The study and identification of a volcanic ash in a Holocene buried peat layer and its chronostratigraphic implication, Banks Peninsula, Canterbury, New Zealand.

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Context

Tephrostratigraphy is widely applied as a correlation and indirect dating tool. In NZ, Quaternary volcanic activity is restricted to the North Island (NI; Fig. 1). Kawakawa-Oruanui Tephra (KOT; 27,095 cal yr BP; Wilson et al., 2006), originating from the Taupo volcanic zone, is the only tephra of Quaternary age known to be widespread in South Island (SI). The occurrence of KOT has been used to infer loess accretion, soil transport and erosion rates, and to discriminate and identify LGM moraines. Chemical fingerprinting of cryptotephra across a large part of SI generally supports correlation with KOT, but without fingerprinting, inappropriate correlations could be made if other unknown cryptotephra occurs in SI.

Introduction to the study

Two cores have been taken from a buried peat layer in a swamp in an enclosed valley on the southern flanks of Banks Peninsula, Canterbury, New Zealand (NZ) (Fig. 1). The swamp formed after a small valley was impounded by the construction of a gravel barrier bar sometime after the culmination of post-glacial sea level rise (Soons et al., 1997). In the first core, taken in 1984, cryptotephra was detected and two carbon dates indicated a Holocene age for the peat, though the data remain unpublished. This MSc project involves the study of a second core (2011) which was taken closer to the deepest part of the valley after intensive drilling along two transects that revealed the stratigraphy (Fig. 2ab). The aim is to identify the earlier reported tephra and discuss the chronostratigraphic implications. Palynological and diatom analyses were carried out to determine the environmental setting during peat formation and tephra deposition.

