s most famous mineral water by tracking the ratio of Oxygen-16 and Oxygen-18 isotopes in different water sources. For its part, the villager’s spontaneous direct action (vignette 2) points also to the contrast between the construction of the pipeline, based on scientific and engineering principles and built to a tight timescale, and the existence of other material processes – other ways of ‘being in the environment’ that included, in this case, the paths taken by livestock as they are moved across a hillside (cf. Pickering, 2013: 80). In a sense, there is nothing unusual about these reports about potential environmental problems. They address what Martin Savransky has called a problematic encounter between two disparate sets of materials or ‘modes of mattering’ (Savransky, 2016: 84, 94): between an oil or gas pipeline, on the one hand, and the physical and social environment, on the other, where the latter is threatened or at risk of contamination by the environmental impact of the former mode of mattering. A closer focus on the relation between two distinct modes of mattering points to the idea that environmental problems are generated through such encounters: ‘for an encounter to happen, two or more entities have to meet, that is, they have to pre-exist the encounter even though they can certainly be affected by it’ (Savransky, 2016: 93). In the final section of this paper, I want to consider further the question of the encounter between modes of mattering as it bears on environmental problems.

Encounters

In *Le rationalisme appliqué*, Gaston Bachelard used a simple example of an encounter between substances to illustrate the concept of the problematic. His example was the observation that dew does not ‘fall from the sky’ or come from plants, as is sometimes supposed, but can be understood in terms of the relation between pressure, volume and temperature:

The technique of using a hygrometer such as those of Daniell or Rignall – to cite only apparatus known in the mid-nineteenth century – gives a guarantee of objectivity less easily obtained from a simple ‘natural’ observation. Once one has received this lesson in objectivity, one can hardly make the mistake made by Renan, who believed he could rectify common sense in these terms: ‘The vulgar also imagine to themselves that dew falls from the sky and have difficulty believing the scientist who assures them that it comes from plants.’ The two statements are equally false. They both bear the mark of an empiricism lacking the organization of laws. Whether dew falls from the sky or comes out of plants, it will only give rise to a very brief problematic. The phenomenon of dew is rationalized by the fundamental law of hygrometry linking the pressure of the vapour to temperature. Relying on the rational organization provided by such a law, one can, without risk of contestation, resolve the problem of dew. (Bachelard, 2004: 51–2, 2012; Maniglier, 2019: 10; Maniglier, 2012)

Bachelard’s explanation makes clear that problems are neither representations nor objects; rather, they are formed and transformed through devices that, in the particular instance he gives, are both mathematical and metrological. Yet while the example of the dew is helpful as an illustration of this point, it also offers a misleading image of an environmental problem. For the environment cannot necessarily be problematized adequately through the application of a fundamental law or model in this way, nor can it necessarily be resolved ‘without risk of contestation’. Four observations follow when this is the case.

First, in comparison with the problem of dew, environmental problems are frequently complicated to construct because of the potentially vast and diverse range of processes involved and therefore the challenge of arriving at the level of abstraction that, as Bachelard explains, is both possible and desirable in the case of dew. Moreover, the formulation of environmental problems is frequently complicated further by a lack of communication and/or the existence of an antagonism concerning what the problem is between the organizations and concerned groups involved – corporations, government agencies, consultancies, environmentalists,

indigenous people, affected populations and so on. Indeed, given the range of methods and concerns involved, there is an important difference between, for example, environmental and medical problems in this respect: for while medical experts should have a common interest in arriving at a cure despite the multiplicity of any particular medical problem (Mol, 2002), we should not expect that different environmental experts and other interested parties will necessarily have a common interest in a particular outcome (Murphy, 2006). As the literature on political ecology and environmental justice shows, environmental problems are bound up not just with systemic inequalities in access to resources that have persisted over time, but also incommensurable differences of interest and concern (Bohme, 2015).

