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The 1717 eruption of Volcán de Fuego, Guatemala: Cascading hazards and societal response

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ABSTRACT

Assessing and communicating the risks posed by natural hazards requires not only a thorough understanding of the hazards themselves but also an understanding of the spatial and temporal impact of successive events from the same source(s). This approach is enhanced by the lens of time, which is often missing from modern responses to recent hazards. Archaeological studies, in contrast, examine the long-term consequences of hazardous events, but often lack details of the event chronology and immediate human impact that are available for recent events. Here we show ways in which historical records can bridge the gap between modern and prehistoric studies. We focus on the volcanically and seismically active region that hosts the capital city of Guatemala, a city that has been relocated twice in response to hazardous events since its original founding in 1527. More specifically, we examine documents – "*Autos Hechos Sobre el Lastimoso, Estrago y Ruina que Padecio esta Ciudad de Guatemala…*" [*Autos*] – that were collected in response to a cascading sequence of volcanic, seismic and mudflow events in 1717 to support a request to the Spanish government to relocate the capital city for a second time. These documents provide exceptional detail about the location of the witnesses, the nature of the hazardous activity and the response of local communities. This detail allows us not only to reconstruct the sequence of events but also to link volcanic activity at Volcán de Fuego to local seismicity and mudflows from Volcán de Agua, which we interpret as triggered by magma intruded after the eruption of Fuego ceased. At the same time, the long and well documented history of the region allows us to examine ways in which a single catastrophic event – in this case a large rainfall-triggered debris flow from Agua in 1541, which destroyed the first capital city – can reverberate through the centuries and affect the response of the local community almost 200 years later, in 1717. The long-term effects are particularly apparent because both the origin and affected area of the mudflow hazard were very different in the two cases. This example thus illustrates the importance of "memorability" (e.g., Slovic, 2000) in both the perception of, and response to, hazardous events.

1. Introduction

Recent volcanic eruptions, such as that of Eyjafjallajökull volcano in Iceland in 2010, have stimulated important interactions among scientists, social scientists and emergency managers. Such studies of recent events tend naturally to focus on immediate impacts; associated hazard management studies focus on responses to immediate physical impacts of hazard (*vulnerability*), often at the expense of developing long-term (and sustainable) strategies for hazard mitigation (*resilience*; e.g., White et al., 2001). This approach ignores the 'long shadow' (e.g., Grattan and Torrence, 2007) of such disasters, where 'long' refers to time scales relevant for either political or cultural change (e.g., Birkmann et al., 2010; Diamond and Robinson, 2010). A long view is provided, in contrast, by archaeological studies of the impact of past volcanic disasters on human societies (e.g., Sheets and Grayson, 1979). A challenge to archaeological studies, however, is that causality must be assumed rather than proven (Coombes and Barber, 2005; Leroy, 2006). The time gap between archaeological and present day research can be bridged by the historical record, which contributes robust chronologies that allow cause and effect to be linked (e.g., Vittori et al., 2007).

Here we draw on documentary sources from eighteenth century Guatemala to examine an unusual cascading sequence of events

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that affected the second capital of Guatemala, Santiago de Guatemala (now Antigua; Fig. 1), in August and September 1717. The experiences of 1717 prompted debate among Santiago's inhabitants regarding the situation of the city, which had been relocated to this (higher) site in the aftermath of a disastrous mudflow from the dormant Volcán de Agua that destroyed the original Spanish capital in 1541 (14 years after it was founded). Debate after the 1717 events centered on the precise nature of the hazards and risks posed to the city by nearby volcanoes, specifically Agua and neighboring, frequently active, Volcán de Fuego. The extensive documentation generated as these risks and hazards were assessed reveals a range of perspectives and understandings; particularly striking, however, is the extent to which the 1541 event loomed large in the memory of the city's population, and served to inform the arguments of those who supported a second relocation of the Guatemalan capital. This is the side of the debate that is reflected in the *Autos*. Detailed analysis of these documents allows us not only to reconstruct the sequence, and analyse the nature, of the events that occurred in 1717, but also to explore the role of past events on the response of the population to an immediate crisis.

2. Background

It is well known that disastrous events can act as natural experiments (Diamond and Robinson, 2010) and/or catalysts of change (e.g., Burby et al., 2000; Pérez, 2001; Birkmann et al., 2010). Change may occur by migration (abandoning the hazardous location) or adaptation, such as risk-based land use planning. To be effective, such planning must balance the benefits, as well as the drawbacks, of living in hazardous areas (e.g., White et al., 2001; Glavovic et al., 2010), and engage both community members and government officials (e.g., Cronin et al., 2004; Cashman and Cronin, 2008; Ricci et al., 2013). A key factor that affects community perceptions of risk is the *memorability* (and imaginability) of individual hazards (e.g., Slovic, 2000), such that an event that is memorable within the community for its real *or perceived* impact will be weighted more heavily in planning decisions than an event that is not as easily imagined. A modern example is the 1979 Three Mile Island nuclear accident in the US and the effect of that accident on perceptions of risk related to nuclear power (e.g., Slovic et al., 1982; Kasperson et al., 1988). A different perspective on memorability can be found in studies of oral traditions. When stories must be passed orally from generation to generation, a community disaster may become "a defining experience that passes into shared memory" (Pérez, 2001). In this way, inherited stories, whether oral or written, are often preserved where the knowledge contained is critical to community survival (e.g., Barber and Barber, 2006), and thus may influence community planning of future generations.

