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U–Pb dating of magmatic and xenocryst zircons from Mangakino ignimbrites and their correlation with detrital zircons from the Torlesse metasediments, Taupo Volcanic Zone, New Zealand

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ABSTRACT

Mangakino ignimbrites are a sequence of voluminous eruptive units in the rhyolitic Mangakino Volcanic Centre (MVC) caldera complex, Taupo Volcanic Zone, New Zealand. U–Pb dating of 113 zircons extracted from four Mangakino ignimbrites reveals magmatic and xenocrystic zircons. Magmatic zircon ages from three ignimbrites are slightly older than K/Ar and $^{40}Ar/^{39}Ar$ ages. Magmatic zircon age-spectra are tightly clustered and support a simple crystallisation history for these three ignimbrites. It is possible that the assimilation of zircon antecrysts leads to magmatic zircon spectra for the Ahuroa ignimbrite being ≥70 ka older than the $^{40}Ar/^{39}Ar$ age. Xenocrystic zircon age spectra correlate with spectra of detrital zircons from the underlying Mesozoic Torlesse metasediments. Our data are consistent with significant assimilation of metasediments and the incorporation of zircon prior to eruption. Systematic variations in the age spectra of xenocrystic zircons in successive Mangakino ignimbrites may be related to the structural development of the North Island, New Zealand.

1. Introduction

Constraining the storage time and assimilative history of silicic magma in the crust is important for understanding active silicic volcanic systems. Magma storage timescales vary from 10^2 to 10^6 years in silicic systems due to the age, composition and structural characteristics of the host region (Houghton et al., 1995; Vazquez and Reid, 2002; Miller et al., 2007; Simon et al., 2008). Storage timescales can be constrained using the crystallisation age of zircon and later crystallizing minerals (e.g. Smith, 1979; Halliday et al., 1989; Christensen and DePaolo, 1993; Davies et al., 1994; Houghton et al., 1995; Reid et al., 1997; Brown and Fletcher, 1999; Charlier et al., 2003; Charlier et al., 2005; Brown and Smith, 2004; Miller et al., 2007; Simon et al., 2008; Wilson et al., 2008). The Taupo Volcanic Zone (TVZ) of New Zealand is an active and highly productive silicic magma system underlain by thick metasedimentary sequences containing well defined detrital zircon age spectra, providing an ideal setting to study the nature of storage and assimilation in silicic volcanism.

The TVZ comprises at least 34 caldera-forming eruptions from eight centres that produced deposits of >16,000 km^3 over the last ~2 Ma (Houghton et al., 1995; Kear, 2004; Fig. 1). Age and petrological data indicate that TVZ silicic magma erupts on timescales between 10^4 and 10^5 years (Houghton et al., 1995; Sutton et al., 2000). Dating of zircon shows continuous crystallisation begins ~50 to ~268 ka prior to these eruptions (Brown and Fletcher, 1999; Charlier et al., 2003). Furthermore, complicated and discontinuous zircon age-spectra indicate phenocrysts, antecrysts and xenocrysts present in single eruptions (Charlier et al., 2005). It is assumed that this difference between zircon age-spectra in magmas is the result of differing geological conditions.

Rare zircon xenocrysts from TVZ rhyolite have previously hinted at a correlation with detrital zircon age populations of the Cretaceous metasedimentary basement and therefore provide evidence for basement contribution to magma petrogenesis (Lindsay et al., 1995; Brown and Smith, 2004; Charlier et al., 2005; Brown and Smith, 2004). It is not known if the rarity of xenocryst zircons (4 out of >300 zircons; Brown and Smith, 2004) reflects limited assimilation of basement, dilution of a small number of zircons in a large volume of magma, or resorption of zircon by Zr-undersaturated magma at any time in the crust (Lindsay et al., 1995; Brown and Fletcher, 1999; Brown and Smith, 2004; Charlier et al., 2005).

Here we present SHRIMP U–Pb data for zircon from four ignimbrites from the MVC in the TVZ (Fig. 1), New Zealand, with the aims being to:

(1) date magmatic zircons and comment on storage timescales relative to published K/Ar and Ar^{40}/Ar^{39} dates; and
(2) date xenocrystic zircons to constrain the pre-eruptive history of the assimilated basement material.

The Mangakino ignimbrites are ideal candidates for this study because they are a succession of large crystal-rich units that have been