Second, even when they can be partially modelled, environmental problems take a form – as stated above – that does not generate singular solutions. Indeed, the environment can be understood as a system that cannot readily be rationalized on the basis of fundamental laws or simple physico-chemical models, for the ‘complexity of nature is inexhaustible’ (Whitehead, 1978: 106; Greco, 2005; Weszkalnys and Barry, 2013). In William Connolly’s terms, environmental problems emerge out of the interferences set up between heterogeneous systems that include, *inter alia*, global capital flows, physical force fields, infrastructural systems and plant ecologies (Connolly, 2011; cf. Born, 2015). In marked contrast to Connolly’s analysis of such heterogeneous entangled systems, or Donna Haraway’s account of sympoiesis of systems without self-defined boundaries (Haraway, 2016: 33), or Stengers’ focus on thermodynamics and open systems (Barry, 2015), Bachelard’s understanding of the problem begins with the study of mathematical physics – rather than from an analysis of the kinds of messy problems that are typically encountered in researching environmental politics. In contrast to those philosophers of science such as Bachelard who focus their thought on discrete problems, then, Stengers, Haraway and Connolly direct us to the singularity and the co-presence of practices associated with problems that are far from discrete or isolated (Stengers, 2011: 372).

Third, as noted earlier, the potential for environmental problems is generated through encounters between what Savransky has termed distinct historical modes of mattering – for example, between a dam, a pipeline or a power station and the social and physical environments in which it is being constructed. Historically, this has often been understood as an encounter between nature and culture, or between a natural environment, on the one hand, and an industrial apparatus, on the other. In practice, however, this assumption no longer holds. As is well known, what was once thought to be the natural environment can no longer be conceived of as natural in the way in which it once was (Strathern, 1992). If the phenomenon of dew could be treated by Bachelard as an encounter between two natural modes of mattering, this is not typical of

environmental problems, which are ‘already constituted by an ecology of dynamic and fragile patterns’ (Savransky, 2016: 38, see also Haraway, 2016; Tsing et al., 2017).

A fourth observation is that environmental problems are generally both geographically variable and situationally specific. Even if there are some similarities, for example, between the environmental impact of dam construction in different settings, there will inevitably be marked differences depending on such factors as the physical design of the dam, the prevalence of seismic activity in the area, the nature and extent of governmental regulation, and the politics potentially mobilized by the displacement of local populations. In the same way, even though climate change has become part of the planetary condition, this condition is manifest in highly variable ways due to the encounter between different modes of mattering in each specific site. For this reason, climate change cannot readily be treated as a single or universal problem (see, for example, Hetherington, 2018). In short, researchers have to be attuned to the geohistorically specific ways in which environments pre-exist their problematization.

Given that environmental problems are situated, it is perhaps not surprising that both environmental activists and scientists sometimes have to insist that accounts of environmental problems should actually reflect the particular, local characteristics of the problems that matter to them. In other words, those who engage with environmental problems cannot rely on, or fall back on, the support of general laws and standardized procedures to determine what is problematic and what is not (Tiles, 2012). Similarly, environmental experts and counter-experts may engage in politics, but when they do they are invariably motivated to refuse to accept that their accounts can be understood as expressions of a pre-given politics. As Pignarre and Stengers suggest, counter-experts can and should engage in a form of minor politics that is irreducible to the molar politics of parties and social movements. The politics of counter-experts is a politics not of whole social formations, such as classes or nations, but of interstices (Pignarre and Stengers, 2011: 115).³

Yet further complexities arise, however, when addressing environmental problems. For not only is the environment no longer natural, but it is also increasingly measured and mapped (Gabrys, 2016). In these circumstances, the knowledge practices of the natural and social sciences are ‘themselves relations that are *added* to an ecology of beings and relations’ (Savransky, 2016: 50–1, my emphasis; cf. Barry, 2013: 186). In this way, different material aspects of the environment become increasingly mediated by, and enriched with, information; indeed, they progressively become what I have called ‘informed materials’ (Barry, 2005; Bensaude-Vincent and Stengers, 1996: 206; Lloyd-Thomas, 2010). Consider, for example, the case of the construction of an undersea trans-Adriatic gas pipeline, a project that has been the object of an escalating series of

