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Magnesium isotope record of fluid metasomatism along the slab-mantle interface in subduction zones

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Abstract

Fluids released from subducting slabs play an important role in mantle metasomatism and arc magmatism. Magnesium could be mobile in subduction-zone fluids and Mg isotopic signatures of mélange rocks may provide information on crust-mantle interactions at subduction zones. To investigate the behaviour of Mg isotopes during fluid metasomatism along the slab-mantle interface, we report Mg isotopic compositions of a set of well-characterized samples from the ultramafic blocks in the Franciscan Complex of California. The partially serpentinized and completely serpentinized peridotites have δ^{26}Mg values (from −0.26 to −0.14) clustered around the mantle value, indicating small Mg isotope fractionation during peridotite serpentinization. Samples with serpentine completely replaced by talc have lower MgO contents and heavier Mg isotopic compositions (δ^{26}Mg of −0.13 to −0.01) than serpentinized peridotites, implying that Mg was non-conservative during this metasomatic replacement. The shift toward higher δ^{26}Mg values of talc-dominated metaperidotites reflects the preferential loss of light Mg isotopes into fluids via Rayleigh distillation during the dehydration reactions that produced talc from serpentine. On the other hand, samples with talc completely replaced by tremolite have lighter Mg isotopic compositions (δ^{26}Mg of −0.50 to −0.41) and higher CaO contents than the talc-dominated samples. These features suggest a metasomatic process involving isotopically light carbonate-rich fluids derived from the subducting slab. Collectively, large Mg isotope fractionation occurs during multistage fluid-rock interactions within the Franciscan subduction channel, which provides direct evidence for significant Mg isotopic variation during fluid metasomatism along the slab-mantle interface. This may account for the observed heterogeneous Mg isotopic compositions of arc lavas. Magnesium isotopes thus could be a potentially useful tracer of crust-mantle interactions at subduction zones.

Keywords: Magnesium isotopes; Fluid metasomatism; The slab-mantle interface; Subduction zones; The Franciscan complex

1. INTRODUCTION

Subduction zones are one of the most important sites for interactions between the crust and the mantle. Fluids released from subducting slabs lead to metasomatism of the mantle wedge and trigger the generation of arc magmas with enrichment of fluid-mobile elements and unique stable and radiogenic isotopic signatures (e.g., Elliott, 2003; Xiao et al., 2011; Spandler and Pirard, 2013; Bebout, 2014; Kelemen et al., 2014). Although early experiments suggested that the solubility of Mg in hydrous fluids is low (Manning, 2004), recent studies documented that Mg could be fluid mobile during subduction metamorphism (Scambelluri et al., 2015; Chen et al., 2016; Wang et al., 2017). Hence, fluid metasomatism at subduction zones

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may cause detectable Mg isotopic variations in the mantle wedge. It has been illustrated that some fresh arc lavas display Mg isotopic compositions (δ^{26}Mg of −0.35 to +0.06; Teng et al., 2016; Li et al., 2017) different from those of fresh mantle peridotites (δ^{26}Mg of −0.28 to −0.21; Teng et al., 2010a). Since mantle melting and basaltic magma differentiation do not significantly fractionate Mg isotopes (Teng et al., 2010a) and potential crustal contamination has little effect on the Mg isotopic systematics of arc basalts due to the relatively low Mg content of crustal materials, the observed Mg isotopic variations in arc lavas likely resulted from the addition of distinct Mg isotopes from the recycled crustal materials by fluids (Teng et al., 2016; Li et al., 2017). However, direct evidence and detailed mechanism of Mg isotope fractionation during fluid metasomatism at subduction zones are still lacking.

Fluids derived from recycled crustal rocks would react first with peridotites at the base of the mantle wedge. Some of these hydrated peridotites will be scraped off into the subduction channel and mix with crustal rocks detached from the subducting slab to form a tectonic mélange (Guillot et al., 2009). The mélange rocks could record multistage fluid metasomatism during subduction processes (e.g., Bebout and Barton, 2002; Bebout and Penniston-Dorland, 2016), making them the best samples for studying fluid-rock interactions along the slab-mantle interface.

