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Short communication

Maar-diatreme volcanism relating to the pyroclastic sequence of a newly discovered high-alumina basalt in the Maroa Volcanic Centre, Taupo Volcanic Zone, New Zealand

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ABSTRACT

Diatreme sequences have previously been described from drill holes within the Taupo Volcanic Zone. The newly discovered Te Hukui Basalt exhibits deep excavation of country rocks that do not appear elsewhere at the surface. The basalt is characterized by proximal deposition of pyroclastic deposits relating to phreatomagmatism. The geochemical composition classifies these rocks as high-alumina basalts. They erupted along the Orakeikorako Fault at the same location where rhyolitic activity of Puketerata occurred at a later point in time. The petrological characteristics of the basalts indicate the mixing of mafic melt with crystalline mush relating to more evolved magmas. The new basaltic occurrence supports frequent mafic recharge of shallow magma reservoirs, inducing basaltic eruptions, in this case the mafic magma intruding into highly crystallized mush zones. This may explain why basaltic eruptions mostly occur on the edge of the central extensional part of the Taupo Volcanic Zone.

1. Introduction

Most of the basalts of the central part of the Taupo Volcanic Zone (TVZ) are considered high-alumina basalts (HAB) (Kuno, 1960) originating from partial melting of the depleted upper mantle (Cole, 1973; Graham et al., 1995). Basaltic volcanism is considered to be only a small portion of the total volume of volcanic material erupted from the TVZ, but it is ubiquitous across the TVZ (Houghton et al., 1987; Wilson et al., 1995; Hiess et al., 2007). Basaltic volcanism plays an important role in the generation of rhyolites and also in triggering silicic eruptions (Graham et al., 1995; Leonard et al., 2002). The rise of basaltic dykes is most likely controlled by extensional tectonism (Gamble et al., 1990) whereas the eruptive vents are linked to major faults and often indicate fissural activity (Hiess et al., 2007). Eruptive styles range from effusive lava to basaltic Plinian activity (Houghton et al., 1987; Brown et al., 1994; Sable et al., 2009). Basaltic eruptions occurring at locations such as Kaiapo and K-Trig (Brown et al., 1994), Acacia Bay (Wilson and Smith, 1985), and Kinloch (Matheson, 2010) demonstrate the effects of magma/water interaction in or close to lake environments. The available data on other known occurrences of mafic deposits in the TVZ (e.g. Ben Lomond, Marotiri, Kakuki) (Fig. 1) also point to phreatomagmatic phases during their evolution, but they are considered to have been dominated by less energetic, predominantly Strombolian-style eruptions (Wilson et al., 1986; Houghton et al., 1987). Detailed field work at the silicic Puketerata Volcanic Complex (Kósik et al., 2016a) has led to the discovery of a previously unknown basaltic rock association characterized by ~50% of SiO_2 (Fig. 1). The chaotically dipping contacts of stratified tuff and lapilli tuff, massive lapilli tuff and polymict country rock breccia indicate that various styles of proximal deposition took place on a steep slope. This kind of deposition is distinctive for diatremes, which typically evolve as a result of the excavation of the country rocks by deep-seated phreatomagmatic eruptions, leading to *syn-* and post-eruptive sedimentation within the crater (White and Ross, 2011; Valentine and White, 2012). The basaltic deposits have been exposed by the excavation of the later rhyolitic eruption of Puketerata, which indicates a long erosional period between the formation of basaltic maar(s) and the Puketerata eruption. Phreatomagmatism also seems to be the dominant process for small-volume eruptions around Puketerata and other parts of the Taupo-Whakamaru area (Fig. 1).