protests since the mid-2010s in the vicinity of Lecce, southeast Italy. This pipeline is not only expected to encounter a marine environment that is already polluted by plastics, petrochemicals, metals and so on – an encounter between two modes of mattering – but this polluted environment is itself an ecological system that has been assessed and measured, and as a consequence has been granted, in some areas, the status of a marine protected environment (Barry and Gambino, 2019). In this light the problematization of pipeline construction by environmentalists and activists inevitably addresses the impact of the pipeline on an ecological system that has itself already been rendered a problem in the past. In short, the encounter between heterogeneous modes of mattering is rendered more complex still through the now recursive historical development of transnational environmental monitoring systems, the sciences associated with them, and the forms of mediation that ensue.

The analysis of encounters between modes of mattering makes a further contribution to the study of environmental problems. A focus on encounters directs us to the way that the geohistory of environments creates the potentiality for the development of new problems – which may or may not subsequently be actualized through scientific, legal or political practices. At the same time, as I have repeatedly stressed, such potential or emerging environmental problems are multiple and are not likely to be amenable to singular solutions. This proposition resonates with Harriet Bulkeley's critical observation that climate change has tended to be understood as a 'problem object' to which social scientists are expected to respond, in part by facilitating what she terms the kinds of 'silver bullet' solutions often associated with geoengineering (Bulkeley, 2019: 5; Hulme, 2014; Barry and Maslin, 2016). Bulkeley's argument is that social scientists should reject this essentially negative and teleological understanding of the problem of climate change, along with its restrictive understanding of the role of the social sciences. Instead, she advocates conceptualizing climate change not as a problem but as 'a condition', and one that is

... more or less amenable to diverse forms of engagement, ethics, knowledge production and resistance. Conceiving of climate-as-condition opens up the possibilities of what are 'necessary and feasible actions' through which responses can take place. It expands its political possibilities. (Bulkeley, 2019: 5)

The notion of climate change as 'a condition' makes sense given the complexity, multiplicity and pervasiveness of the environmental problems with which climate change is associated. Bulkeley's criticism is an important one; but rather than dispense with the idea of the problem, my contention is that the idea of climate change as a problem, properly understood, conveys a sense that climate change should not be expected

to lead to singular or global solutions – just as Bulkeley advises. The notion of the problem developed in this paper has value, then, precisely because it elucidates how essentially negative, instrumental or narrowly scientific understandings of the concept of problem can be rethought.

Conclusions

One of the impulses behind the development of science and technology studies was to rescue the study of science from the rational reconstructions of the philosophers. In this context, the early actor-network theory interpretation of the concept of problematization developed, through sociological and empirical research, the idea that the sciences were focused on the generation of new problems. Although the concept of the problem did not explicitly play a central role in the subsequent development of actor-network theory, I propose that ANT can properly be conceived as a sociological approach to the study of how problems are generated and transformed.

As I have indicated, two lines of developments – evident in the work of many writers, and notably Callon, Latour and Marres – followed from this sociological and empirical orientation to problems on the part of ANT. One line of development led to giving empirical substance to Foucault's brief reflection on the role played by political analysis (and action) as well as scientific research in the process of problematization. The other led to attempts to refocus the study of problems away from both the mathematical and the life sciences in order to address scientific and political research more broadly, including research on the environment. Indeed, the movement of ANT's approach to the formation of problems beyond the laboratory reflected the wider prominence of environmental problems in late 20th-century politics.

In this essay, rather than return to the history of the concept, I have sought to extend this empirical programme of research on problems and problematization, and I have taken bearings from the specific challenges posed by environmental problems. Against this background, my contention is that the actor-network theoretical approach to problems, while generative of empirical research, has also tended to be too narrowly empiricist. The insistence on the need to find what Latour termed 'observable traces' of agency derived from an understandable opposition to the idea that the production of scientific knowledge could be accounted for by reference to hidden social forces and economic interests. Problems, after all, should be understood as treatments or constructs, not merely social constructs or projections. Yet while ANT is often associated with a flat ontology of human and nonhuman actors that is resistant to orthodox sociological explanation, it is clear that its commitment to a certain form of empiricism is at stake if we are to assess

the strengths and weaknesses of the actor-network theoretical approach to problematization.