Here, we present Mg isotopic data for a set of well-characterized metaperidotite samples from the ultramafic blocks in the Franciscan Complex of California. These samples record multistage infiltration of fluids (King et al., 2003), hence are ideal for investigating the behaviour of Mg isotopes during subduction-zone metasomatism. We found large Mg isotopic variations during multistage metasomatic reactions between peridotites and infiltrating fluids, providing direct evidence for significant Mg isotope fractionation during fluid metasomatism along the slab-mantle interface. Our results present a possible explanation for the Mg isotopic heterogeneity in arc lavas and imply that Mg isotopes can potentially be used to trace crust-mantle interactions at subduction zones.

2. SAMPLES

The Franciscan Complex, a Mesozoic accretionary prism, is widely distributed throughout the California Coast Ranges (Ernst, 1970). The complex in the study area (Fig. 1) is principally composed of metagraywacke flow mélange (Cloos and Shreve, 1988). Ultramafic (metaperidotite) blocks occur as tectonic inclusions and were incorporated into the mélange at depth in the Franciscan subduction channel (King et al., 2003). Brittle deformation of the rigid peridotite in the viscous matrix provided pathways for fluid infiltration, which drove serpentinization and metasomatism of the ultramafic blocks. Previous petrological and geochemical studies suggested that metaperidotites from the study area record a series of metasomatic processes that occurred along the slab-mantle interface in the Franciscan paleo-subduction zone, during which many elements including Mg were partitioned into or out of the metaperidotites and infiltrating fluids (King et al., 2003). This finding makes these metaperidotites ideal objects to explore the mechanism of Mg isotope fractionation during metasomatic interactions between mantle wedge peridotites and subduction-zone fluids.

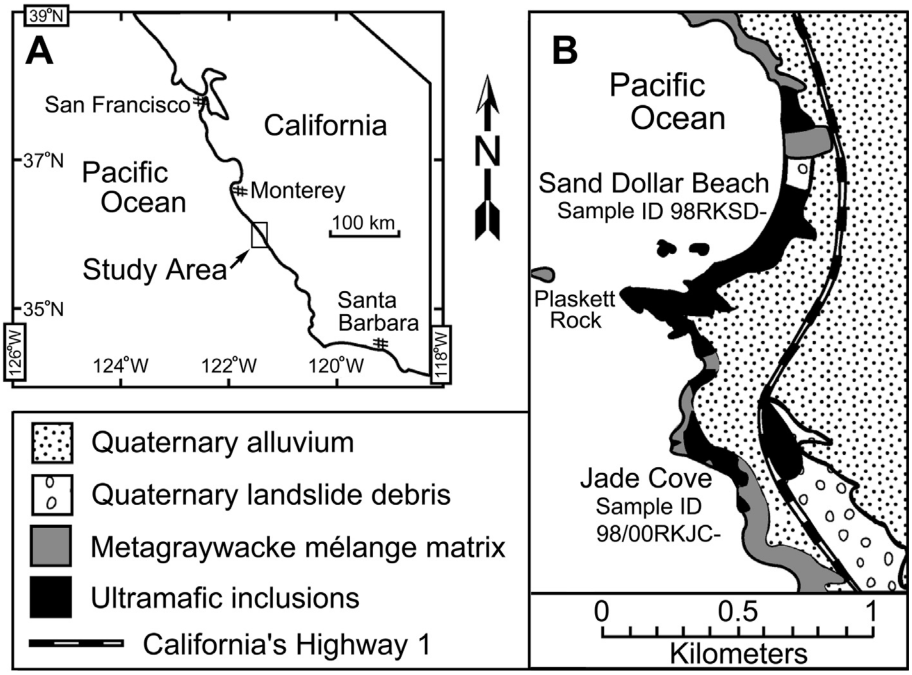

Fig. 1. (A) Simplified map of central coastal California, USA, with the location of the study area. (B) Sketch geological map of the Franciscan Complex in the study area with sample locations. Maps are modified after King et al. (2003).

Table 1
Mineral assemblage of different groups of the investigated metaperidotites from the Franciscan Complex of California.