2. Geological background

Maroa Volcanic Centre (MVC) is located at the NE quadrant of Whakamaru Volcanic Centre (WVC), which was the source of at least 2200 km^3 DRE ignimbrite at ~350 ka (Downs et al., 2014; Gravley et al., 2016). In the south, the WVC overlaps with the younger Taupo Volcanic Centre, which sourced two climactic eruptions associated with caldera formations at 25.4 and 1.8 ka (Wilson and Walker, 1985;

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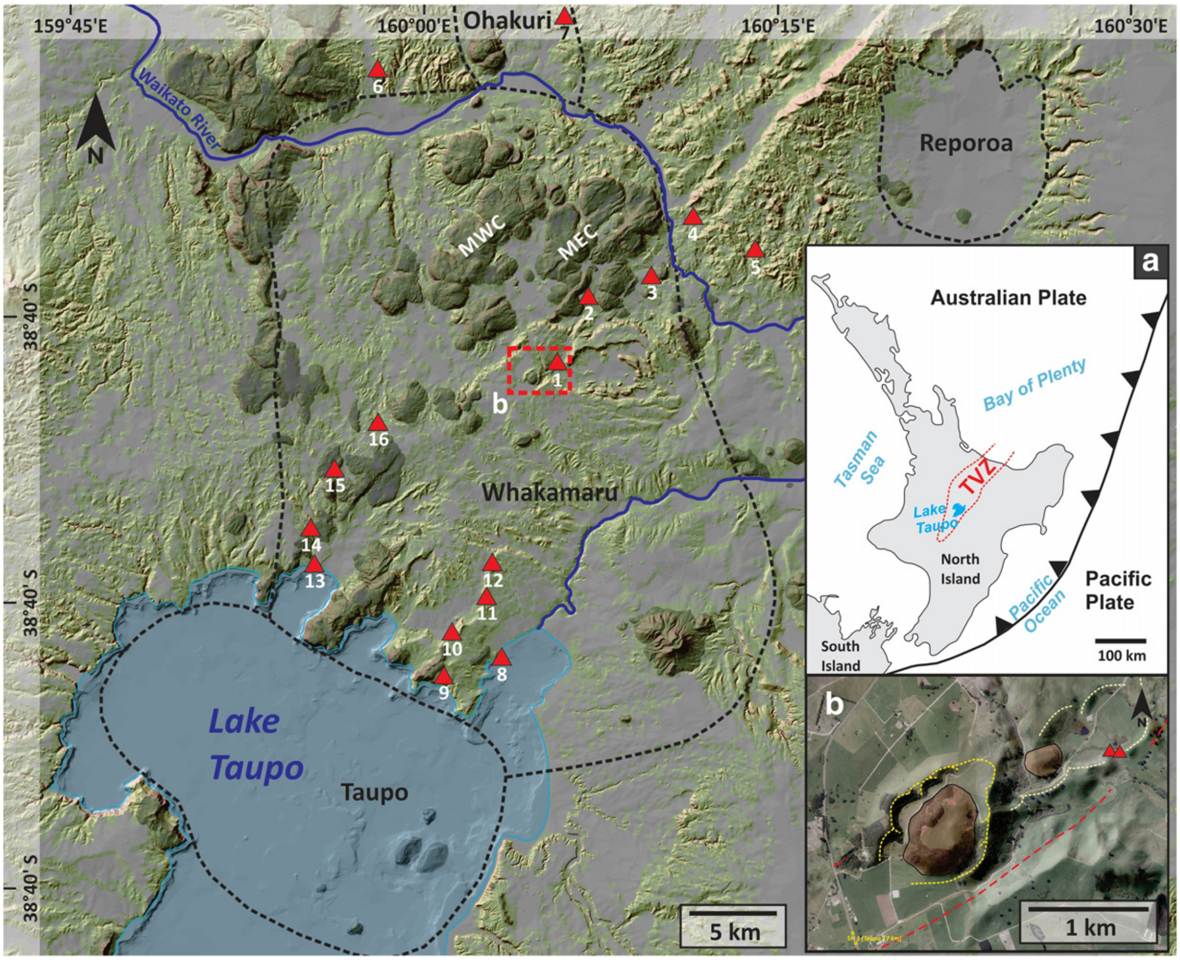

