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Supporting Information for

Tracking the evolution of magmas from heterogeneous mantle sources to eruption

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Introduction

The supporting information complements the main text by:

- Providing additional detailed descriptions and references to Figure 9 (Text S1)

- Complementing Fig. 6 with additional oxide vs MgO diagrams (Fig. S1)

- Providing the solid phase compositions from Lambart et al. (2009) used in Fig. 4.(Tables S1-S4)

- Providing the complete compilation of data of used in Fig. 6 (Tables S5-S8)

- Providing the full results of the calculations used section 4.2.1 and in Figs. 7&8 (Table S9)

Text S1. Caption to Figure 9 with references.

(a) Experimentally produced peridotite partial melts without H_2O, with H_2O but no co-existing aqueous vapor, and co-existing with aqueous vapor plotted in SiO_2 versus total alkali space (Takahashi, 1986; Falloon et al., 1988; Falloon and Green, 1988; Kinzler and Grove, 1992; Hirose and Kushiro, 1993; Hirose and Kawamoto, 1995; Hirose, 1997; Gaetani and Grove, 1998; Kogiso et al., 1998; Walter, 1998; Parman and Grove, 2004; Grove et al., 2006; Tenner et al., 2012; Till et al., 2012; Mitchell and Grove, 2015). Partial melts of peridotite metasomatized by hydrous crustal partial melts are also plotted (Rapp et al., 1999; Prouteau et al., 2001; Mallik et al., 2015; Mallik et al., 2016). The partial melts of olivine metasomatized by hydrous silicic melt at 3.5 GPa (Pirard and Hermann, 2015) are likely vapor-saturated. (b) H_2O versus SiO_2 concentrations of experimentally derived partial melts in equilibrium with olivine and orthopyroxene. This subplot is a modification of Figure 7 in Mallik et al. (2016). Melt compositions in Figure 9a that co-exist with olivine and orthopyroxene are plotted here. All compositions plotted in the subplots have been normalized to a volatile-free basis. (c) Pressure-temperature space showing the solidi of nominally anhydrous peridotite (He00 - Herzberg et al., 2000; Hi00 - Hirschmann, 2000), peridotite with 50 and 200 ppm H2O (O'Leary et al., 2010), wet but vapor absent peridotite solidi (MG89 - Mengel and Green, 1989; CG04 - Conceição and Green, 2004; CM14 - Condamine and Médard, 2014; M15 -

Mallik et al., 2015; C16 - Condamine et al., 2016) wet but vapor present peridotite solidi (G06 - Grove et al., 2006; G10 - Green et al., 2010; T12 - Till et al., 2012; G14 - Green et al., 2014), nominally anhydrous oceanic crust or basalt (Y94 - Yasuda et al., 1994; PH03 - Pertermann and Hirschmann, 2003; S08 - Spandler et al., 2008), vapor present basalt (LW72 - Lambert and Wyllie, 1972), wet but vapor absent basalt (WW93 - Wyllie and Wolf, 1993), nominally anhydrous sediments (S10 - Spandler et al., 2010) and wet sediments (Johnson and Plank, 2000; Hermann and Green, 2001; Schmidt et al., 2004; Auzanneau et al., 2006; Hermann and Spandler, 2008; Thomsen and Schmidt, 2008; Tsuno and Dasgupta, 2012). The ridge and plume adiabats as well as the hot, intermediate and cold subduction geotherms are the same as in Figure 5. Primary arc magma compositions were compiled from melt inclusions that were trapped by olivine hosts with Mg# ≥ 85 (Cervantes and Wallace, 2003; Benjamin et al., 2007; Auer et al., 2008; Johnson et al., 2008; Portnyagin et al., 2008; Sadofsky et al., 2008; Shaw et al., 2008; Vigouroux et al., 2008; Roberge et al., 2009; Johnson et al., 2009; Ruscitto et al., 2010; Zimmer et al., 2010; Cooper et al., 2010; Ruscitto et al., 2011). These melt inclusion compositions were already corrected to be in equilibrium with their host olivine composition. Melt inclusions hosted by olivines with Mg# < 90 were corrected to be in equilibrium with olivine of Mg# 91 (primary mantle olivine composition) using K_D Fe-Mg $(([FeO/MgO]_{olivine)}/([FeO/MgO]_{melt})) = 0.3$. The pressure-temperatures of formation of primary arc magmas were calculated using the thermo-barometer of Lee et al., (2009). Melt inclusions almost never preserve the H_2O contents at their time of formation due to diffusive loss of H_2O through the host olivines (Gaetani et al., 2012). Hence, H_2O concentrations of high H_2O melt inclusions only show a minimum estimate of primary H_2O. We have estimated pressure-temperatures of the formation of primary magmas with 7 and 13 wt.% H_2O. 7 wt.% H_2O represents the highest H_2O content measured in olivine-hosted melt inclusions (Auer et al., 2008; Zimmer et al., 2010) while 13 wt.% is the highest H_2O content of peridotite partial melt produced in the experiments performed by Grove et al., (2006). It is interesting to note that temperatures of magma formation decrease with increasing H_2O contents. (d) SiO_2 versus total alkali (Na_2O + K_2O) space with partial melts of sediments and altered oceanic crust (Rapp and Watson, 1995; Johnson and Plank, 2000; Hermann and Green, 2001; Schmidt et al., 2004; Auzanneau et al., 2006; Hermann and Spandler, 2008; Spandler et al., 2010; Tsuno and Dasgupta, 2012) produced in experiments, primary arc magmas (same as plotted in Figure 9a), and naturally occurring peridotites, mid-ocean ridge basalts (GEOROC database; http://georoc.mpch-mainz.gwdg.de/georoc/) and subducting sediments (Plank and Langmuir, 1998) are plotted. The classifications of rock types in the figure are based on Le Bas et al., (1986).

