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Volcanic Activity and Human Society

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ABSTRACT: Humans have a long relationship with volcanoes, volcanic eruptions and the landscapes they produce. At times this relationship has been calamitous and human communities, societies, civilisations even have been subject to volcanic disasters, directly or indirectly. At other times, people have taken advantage of volcanic products. Either way volcanoes and eruptions have often found their way into peoples' very cosmologies. They have been and continue to be significant ecological and social factors in relation to human livelihoods. This brief introductory paper frames the rationale for this special issue of Quaternary International: To take stock of the field of past human impacts of volcanic activity and their relationship to aspects of human ecology and society, and to showcase the diversity of contemporary approaches to past volcanism and its many and varied human impacts.

Volcanic activity, human ecology and human society

In 1979, just over 35 years ago, Payson Sheets and Donald Grayson (1979b) published a keystone edited volume on volcanic activity and human impacts with the title *Volcanic Activity and Human Ecology*. This ground-breaking volume – with some of the greats of volcanology and archaeology such as Fred Bullard, Sigurdur Thorarinsson and Colin Renfrew amongst the contributors – was assembled in the spirit of interdisciplinarity and with the aim of not merely relating human ecology and culture change to volcanic eruptions and ash-fall chronologically but also causally. The decades following this anthology have been witness to a steady flow or indeed an increase, in papers, special issues and edited volumes on past natural disasters in general and on past volcanic eruptions and their human impacts in particular (e.g. Cashman and Giordano, 2008; Cooper and Sheets, 2012; de Boer and Sanders, 2002; Estévez, 2005; Grattan and Torrence, 2007; Grattan, 2006; Oppenheimer, 2011; Raynal et al., 2002; Torrence and Grattan, 2002). In these, a welcome shift in focus from primarily the documentation of eruptions and their ecological effects to a consideration of socio-ecological vulnerability – the ‘potential for loss’ (Cutter et al., 2003, 242) of both lives and livelihoods – is observable. However, operational definitions of vulnerability abound (see Wolf et al., 2013) and actually measuring this property qualitatively or quantitatively remains challenging (see Birkmann, 2006; Birkmann, 2007). Ironically but also insidiously, vulnerability of contemporary communities can only be fully assessed post-hoc, i.e. once they are subject to a given calamity. Here, studies of past volcanic eruptions and their human impacts can, despite the difficulties inherent in archaeological and historical source materials, make a significant contribution: Volcanic eruptions are often geologically instantaneous (t_0) and sometimes even create patently useful isochronous fallout tephra horizons. These strata can then be used to consider both post-eruption impacts at t_{+1} as well as socio-ecological constellations in the pre-eruptive

past at t_{-1} . In this way, we can seek correlations between impact and vulnerability parameters recorded prior *and* posterior to the eruption event in question. In addition, the temporal perspective can often be extended to t_{-n} as well as t_{+n} in order to consider the kinds of long-term developments of both vulnerability and impact that are particularly elusive in many anthropological and sociological studies of human impacts.

A further advantage of the historical and prehistoric records of past eruptions and their human impacts is that we are able to carefully choose case studies for comparative analysis (cf. van Bavel and Curtis, in press); they represent natural experiments of history (Diamond and Robinson, 2010). In this special issue of *Quaternary International*, the case studies by Torrence (in press), Oetelaar and Beaudoin (in press), Riede (in press), Pendea et al. (in press) and those by Hutchison et al. (in press), Zeidler (in press) and Le Pennec et al. (in press) respectively should be read in relation to each other and in comparison. In all of these case studies, volcanic eruptions and their fallout are shown to have directly affected human societies, albeit in different ways and under varying circumstances. In contrast – and perhaps more controversially – the contribution by Fei and Zhou (in press) argues that human impacts in China were caused by regional climatic forcing (subsequently acting on economic, migratory and socio-political dimensions) related to a particular and distant Icelandic eruption – a particular instance of the general linkage of environmental factors and far-eastern past geopolitics (Fan, 2015). Such links are notoriously difficult to substantiate, but do find support in recent suggestions of similar forcing mechanisms in 6th- (Gräslund and Price, 2012; Price and Gräslund, in press) and 13th-century Europe (Lavigne et al., 2013; Lavigne and Guillet, in press), notably by teams led both by historians (McCormick et al., 2007) as well as by climatologists (Sigl et al., 2015).