The long history (~300 years) of Spanish colonisation in Guatemala, which was centered on the city of Santiago, produced an extensive written record of hazard events in the area around Volcán de Fuego [Fuego] and neighboring Volcán de Agua [Agua]. Both volcanoes form part of the Central American volcanic arc (Fig. 1). Fuego has been one of the most persistently active of the Guatemalan volcanoes, with 57 confirmed eruptions, and several more unconfirmed, since the arrival of Spanish colonists in 1524 (Smithsonian Institute, Global Volcanism Program [GVP] database). Agua, in contrast, has no documented eruptions in the Holocene (Bonis and Salazar, 1973; Schilling, 2001; GVP). It has had, instead, numerous mudflows that have typically affected the area to the north of the volcano, including the first capital city (Peraldo Huertas and Montero Pohly, 1996).

Fuego is basaltic andesite in composition, and most of its eruptions have been moderate in size and intensity (VEI 2 or 3; GVP). At the extremes are periods of persistent low level 'open vent' activity (Lyons et al., 2010), and larger (VEI 4) eruptions (Rose et al., 1978; Lyons et al., 2010; GVP). Recorded activity is episodic, with four 20–70 year periods of high activity accounting for 75% of the total number of eruptions (Fig. 2). Interestingly, this episodicity appears to be regional, such that activity at Fuego mirrors the rest of the Central American volcanoes (Martin and Rose, 1981). More importantly, as evidenced by the *Autos*, the frequent activity meant that the inhabitants of Santiago de Guatemala in 1717 were familiar with Fuego's range of volcanic activity.

Mudflows from Agua also vary in intensity, the most severe being that of September 1541 (Schilling, 2001). The mudflow was caused by a debris flow that originated from the volcano's summit

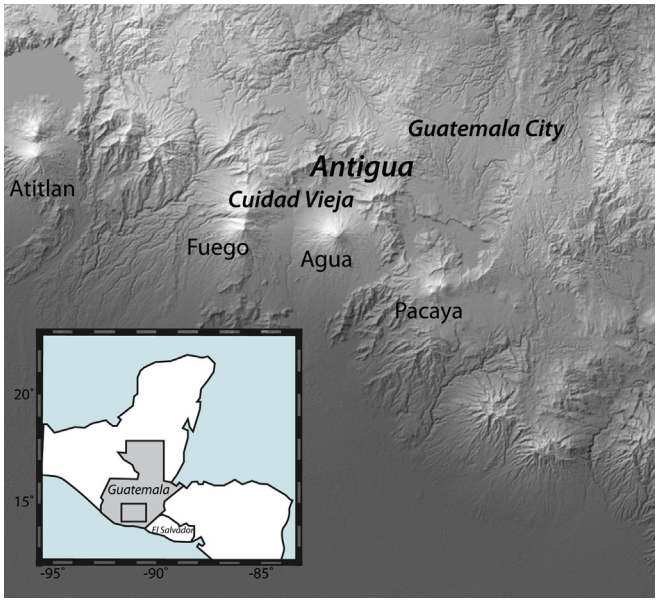

Fig. 1. Location map showing the three capital cities of Guatemala and the nearby volcanoes. The cities are currently known as Ciudad Vieja (formerly Santiago de los Caballeros, founded in 1527), Antigua (formerly Santiago de Guatemala, relocated in 1542), and Guatemala City (relocated in 1773 following a large regional earthquake). The volcanoes Atitlan, Fuego, Agua and Pacaya lie along the Central America volcanic arc. All have been active during historical times except Agua.

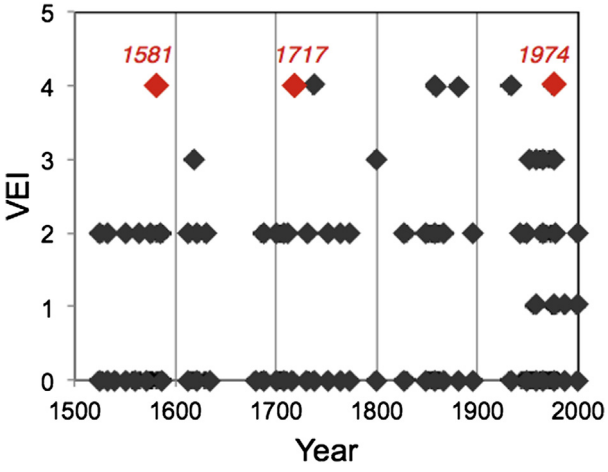

Fig. 2. Eruptive history of Fuego volcano since 1524, when the Spanish first arrived in the area. Data are from the Smithsonian Global Volcanism Program database [http://www.volcano.si.edu/] and provide a measure of the eruption size using the Volcano Explosivity Index [http://volcanoes.usgs.gov/images/pglossary/vei.php]. VEI 4 eruptions of 1717 and 1974 are highlighted, as is the only other VEI 4 eruption between 1524 and 1717, in 1581.