Group	Rock type	Relict minerals	Neoblastic minerals
Group 1	Partially serpentinized peridotites	Ol, Cpx, Opx, Spl	Srp, Mag, Chl, Di
Group 2	Completely serpentinized peridotites	Spl	Srp (85–90% of the mode), Mag, Chl
Group 3	Talc-dominated metaperidotites	Spl	Tlc (85–90% of the mode), Chl
Group 4	Tremolite-dominated metaperidotites	Spl	Tr (80–85% of the mode), Chl, Hbl, Czo, Ttn, Ap, Zrn

Mineral abbreviations: *Ol* olivine, *Cpx* clinopyroxene, *Opx* orthopyroxene, *Spl* spinel, *Srp* serpentine, *Mag* magnetite, *Chl* chlorite, *Di* diopside, *Tlc* talc, *Tr* tremolite, *Hbl* hornblende, *Czo* clinozoisite, *Ttn* titanite, *Ap* apatite, *Zrn* zircon.

The metasomatized peridotites of the Franciscan Complex from Sand Dollar Beach and Jade Cove were classified into four groups in King et al. (2003), based on their mineralogy (Table 1). Group 1 samples preserve the partial serpentinization of relict peridotite phases and Group 2 samples represent complete serpentinization (antigorite comprises 85–90% of the mineral mode). The complete replacement of antigorite by talc defines Group 3 samples (85–90% modal talc) and the complete replacement of talc by tremolite defines Group 4 samples (80–85% modal tremolite). Based on the models of metasomatic reactions between peridotites and Si-rich fluids in the system MgO-SiO_2-H_2O (Manning, 1995, 1997) and the presence of syn-metamorphic calcite veins in the ultramafic blocks, King et al. (2003) proposed the idealized reactions outlined below to account for the transformation of antigorite into talc first, then the transformation of talc into tremolite, respectively.

$$\begin{aligned}&Mg_{48}Si_{34}O_{85}(OH)_{62}\ (\textit{Antigorite}) + 30SiO_2(aq)\\&\quad = 16Mg_3Si_4O_{10}(OH)_2\ (\textit{Talc}) + 15H_2O \qquad (1)\end{aligned}$$

$$\begin{aligned}&5Mg_3Si_4O_{10}(OH)_2\ (\textit{Talc}) + 4SiO_2(aq) + 6CaCO_3(aq)\\&\quad = 3Ca_2Mg_5Si_8O_{22}(OH)_2\ (\textit{Tremolite}) + 2H_2O + 6CO_2 \qquad (2)\end{aligned}$$

Fifteen whole-rock samples from all four groups described above were analyzed here for Mg isotopic compositions. They were collected from two profiles along the coast (Sand Dollar Beach and Jade Cove), both of which extend over distances of several hundred meters (Fig. 1). Oxygen isotopic data suggest that these metaperidotites equilibrated with metasomatic fluids during serpentinization and the subsequent reactions (1) and (2) at a constant temperature of 450–500 °C at depth in the subduction channel, and underwent little retrograde metamorphism during their exhumation within the upwelling flow mélange (King et al., 2003).

3. ANALYTICAL METHODS

Magnesium isotopic analyses were performed at the Isotope Laboratory of the University of Arkansas, Fayetteville, following previously established procedures (Yang et al., 2009; Li et al., 2010; Teng et al., 2010a; Teng and Yang, 2014). Whole-rock powders were dissolved in screw-top beakers in a combination of Optima-grade concentrated HF–HNO_3–HCl. Separation of Mg was achieved by cation exchange chromatography with Bio-Rad 200–400 mesh AG50W–X8 resin in 1 mol L^{-1} HNO_3 media. The column chemistry was performed twice in order to obtain a pure Mg solution for mass spectrometry. The Mg yields through column chemistry, based on analyses of Mg content in the elution collected before and after the Mg cut, were >99.8%. Magnesium isotopic compositions were analyzed by the standard-sample bracketing method using a Nu Plasma multi-collector inductively coupled plasma mass spectrometry (MC–ICP–MS) in the low resolution mode.