Comparative and synthesising studies of the past human impact of volcanic eruptions require robust dating frameworks, both for the eruptions and the associated human activities. Recent advances in tephrochronology – the detection and extraction of volcanic particles from terrestrial, marine and ice archives – are increasingly proving useful for such impact studies, especially as they are being applied specifically to *archaeological* stratigraphies (Housley and Gamble, 2015; Lane et al., 2014; Lowe et al., 2012; Riede and Thastrup, 2013). In this volume, the contribution by Jouannic et al. (in press) presents an advanced approach using magnetic susceptibility to assess tephra occurrence specifically in Loess sediments, an approach of potentially great interest as Loess stratigraphies provide key chronostratigraphic frameworks for studies of Pleistocene human evolution and dispersal in the Northern Hemisphere. The remaining case studies draw on macro- as well as micro- or cryptotephra to correlate between archaeological sites and between archaeological and environmental archives. Holmberg (in press) does also sound a cautionary note, however: In reminding us of how powerful a taphonomic agent humans can be, she demonstrates that the complexities of tephra deposits in archaeological contexts cannot always be solved by analytical techniques, but that the relationships between humans and this material can be deeply influenced by idiosyncratic behaviours.

Table 1

In this special issue, both Holmberg (in press) and Torrence (in press) in particular make a case for non-deterministic relationships between volcanic eruptions, human behaviour and the historical trajectories of certain societies (see also Grattan, 2006). But can we

nonetheless generalize; can we learn from such calamities? One of the founding fathers of American disaster sociology, Gilbert White (1974) had already argued that both disaster responses as well vulnerability varied between what he termed pre-industrial and industrial societies (Table 1). More importantly still, he also suggested that the optimal response to a given hazard is a blend between the pre-industrial and industrial modes, an observation especially pertinent when it comes to hazards such as volcanic eruptions that are difficult to mitigate technologically or when the societies affected do not have the means to engage in the often expensive industrial mitigation procedures (Schmincke and Hinzen, 2008). Chester et al. (2012) have used White's framework explicitly in their work on historical eruptions of Mount Erna. Disaster sociologists since White have, however, focused almost exclusively on events of the very recent past (Lovekamp and Trainor, 2013) and on societies falling squarely into White's category of 'industrial'. They have, despite occasional calls for comparative approaches (Alexander, 1997; Clarke, 2004), eschewed generalization. Widening the chronological scope of societies at risk may present a possible thematic and disciplinary meeting ground.

Past societies varied along a wide range of characteristics salient for vulnerability assessments. The fragmentary archaeological and historical records engender an almost automatic degree of reductionism and a focus on material, albeit not necessarily only economic aspects of livelihood (cf. Sheets, 2004; Sheets, 2011). Through the sites and objects that have survived past calamities, the dire geographies of impact and of response can be explored and used, in turn, to reflect on past vulnerabilities (Riede, 2014b). Likewise, the seemingly ubiquitous disaster response of movement or displacement bridges past and present (Witham, 2005) and is arguably highly relevant in light of the ever more pressing issue of environmental/disaster refugees in the present (e.g. Black et al., 2011; Lennard,

2014; Oliver-Smith, 2009). Many of the papers in the special issue lend support to the notion that movement and relocation are key responses to volcanic eruption – but also to people’s evident desire to return to their areas of origin.

Even if we may not be able to learn directly from distant and often woefully coarse-grained case studies of past volcanism, the narratives that emerge from these cases can be used in contemporary debates about ethical engagement with the environment (e.g. Bohle, 2015) or for scenario building that can, despite the often hypothetical nature of such exercises, be of value for ‘taming disaster’ (Clarke, 1999) and for building resilience (Clarke, 2007; Clarke, 2008a; Clarke, 2008b; Clarke and Molotch, 2010). Volcanologists have a strong tradition of framing such scenarios quantitatively through probability assessments and event trees, for instance (Baxter et al., 2008; Martì et al., 2008; Neri et al., 2008). Archaeologists and historians tend to opt for more qualitative descriptive accounts of possible future events. Both communities, however, draw on data from the past – palaeoenvironmental and ‘palaeosocietal’ (see Riede, 2014a) respectively – to build their scenarios. Extending emerging approaches of ‘social volcanology’ (Barclay et al., 2015; Donovan, 2010) and the recent interest in oral histories and locally specific perceptions of volcanic risk (e.g. Cashman and Cronin, 2008; Donovan, 2010; Németh and Cronin, 2009; Vitaliano, 2007) into the historical realm, cultural heritage can, perhaps, be harnessed for environmental literacy and action by offering historically informed, evidence-based information on the socio-cultural parameters of past volcanic eruptions. This may be particularly pertinent in regions that have no history of recent volcanism and hence no traditional knowledge of appropriate responses, but are nonetheless at risk from low-frequency/high-magnitude occurrences.