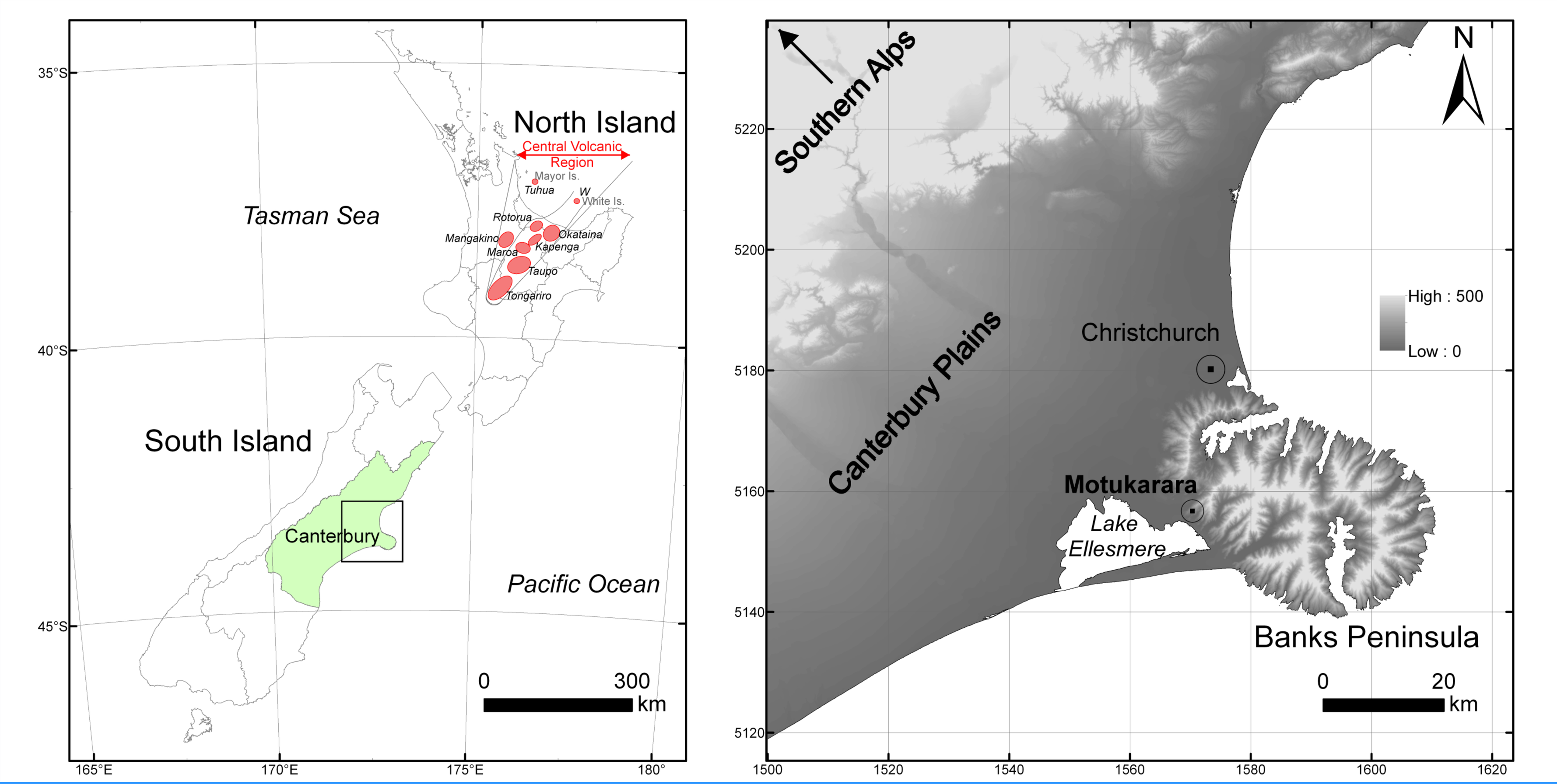

Figure 1: New Zealand with the Central Volcanic Region and the location of Motukarara, Banks Peninsula, Canterbury, New Zealand.