The results are reported in δ–notation in per mil relative to DSM3: $\delta^{X}Mg = [(^{X}Mg/^{24}Mg)_{sample}/(^{X}Mg/^{24}Mg)_{DSM3} - 1] \times 1000$, where X refers to mass 26 or 25. Based on replicate analyses of a seawater sample from Hawaii and an in-house standard KH–olivine, the long-term external precision is ±0.07 for $\delta^{26}Mg$ (2SD, Teng et al., 2015). The reference material Allende chondrite was processed through column chemistry with samples for accuracy check, and yielded $\delta^{26}Mg$ of -0.32 ± 0.04 (2SD, $n = 3$), consistent with the recommended value (e.g., -0.32 ± 0.03, Li et al., 2010; -0.30 ± 0.05, Teng et al., 2010a). This, combined with the indistinguishable results for replicate analyses (Table 2), assures the accuracy of our data.

4. RESULTS

The Mg isotopic data of metaperidotites from the Franciscan Complex are reported in Table 2. All samples analyzed in this study fall on an isotopic mass-dependent fractionation line with a slope of 0.515 on the Mg three-isotope diagram (not shown). Hence, only $\delta^{26}Mg$ is used in the subsequent discussion.

The partially serpentinized peridotites from Group 1 and completely serpentinized samples from Group 2 have $\delta^{26}Mg$ values (from -0.26 to -0.14 with an average of -0.21 ± 0.08, 2SD, $n = 8$) clustered around those of fresh mantle peridotites (Fig. 2). By contrast, the talc-dominated metaperidotites from Group 3 have higher $\delta^{26}Mg$ values (from -0.13 to -0.01 with an average of -0.06 ± 0.11, 2SD, $n = 4$), whereas the tremolite-dominated samples from Group 4 have lower $\delta^{26}Mg$ values (from -0.50 to -0.41 with an average of -0.44 ± 0.10, 2SD, $n = 3$), both significantly different from those of fresh mantle peridotites (Fig. 2).

5. DISCUSSION

In this section, we first study the behaviour of Mg isotopes during (1) peridotite serpentinization, (2) metasomatic replacement of antigorite by talc, and (3)

Table 2
Magnesium isotopic compositions and selected elemental contents of the investigated metaperidotites from the Franciscan Complex of California.

Sample ID	δ^{26}Mg	2SD[a]	δ^{25}Mg	2SD	SiO_2[b] (wt%)	MgO[b] (wt%)	CaO[b] (wt%)
Group 1 – Partially serpentinized peridotites							
98RKSD-8A	−0.22	0.05	−0.11	0.04	39.34	33.66	2.55
98RKSD-9A	−0.22	0.05	−0.11	0.04	40.68	33.94	3.30
98RKSD-13A	−0.22	0.05	−0.11	0.04	41.48	35.07	4.93
Group 2 – Completely serpentinized peridotites							
98RKSD-12A	−0.23	0.05	−0.13	0.04	38.01	36.17	0.11
98RKSD-17A	−0.14	0.05	−0.09	0.04	39.51	35.50	0.03
98RKJC-4A	−0.18	0.05	−0.09	0.04	42.35	36.84	0.10
Replicate[c]	−0.14	0.07	−0.09	0.06			
98RKJC-12A	−0.26	0.05	−0.12	0.04	41.24	33.59	0.12
98RKJC-109	−0.23	0.05	−0.13	0.04	40.66	37.98	0.32
Group 3 – Talc-dominated metaperidotites							
98RKJC-2B	−0.01	0.05	−0.01	0.04	49.58	26.88	1.06
Replicate	−0.02	0.07	−0.01	0.06			
00RKJC-101	−0.13	0.05	−0.08	0.04	57.39	29.81	b.d.
00RKJC-102	−0.01	0.05	0.00	0.04	56.61	30.71	b.d.
00RKJC-103	−0.07	0.05	−0.03	0.04	58.02	29.31	1.42
Group 4 – Tremolite-dominated metaperidotites							
98RKJC-7B	−0.42	0.05	−0.21	0.04	50.67	23.94	9.03
98RKJC-105	−0.41	0.07	−0.21	0.06	42.47	23.08	6.89
98RKJC-107	−0.51	0.05	−0.25	0.04	48.57	24.17	9.15
Replicate	−0.49	0.07	−0.26	0.06			

[a] 2SD = two times the standard deviation of the population of n (n > 20) repeat measurements of the bracketing standard during an analytical session.
[b] Data are from King et al. (2003); b.d. indicates the content was below analytical detection.
[c] Replicate = repeat column chemistry and measurement of different aliquots of a stock solution.