Past volcanism and human history in a wider disciplinary setting

Amongst historians, a renewed interest in and awareness of the role of environmental events and processes is growing in the form of so-called eco-historicism (Wood, 2008). Likewise, scholars of literature have begun to take a renewed interest in the environment (Buell, 2011). Recent volcanic activity has done its part for raising this aspect of human-environment interaction to the surface of public and scholarly attention and many engaging studies of the human dimensions of eruptions such as the Eyjafjallajökull eruption of 2010 have been conducted (Adey and Anderson, 2011; Benediktsson et al., 2011; Birtchnell and Büscher, 2011; Budd et al., 2011; Jensen, 2011; Lund and Benediktsson, 2011; Martin, 2011). These studies explore the complex ways in which humans individually and collectively respond to volcanic activity. In the wake, popular book-length works looking at similar complexities in historical eruptions such as the Laki fissure eruption of AD 1783 (Witze and Kanipe, 2014) and of the Tambora eruption of 1815 (Wood, 2014) have appeared. In parallel, historians have also begun to investigate past disasters as both sources of historical knowledge and as possible causal agents of historical change (e.g. Janku et al., 2012; Juneja and Mauelshagen, 2007; Juneja and Schenk, 2014; Luterbacher and Pfister, 2015; Mitchell, 2011; Parker, 2013; Schenk, 2007; Schenk, 2014). In the spirit of interdisciplinarity, this special issue is built around papers delivered at conference sessions on past volcanic activity at the Annual Meeting of the Society for American Archaeology on Hawai'i in 2013 (papers by Oetelaar and Beaudoin, Torrence, Riede, and Pandeia et al.) – an archaeological conference – and at the Cities on Volcanoes 8 meeting in Indonesia in 2014 (papers by Le Pennec et al., Holmberg) – a volcanological conference. Supplemented by the remaining papers, they provide a state-of-the-art in terms of how historical, archaeological and volcanological data can be integrated.

What is at stake?

In investigating aspects of past volcanic activity, two important issues are at stake. First, the relationship between volcanoes and humans has an evolutionarily long pedigree (e.g. de Lumley et al., 2008; Feibel, 1999; King and Bailey, 2006; Williams, 2012). Volcanoes do and did erupt and they may indeed have played an important role as triggers of particular cultural or demographic changes at particular junctures in time and at various social and geographic scales. Establishing if and how such extreme and for the most part unexpected environmental events have contributed to evolutionary and historical trajectories must be an important priority of any research into past volcanism.

Second, volcanic activity is a constant threat globally and the number of people at risk from volcanic activity is rising in lock-step with increased urbanization and population growth (Chester et al., 2001; Small and Naumann, 2001). Self (2006) suggests that the probability of at least one Magnitude, $M=6$ eruption – several case studies in this special issue concern eruptions of such magnitude – occurring in the present century is 100% and tersely recounts some of the potentially dire consequences of such a large event. Donovan and Oppenheimer (2014) are even more explicit in their risk assessment. Yet, what turns even such massive events into super-eruptions and disasters or even mega-disasters is largely the ‘where’, ‘when’ and ‘whom’ of impact. An eruption of $M=6$ occurring in sparsely settled Kamchatka is unlikely to have the same impact as an eruption of that size occurring in, for instance, the Mediterranean, the Cascades Range of North America, or the Eifel volcanic zone in western Europe. This special issue contributes to the growing body of historical and archaeological knowledge relating to past volcanism. Some 35 years after the landmark publication of Sheets and Grayson (1979b), this database has reached a substantial size. In

their introduction to that publication, Sheets and Grayson (1979a: 6-7) also outlined a series of challenges as they perceived them then:

Can patterns in responses to volcanic hazards and disasters by human societies be seen, and are these patterns related in a predictable way to the nature of that volcanism and to the kind of society affected? Is it reasonable to hope for prediction of potentially hazardous volcanic events, and, if so, how can such prediction be used in formulating public policy so as to lessen the impact of the predicted event?...Answers to questions relating to major aspects of the interrelationships between volcanism and human societies are many years in the future.

In volcanology, the existing quantitative databases of past volcanism (e.g. Bryson et al., 2006; Crossweller et al., 2012; Siebert et al., 2010) are used for predicting future occurrences. These databases are, however, largely silent on the dimensions of human impact. The largely qualitative nature of the historical and archaeological case studies does not make for straightforward integration of these approaches, but may offer a fruitful avenue for future research. The arguments, first presented by Grayson and Sheets (1979), for widening the chronological and thereby also cultural scope of impact studies to beyond the last decades are as valid today as they were 35 years ago. Concluding this special issue, Payson Sheets himself assesses whether we have reached the goals that they defined then. No doubt, a remarkable number of detailed case studies have been assembled. Yet, the influence of environmental archaeology on policy-making remains marginal, despite the fact that an increasing number of senior practitioners do make such attempts (e.g. Sabloff, 2009; Van de Noort, 2013; Weiss and Bradley, 2001). Volcanology is perhaps somewhat better placed (e.g. Donovan and Oppenheimer, 2012; Oppenheimer, 2015), in part because volcanologists have long been more willing to accept the responsibility that comes with that form of

engagement, but probably also in part due to a systematic funding bias in those subjects concerned with human impacts of extreme environmental events towards the natural science (see Sheets, 2012). Both disciplines could, however, potentially benefit from a closer alliance when it comes to translating their findings into scenarios and policy documents, basing these on equally well-founded historical and geological evidence and making use of the well-established outreach channels – museums of both natural and cultural history – that are affiliated with these subjects. The case studies presented in this special issue contribute to this endeavour.

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