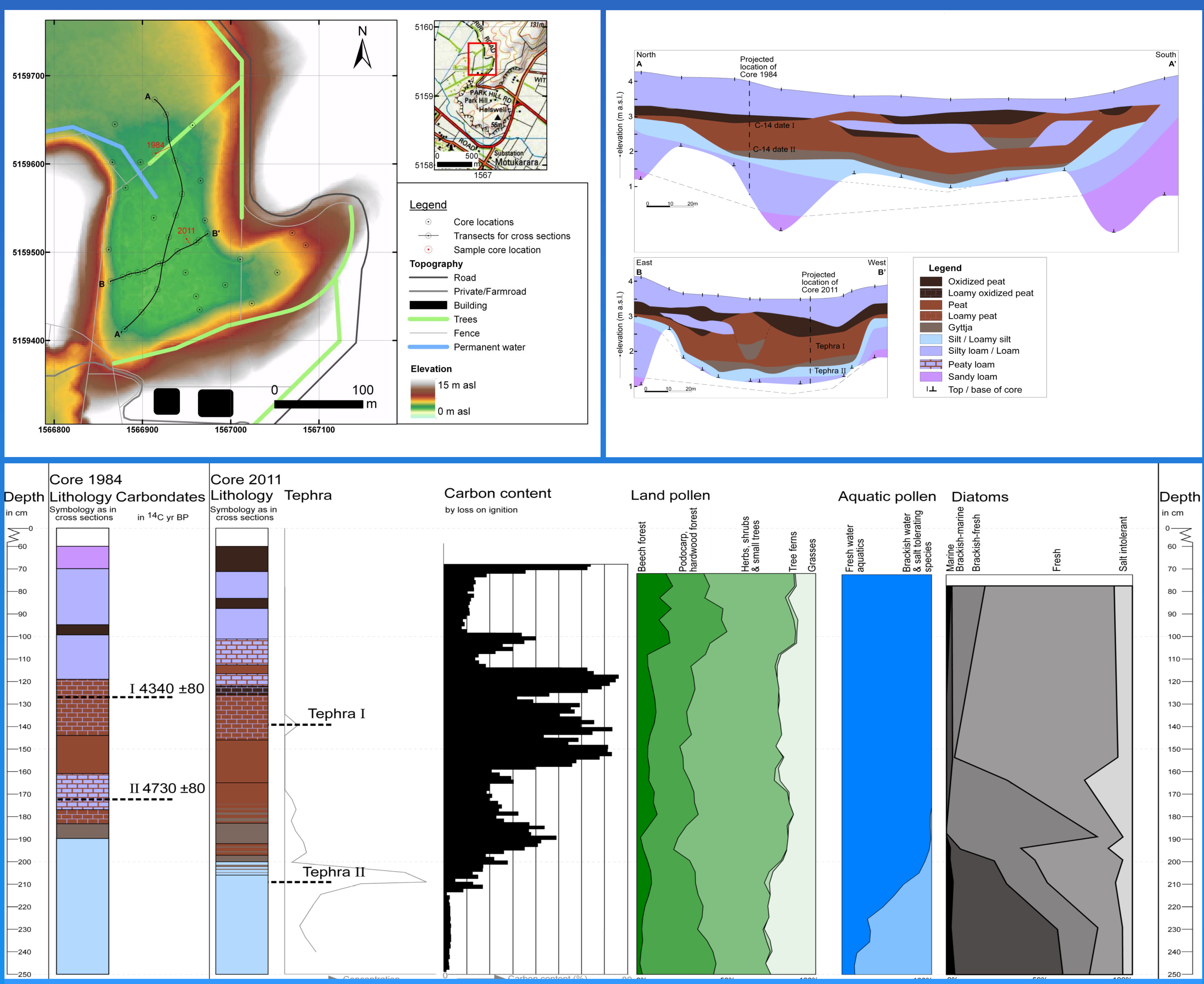

Figure 2: a: Motukarara Valley near Motukarara (fig 1) with the locations of b and c. b: lithological cross sections with projected locations of Core 1984 and 2011. c: Lithology and carbondates for Core 1984 and for Core 2011 lithology, tephra concentration profile, carbon content graph and simplified pollen and diatom diagram.

Core analysis

Stratigraphy from base to top, exists of loam silts, peat and silt loams (Fig. 2b) with a small channel with loamy levee deposits in the peat as a result of variability in mineral input. The variability in mineral input during peat formation for core 2011 is recorded in the carbon content (Fig. 2c). Pollen and diatom analyses indicate a transition from brackish to fresh water environment, coinciding with the beginning of peat formation.

Tephra II is imbedded in the lower loam silt deposits. Tephra I is embedded in the peat. Despite that the two radiocarbon dates, the pollen and the stratigraphy of the site, especially for Tephra I, suggest that the tephra are of Holocene age, the best correlation based on microprobe analysis is with KOT (Table 1). More analyses should be done on Tephra I, but it looks like both cryptotephra peaks reflect redeposition of KOT from the surrounding loess landscape (Almond et al., 2007), but no clear associations of erosion events can be identified with environmental change.

Table 1: Mean major element composition of glass shards from Motukarara Valley & potential South Island & offshore tephra correlatives

	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	Cl	H2)	N
Tephra I [a]	78.39	0.14	12.56	1.24	0.07	0.13	1.02	3.40	3.05	nd [b]	7.70	1
Tephra II [a]	78.39	0.12	12.59	1.18	0.05	0.12	0.97	3.53	3.03	nd [b]	3.71	11
	(0.18)	(0.02)	(0.08)	(0.05)	(0.02)	(0.01)	(0.06)	(0.12)	(0.15)		(1.69)	
Whakatane Tephra, Pitt Island, Chatham Islands [c]	77.84	0.15	12.16	0.87	0.06	0.08	0.65	4.11	3.85	0.25	6.44	14
	(0.19)	(0.05)	(0.12)	(0.06)	(0.07)	(0.06)	(0.06)	(0.15)	(0.17)	(0.03)	(0.51)	
Kawakawa Tephra, Okarito Lagoon, south Westland [d]	78.04	0.14	12.65	1.13	0.06	0.13	1.02	3.34	3.27	0.20	5.05	20
	(0.30)	(0.03)	(0.15)	(0.10)	(0.06)	(0.02)	(0.07)	(0.41)	(0.34)	(0.05)	(1.42)	
Kawakawa Tephra, Galway Tarn, south Westland [d]	77.75	0.13	12.59	1.13	0.08	0.13	1.04	3.79	3.06	0.23	4.40	20
	(0.36)	(0.03)	(0.16)	(0.13)	(0.05)	(0.03)	(0.06)	(0.24)	(0.11)	(0.16)	(1.62)	
Kawakawa Tephra, AT-331, ODP Site-1123, 1.01 mcd [e]	77.98	0.13	12.31	1.16	nd	0.11	1.07	3.98	3.05	0.15	4.23	15
	(0.29)	(0.03)	(0.12)	(0.08)		(0.02	(0.11)	(0.10)	(0.19)	(0.02)	(1.02)	

a All major element determinations were made on a JEOL Superprobe (JXA-8230) housed at Victoria University of Wellington, using the ZAF correction method. Analyses were performed using an accelerating voltage of 15 kV under a static electron beam operating at 8 nA. The electron beam was defocused to 20 μm. All elements calculated on a water-free basis, with H2O by difference from 100%. Total Fe expressed as FeOt. Mean and ± 1 standard deviation (in parentheses), based on *n* analyses. All samples normalised against glass standard VG-568. Analyst: B. V. Alloway. b Not determined or not available. Analyst and/or sources of analyses – c D.J. Lowe in Holt *et al.* in press; d J.L. Horrocks in Newnham *et al.,* 2007; d Alloway *et al.* 2005.

