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# Experimental studies on trace elements partitioning between mafic minerals and alkaline melts

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## Introduction

Trace elements in minerals and melts are widely used as geochemical fingerprints because their variability is sensitive to the physicochemical parameters of the system. Therefore, they notably and distinctively record the processes of genesis and evolution (e.g., Rollinson, 1993; Wood & Blundy, 2003). Trace elements are called incompatible (ITE) if they prefer to reside in the melts instead of the minerals with which they coexist, and conversely, they are called compatible (CTE) (Goldschmidt, 1937). The distribution of trace elements is quantified by partition coefficients (weight fraction ratio of trace element [i] in crystals and melts,  $D=[i]_{\text{crystal}}/[i]_{\text{liquid}}$ ), which depend mainly on the temperature, the melt and mineral compositions, the ionic radius and the electrical charge of the element of interest and, to some degree, the pressure (Watson, 1976; Blundy & Wood, 2003; Wood & Blundy, 2003). Trace element partition coefficients are essential parameters for any petrological and geochemical modeling of melting, crystallization, assimilation and magma mixing processes (Wood & Blundy, 2014).

## Experimental studies on trace elements: a brief review

Partition coefficients have been investigated experimentally for several decades and the available data-set increased considerably and is under continuous update (e.g. GERM- Geochemical Earth Reference Model, Staudigel et al., 1998). This is because there is a development of more precise analytical methods for quantification of trace element concentrations at  $\mu\text{g/g}$  level (e.g., LA-ICP-MS, SIMS). This database comprised mafic and felsic minerals studied under pressures from 0 to 20 GPa, using natural and synthetic tholeiitic basalts to rhyolite starting materials. However, experimental studies performed with compositions of alkaline affinity are more restricted, and they are summarized in table 1

## Experimental and analytical methods

1. Experimental design and set-ups.
2. Preparation of natural and synthetic starting materials.
3. Experimental runs under P, T,  $f_{\text{O}_2}$  and  $f_{\text{H}_2\text{O}}$  conditions (PC and VTF)
4. Textural and chemical quantitative analyses (SEM, EPMA, LA-ICPMS, XRD)

## Acknowledgements



Table 1. Previous experimental studies on trace element partition coefficients between mafic minerals and alkaline melts. Ol=olivine, Opx=orthopyroxene, Cpx=clinopyroxene, Grt= garnet, Amp=amphibole, Spn= spinel, Bt=biotite, Phl=phlogopite. LIL=large ion lithophile, HFS= high field strength, RE= rare earth, FSTM= first series transition metals, M=major elements.

Mineral	Experimental conditions			Elements	Reference
	P (GPa)	T (°C)	H <sub>2</sub> O (wt%)		
<i>Alkali basalt</i>					
Cpx	0.0-0.2	1000-1200	0-3	Li, LIL (2), RE (7), HFS (7)	(Wood & Triguila, 2001)
Cpx, Grt	2.0-3.0	1210-1350		LIL (2), RE (10)	(Shimizu, 1980)
Cpx, Grt	3.0-20	1550-2200		Li, M (7), LIL (2), RE (14), HFS (5), FSTM (4), (Ga, In)	(Suzuki <i>et al.</i> , 2012)
<i>Alkali olivine basalt</i>					
Amp	1.4	850-1000	0-5	Y+RE (14)	(Bottazzi <i>et al.</i> , 1999)
Spn	0	1250-1300		Ga, FSTM (3), HFS (5)	(Horn <i>et al.</i> , 1994)
<i>Basanite</i>					
Ol	1.4	1055		Li, Be, B, M (2), LIL (2), FSTM (3), RE (9), HFS (7)	(Zanetti <i>et al.</i> , 2004)
Amp, Cpx	0.5-2.5	1000-1350	2-12	HFS (1), LIL (1), RE (4)	(Adam & Green, 1994)
Amp, Cpx	1.0-2.5	1000-1050		LIL (2), HFS (5)	(Green <i>et al.</i> , 1993)
Ol, Opx, Cpx, Amp, Bt, Grt	1.0-3.5	1000-1200	5-12	Li, Be, B, M (3), LIL (4), HFS (11), FSTM (6), RE (9) (Ga, Ge, As, Mo) (Ag, Cd, In, Sn, Sb) (W, Ti, Bi)	(Adam & Green, 2006)
Cpx, Grt	3.0-7.5	1100-1220	10-20	LIL (2), HFS (5), RE (13)	(Green <i>et al.</i> , 2000)
Amp	1.5	1100	10	LIL (4), HFS (6), RE (14)	(Dalpé, 1994)
Amp, Phl	1.5-20	1090-1100	15	Be, F, Na, LIL (3), HFS (7), RE (9)	(LaTourrette <i>et al.</i> , 1995)
Amp	1.0-3.0	1000-1050	8-10	LIL (3), HFS (5)	(Adam <i>et al.</i> , 1993)
Phlog	3.0-7.5	1100-1220	10-20	LIL (2), HFS (5), RE(2)	(Green <i>et al.</i> , 2000)

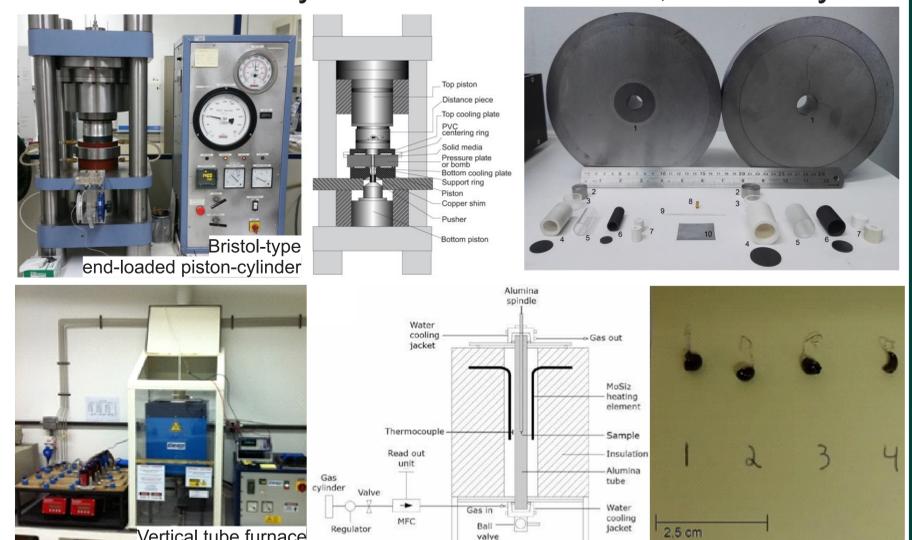


Figure 1. Apparatuses of Experimental Petrology and Geochemistry Lab (USP). Modified from Vlach *et al.*, in press and Mallmann *et al.*, 2014.