I suggested above that there are two weaknesses in ANT's empiricist approach to problematization. The first follows from recognition of the ways in which disparate materials both pre-exist and are transformed by the process of problematization. Yet ANT – because of its empiricist commitment to the detection of observable traces, and its reasoned mistrust of reductive sociological and historical explanation – has not been alert to the multiple dynamics of historical change and the ongoing transformations of living environments that participate in the generation of problems. As the material discussed earlier suggests, engagement with environmental problems requires researchers not only to recognize the contingency of political situations, and to address the specificity of the encounter between unlike materials, but to be attuned to the interference between diverse, pre-existing geological, biological and historical dynamics (Mitchell, 2002; Asdal, 2012; Latour, 2018). Indeed, grasping the various scales and kinds of historical dynamic at work in environmental problems vividly dramatizes the need for new kinds of interdisciplinary research and collaboration between natural and social scientists and historians, as well as between non-experts and experts (Weszkalyns and Barry, 2013; Bulkeley, 2019).

The second weakness in ANT's approach to problematization is revealed through enhanced empirical research on the construction of environmental problems. As I have indicated, critical empirical research can and should direct the researcher to interrogate the boundaries between what can and cannot be problematized, what can and cannot be rendered public, and what voices and arguments have and have not been heard – including those responses and feelings that may exist 'beyond the threshold of conscious communication and intent' (Colebrook, 2008: 127). The challenge for the social researcher carrying out research on environmental problems is therefore not to be less empirical but, arguably, to be more empirical, by recognizing the need to interrogate the limits of what is readily observable and discernible, as well as by tracing the connections between environmental and other problems that enter into the political situation. Environmental problems – unlike Bachelard's formulation of the problem of dew – do not take the form of distinct issues, but are associated with what I have called political situations, the outlines and complexities of which can invariably be deciphered initially by following the abductions of participants – as well as by making evidentially-based abductive inferences as an analyst (Barry and Gambino, 2019). Abduction relies on demanding and rigorous empirical research, and the researcher has no alternative but to rely on abduction in order, in Peirce's words, to 'furnish. . . ideas concerning real things, *beyond what are given in perception*' (Peirce, 1958b: 168; Forster, 2011: 136, emphasis added). Such abductive inferences are valuable

guides as to what pre-exists and enters into the political situation generated by an environmental problem.

The idea that problems are generated by empirical and historical research runs through this essay. Problematization does not come about through the ‘creation through discourse of an object that doesn’t exist’ (Foucault, 1989: 296), nor through the projection of political categories or economic strategies on to the ‘concrete situations where practitioners operate’ (Stengers, 2005: 994). The analysis of environmental problems should be empiricist in so far as it is equally sceptical of the claims of those who know in advance what the solution to the problem is and of those who know what hidden forces have determined what has happened. But the analyst must nonetheless take these claims into account. In these circumstances, those concerned with the analysis of environmental problems are faced with dual challenges. One is to address the general problem of how to engage with particular situations, and thus to be alert to, contribute to and sustain the existence of those ‘surprising facts’, to use Peirce’s term, that should not merely be explained away (Peirce, 1934). The second is to demonstrate the value of rigorous abductive inferences that do not necessarily lead to determinate solutions but, to the contrary, might come to pose further problems.⁴

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Notes

1. I have not discussed the first two of these vignettes previously, while the third example is analysed further in Barry (2016).
2. On the methodological significance of fragments and the relevance of a focus on singularity, see also Tariq Jazeel’s manifesto for ‘incomparable geographies’ (2018).
3. This idea of an interstice is a reference to Whitehead (1978).
4. My thanks to Mariam Motamedi-Fraser, Martin Savransky, Georgina Born and three anonymous readers for their insightful comments on an earlier draft of this paper, and to Patrice Maniglier for an earlier discussion concerning the question of the problem.

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