Discussion and conclusion

No previously unrecognized cryptotephra have been identified in this study. Kawakawa Tephra remains the only unequivocally recognised late Quaternary tephra in the South Island of NZ. The results of this research do, however, show that very small traces of volcanic ash can be found and identified, although chemical fingerprinting of the small glass grains associated with these tephras is challenging.

The recent eruptions of the Puyehue-Cordón volcano, Chile (June 2011) have shown just how far volcanic ash can travel (Fig. 3). Other tephra from the CVR or from other volcanic sources are likely to have dispersed over South Island and therefore must have been deposited, and potentially preserved in favourable environments. We will be exploring new techniques to isolate the small glass grains associated with this kind of tephra deposit, and refined methods of electron microprobe analysis to better identify geochemical affinities.

An interesting outcome of the research is the observation that the transition from a brackish to a fresh water environment, occurs above present sea level. This result has significance for sea level reconstruction in NZ, or for constraining uplift rates on Banks Peninsula. The latter has been made very pertinent by the recent demonstration of reverse faulting and uplift associated with the devastating Canterbury earthquakes of 2010 and 2011.

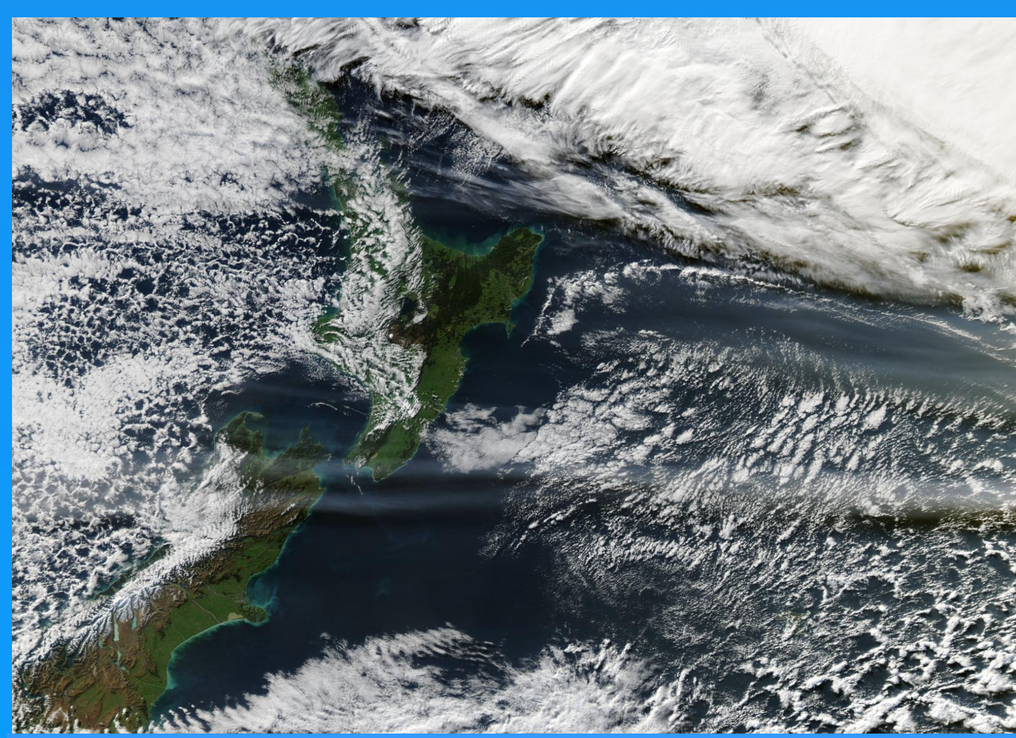

Figure 3: Satellite image (NASA) showing dispersion above New Zealand of the volcanic ash cloud, originating from the Puyehue-Cordón volcano, Chile (June 2011).

References
-Almond, P.C., Shanhun, F.L., Rieser, U. and Shulmeister, J., 2007. An OSL, radiocarbon and tephra isochron-based chronology for Birdlings Flat loess at Ahuriri Quarry, Banks Peninsula, Canterbury, New Zealand. Quaternary Geochronology, 2: (QUAGEO-D-06-00086) 4-8.
-Soons, J.M., Shulmeister, J. and Holt, S., 1997. The Holocene evolution of a well nourished gravelly barrier and lagoon complex, Kaitorete "Spit", Canterbury, New Zealand. Marine Geology, 138(1-2): 69-90.
-Wilson, , C.J.N., Blake, S., Charlier, B.L.A. and Sutton A.N., 2006. The 26.5ka Oruanui eruption, Taupo volcano, New Zealand: development, characteristics and evacuation of a large rhyolitic magma body. - Journal of Petrology, 47, 34-69.

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