Fig. 1. Spatial distribution of the basaltic vents within the Whakamaru-Taupo area as displayed on a shaded slope map derived from a 8 m DEM (LINZ - Land Information New Zealand, 2012). Shaded areas represent the edifices of silicic lava domes. Basaltic vents: 1 Te Hukui, 2 Tatua, 3 Kakuki, 4 Akatarewa Stream, 5 Mangamingi Road, 6 Ongaroto, 7 Trig 8543/Matapan, 8 Acacia Bay, 9 Pekanui, 10 Kaiapo, 11 K-Trig, 12 Punatekahi, 13 Kinloch, 14 Otaketake Stream, 15 Marotiri, 16 Poihipi/Ben Lomond. Caldera margins with black dashed line after Houghton et al. (1995). Inset maps: (a) shows the geographic position of TVZ; (b) red triangles indicate the location of Te Hukui Basalt exposures in relation with the architecture of the Puketerata Volcanic Complex (shaded structures are lava domes of Puketerata, yellow and white dashed lines show the rim of ejecta ring and maar craters, red dashed line represents the Orakeikorako Fault) (Kósik et al., 2016a).

Vandergoes et al., 2013). Early activity of the MVC was characterized by vigorous explosive activity with the eruption of locally distributed, relatively small-volume ignimbrites (e.g. Putauaki, Orakonui) and isolated lava domes from 305 to ~250 ka (Leonard, 2003). Maroa volcanism culminated between 251 and 222 ka with the emplacement of the majority of the domes of the Maroa Western (MWC) and Eastern Complexes (MEC) (Fig. 1). Subsequent activity formed mostly smaller silicic dome complexes and isolated lava domes and flows, characterized by decreasing recurrence time and erupted volumes of single eruptions (Leonard, 2003). The 16.5 ka Puketerata Volcanic Complex is the youngest volcano of the Maroa system and erupted along a 2.5 km long fissure parallel to the Orakeikorako Fault (Brooker et al., 1993; Kósik et al., 2016a). The initial maar-forming phase was followed by emplacement of two lava domes accompanied with phreatomagmatic activity (Kósik et al., 2016a).

Compared with rhyolitic eruptions basaltic volcanic activity of the Taupo-Whakamaru area is insignificant representing less than 0.1% volume of the total erupted material (Wilson et al., 1995), however petrological features of rhyolitic rocks indicate that mafic magmas have a vital role in the evolution of silicic magmas (Houghton et al., 1987; Leonard et al., 2002). The available stratigraphic evidence indicates that basaltic eruptions occurred between 200 and 10 ka within the Taupo-Whakamaru area (Wilson et al., 1986; Matheson, 2010).

3. Stratigraphy and sedimentology

The newly discovered basalt (Te Hukui Basalt – suggested stratigraphic name) is exposed on both sides of the Te Hukui Stream, where the stream cuts across the southeastern side of the crater wall of Puketerata (Kósik et al., 2016a) (Fig. 1b). At the left bank of the stream (38° 32′41.15″S; 176° 4′11.73″E) the basaltic deposits are underlain by the ignimbrite of the Orakonui Formation (Brooker et al., 1993). The lowest 10–40 cm of the Te Hukui sequence is a well-sorted strongly cemented and altered lapilli unit (A) exhibiting yellowish-brownish discoloration. This is followed by an at least 5 m thick matrix-supported breccia unit with a sharp basal erosional contact (unit B). The breccia is characterized by mostly angular variably-altered blocks up to 40 cm across, set within a weathered light grey ash (Figs. 2a, d). The lithic fragments of the breccia comprise ignimbrite of the basement (Fig. 3b) and at least five different types of silica-rich extrusive rocks (Fig. 3a) which are neither similar to the immediate basement nor to the vesiculated basalt lithics found within the upper part of the sequence. Four faults dipping westward are visible within the 25 m long section of the breccia, with throws ranging between 30 and 150 cm. The subsequent unit (C) is approximately a 1 m thick, poorly-sorted and strongly-cemented lapilli tuff with lithic clasts up to 2–3 cm in size, including rare basaltic fragments and pumices and lithic clasts of the basement (Fig. 4a),