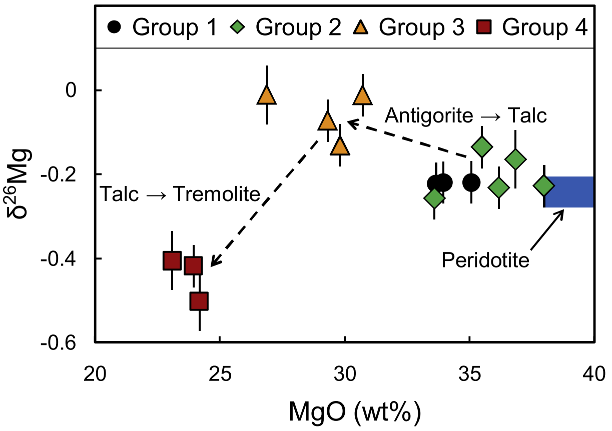

Fig. 2. δ^{26}Mg vs. MgO (wt%) of metaperidotites from the Franciscan Complex. The blue square represents fresh peridotite xenoliths (MgO = 38.0–51.9 wt%, δ^{26}Mg = −0.28 to −0.21; Teng et al., 2010a). Two arrows represent the metasomatic reactions to form talc from antigorite, and form tremolite from talc, respectively (see text for details). Error bars represent the 2SD uncertainties of individual samples. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

metasomatic replacement of talc by tremolite, in turn. We then discuss the implications of our results on Mg isotopic heterogeneity in arc lavas through fluid metasomatism.

5.1. Small Mg isotope fractionation during peridotite serpentinization

The Groups 1 and 2 samples represent partial serpentinization and complete serpentinization of mantle wedge peridotites, respectively (King et al., 2003). They have Mg isotopic compositions within or minimally heavier than the range of fresh mantle peridotites (Fig. 2), suggesting that Mg isotope fractionation during peridotite serpentinization, if any, is small. This observation is consistent with previous studies of peridotites serpentinized during hydrothermal alteration within the crust (Beinlich et al., 2014) or during seawater alteration (Liu et al., 2017).

5.2. Significant Mg isotope fractionation during the metasomatic replacement of antigorite by talc

The Group 3 samples have lower MgO contents and higher δ^{26}Mg values than the Groups 1 and 2 samples (Fig. 2), indicating significant Mg loss and isotope fractionation during the metasomatic replacement of antigorite by talc. Although diffusion-driven Mg isotope fractionation has been documented within a meter-thick reaction zone between serpentinites and schists in the Syros mélange (Pogge von Strandmann et al., 2015), such a mechanism was unlikely to operate on the samples investigated here, which were collected from profiles several hundred meters wide (Fig. 1). Alternatively, the observed Mg isotopic shift may reflect preferential partition of heavy Mg isotopes into talc and loss of light Mg isotopes into fluid during antigorite dehydration. This suggestion implies that Mg was non-conservative in terms of the investigated metaperidotites during antigorite breakdown. However, the reaction (1) proposed in King et al. (2003) does not involve a phase showing Mg mobility, hence cannot account for the observed whole-rock Mg isotopic variation. In order to reflect that some fraction of Mg was released into fluid during the metasomatic replacement of antigorite by talc, a schematic reaction with dissolved Mg may be written as:

$$\begin{aligned} &2Mg_{48}Si_{34}O_{85}(OH)_{62}\ (\textit{Antigorite}) \\ &= 17Mg_3Si_4O_{10}(OH)_2\ (\textit{Talc}) + 45MgO(aq) + 45H_2O \end{aligned} \quad (3)$$

The enrichment of ^{26}Mg in talc compared to the fluid with dissolved Mg generated by antigorite breakdown is consistent with the preferential incorporation of ^{26}Mg into sheet silicate minerals during water-rock interactions involved in continental weathering (e.g., Teng et al., 2010b; Opfergelt et al., 2012; Wimpenny et al., 2014) and seafloor weathering (Higgins and Schrag, 2010; Liu et al., 2017). A Rayleigh distillation model yields the apparent fractionation factors [$\alpha_{\text{talc-fluid}} = (^{26}Mg/^{24}Mg)_{\text{talc}}/(^{26}Mg/^{24}Mg)_{\text{fluid}}$] varying from 1.0003 to 1.0012 (Fig. 3), suggesting that significant Mg isotope fractionation between talc and fluid could also occur at high temperatures, e.g., 450–500 °C of the samples studied here (King et al., 2003).