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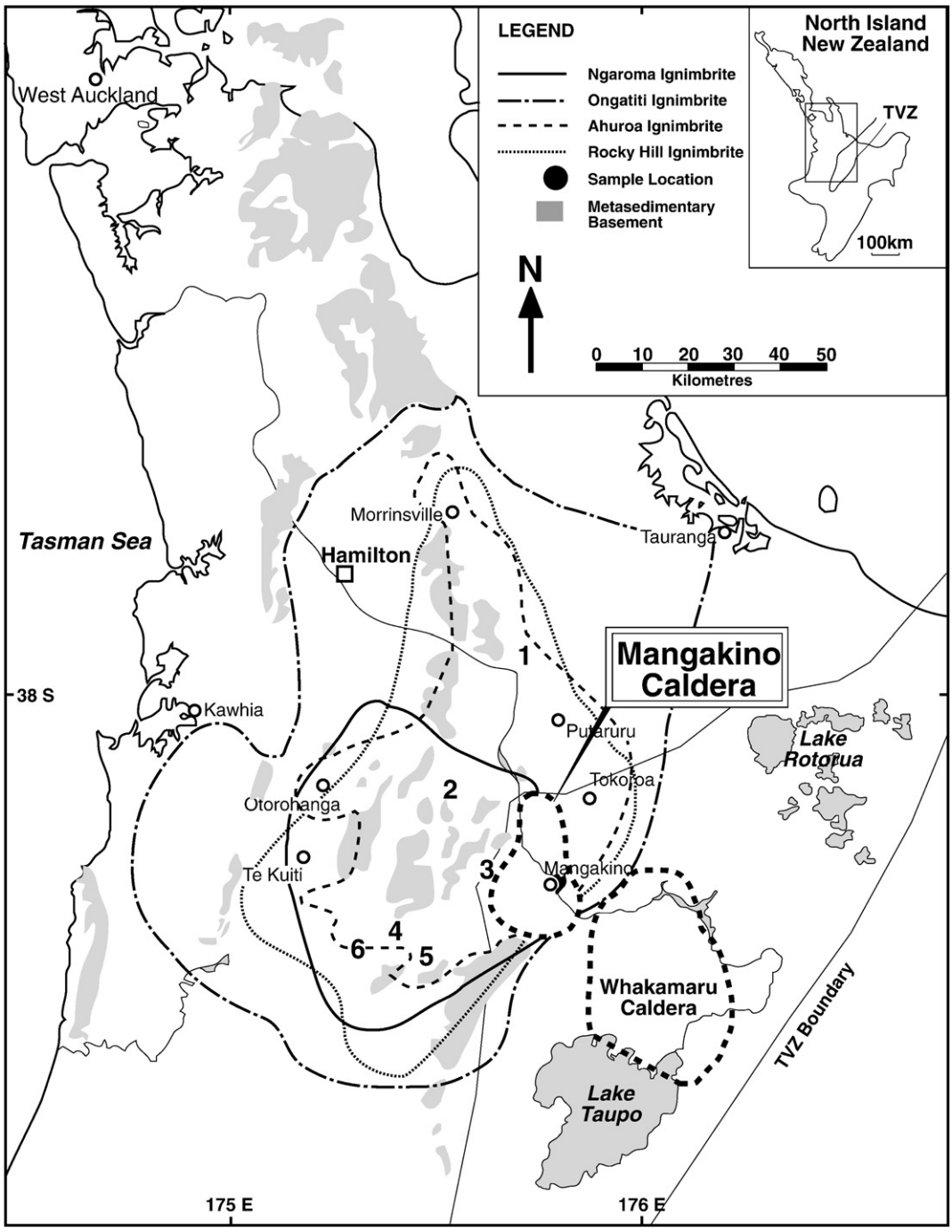

Fig. 1. Known distribution of the Ngaroma, Ongatiti, Ahuroa and Rocky Hill ignimbrites. Boundaries delineated by stippled lines and outcropping metasedimentary basement [Adapted from Briggs et al. (1993) and R. Smith (pers. commun., 2005)]. Location of Mangakino and Whakamaru calderas based on Brown and Smith (2004) following Wilson et al. (1984). Location of sampling sites shown; 1 = Hinuera Quarry; 2 = Casper Farm; 3 = Mangawhio Road; 4 = Mangaokewa Stream Valley; 5 = Head of Kaama Stream; 6 = Road cutting on state highway 30.

the focus of volcanological, chemical and micro probe studies (e.g., Wilson, 1986; Briggs et al., 1993; Brown and Smith, 2004). In addition, rare zircon xenocrysts indicate that silicic magma genesis possibly involves material from the country rock (Ewart and Stipp, 1968, Graham et al., 1992; McCulloch et al., 1993; Graham et al., 1995).

2. Regional setting

The TVZ has been the focus of rhyolitic volcanism in the central North Island of New Zealand since ~1.6 Ma. The TVZ is NNE-trending region, 300 km long and up to 60 km wide that is associated with the westward subduction of the Pacific plate beneath the Indo–Australian plate (Hochstein, 1995; Wilson et al., 1995; Reyners et al., 2006; Fig. 1). The prolific volcanic activity and normal/extensional faulting reflects a sphenochasm of continental crust proximal to the subduction of oceanic crust (Cole, 1990; Wilson et al., 1995; Kear, 2004; Reyners et al., 2006; Fig. 2).

The MVC (Fig. 2) is west of the active volcanism and hosts the Mangakino Caldera complex that represents the earliest known caldera-forming eruption in the TVZ. Kear (2004) proposed that the Mangakino Volcanic Zone (MVZ) and associated caldera complex formed during the Kaimai Tectonic Event (5.0–2.5 Ma), where 35–