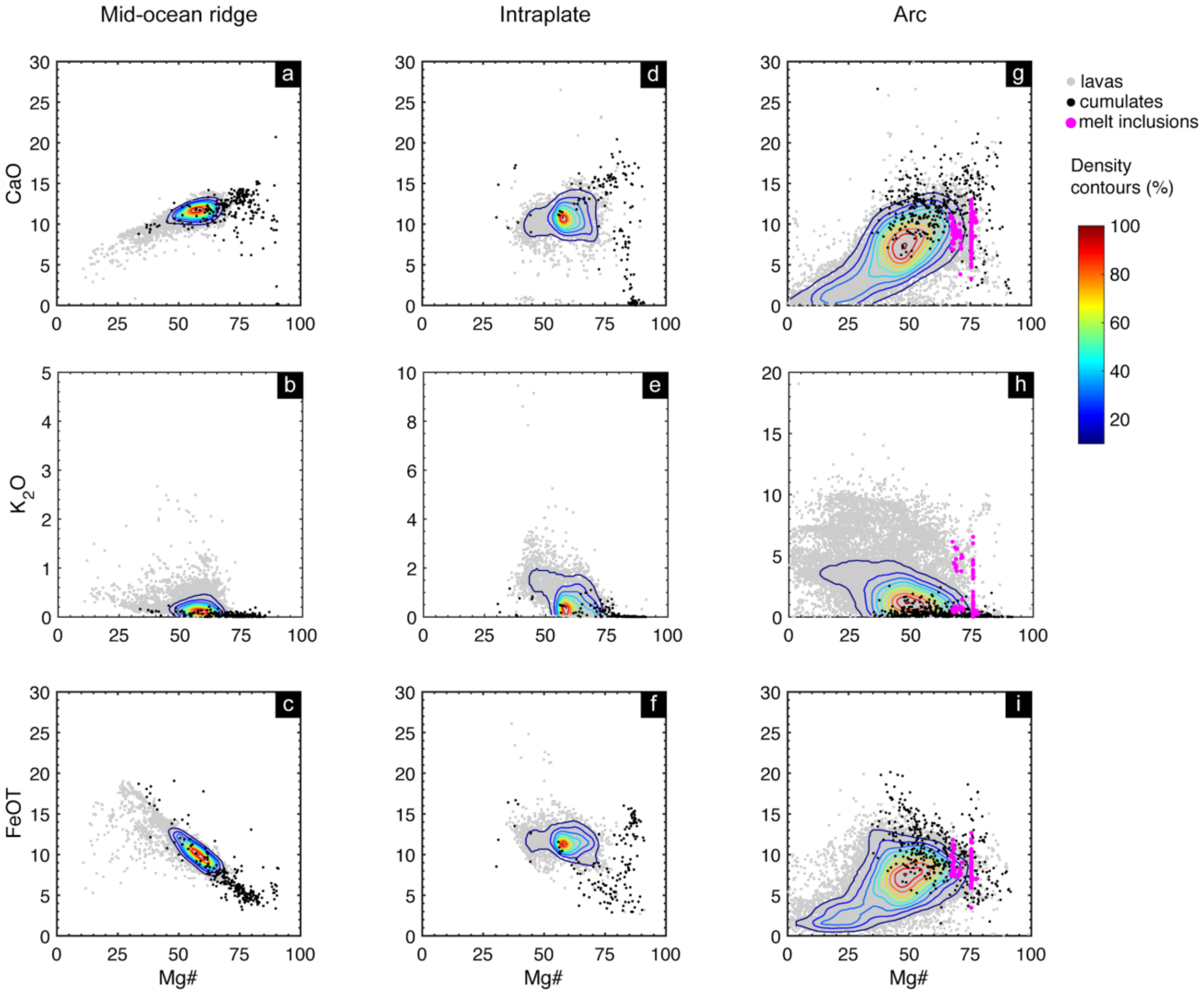

Figure S1. CaO, K_2O and total FeO (wt.%) vs. Mg# for lavas (gray circles), cumulates (black circles), and melt inclusions (magenta symbols, from volcanic arcs only). Colored curves show the density contours (10%) for volcanic rocks.

Table S5. Number of samples and references for data plotted in Figures 6 and S1.

	# samples	**source**
arc lavas	38,496	GEOROC[a] (Table S6)
arc cumulates	387	compilation of Chin et al., 2018 (Table S6)
arc melt inclusions	205	Auer et al., 2008; Benjamin et al., 2007; Cervantes and Wallace, 2003; Cooper et al., 2010; Johnson et al., 2008; Johnson et al., 2009; Portnyagin et al., 2008; Roberge et al., 2009; Ruscitto et al., 2010; Ruscitto et al., 2011; Sadofsky et al., 2008; Shaw et al., 2008; Vigouroux et al., 2008; Zimmer et al., 2010 (Table S6)
MORBs	14,788	Gale et al., 2013 (Table S7)
MORB cumulates	236	compilation of Chin et al., 2018 (Table S7)
OIBs	4865	GEOROC[b] (Table S8)
OIB cumulates	148	Neumann et al., 2000; Schmincke et al., 1998; Hari et al., 2011; Peters et al., 2016; Shamberger and Hammer, 2006; Jackson et al., 1981; Ishikawa et al. 2007 (Table S8)

a data downloaded in 2018 were filtered for samples with oxide totals between 98 and 101 wt.%.
b data downloaded in 2011. No filter used. Only whole rock and glass data were taken

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