5.3. Significant Mg isotope fractionation during the metasomatic replacement of talc by tremolite

The Group 4 samples have distinctly lower δ^{26}Mg values than the Group 3 ones (Fig. 2), indicating a significant Mg isotopic shift during the metasomatic replacement of talc by tremolite. Based on the presence of calcite veins in the ultramafic blocks within the Franciscan Complex and the much higher CaO contents of the Group 4 samples than the Group 3 ones (≥6.9 wt% vs. ≤1.4 wt%, Table 2), King et al. (2003) proposed the carbonate-added reaction (2) for the production of tremolite from talc. Similar to the case of reaction (1), no phase showing Mg mobility is involved in the reaction (2). However, the observed Mg isotopic shift indicates that Mg was non-conservative during the transformation of talc into tremolite and, hence, the metasomatic reaction (2) might be rewritten as:

$$\begin{aligned} &5Mg_3Si_4O_{10}(OH)_2\ (\textit{Talc}) + 4SiO_2(aq) + 6(Mg_xCa_{1-x})CO_3(aq) \\ &= 3Ca_{2-2x}Mg_{5+2x}Si_8O_{22}(OH)_2\ (\textit{Tremolite}) + 2H_2O + 6CO_2 \end{aligned} \quad (4)$$

Previous studies demonstrated that calcite can be dissolved (not decarbonated) in aqueous fluids at subduction zone conditions (Frezzotti et al., 2011; Ague and Nicolescu, 2014; Kelemen and Manning, 2015), and Mg-calcites have heterogeneous and low δ^{26}Mg values of −5.57 to −1.04 (see review of Teng, 2017). Hence, carbonate-rich fluids derived from the subducting slab could provide a low-δ^{26}Mg end-member. Mixing of such fluids with the precursor talc via the reaction (4) would produce the isotopically light tremolite. A binary mixing calculation suggests that addition of ~20% aqueous Mg-calcite with the formula of $(Mg_{0.17}Ca_{0.83})CO_3$ and δ^{26}Mg of −5 to the Group 3 samples can account for the elevated CaO and reduced MgO contents as well as the light Mg isotopic compositions of the Group 4 samples (Fig. 4). Although the exact formula and Mg isotopic composition of Mg-calcite involved in the reaction (4) may be somewhat different from the fitting results, it does not affect our suggestion that the light Mg isotopic composition of the tremolite-dominated metaperidotites originated from carbonate-rich fluids within the subduction channel, as carbonates are the only candidate among terrestrial reservoirs that has δ^{26}Mg values as low as ca. −5 (see Fig. 2 in Teng, 2017). Hence, our observations provide the first Mg isotopic evidence for dissolution of Mg-calcite at 450–500 °C (King et al., 2003) along the slab-mantle interface.

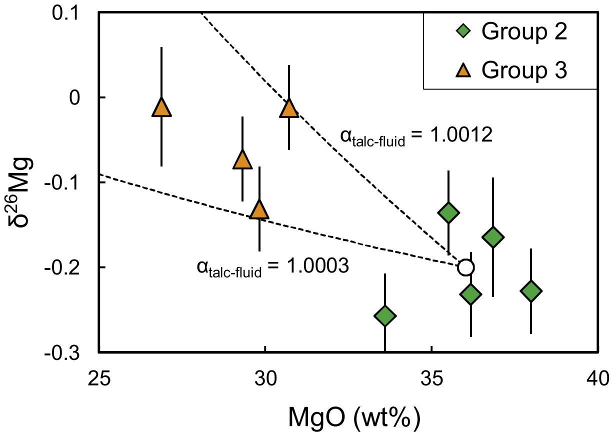

Fig. 3. δ^{26}Mg vs. MgO (wt%) of the Groups 2 and 3 metaperidotites from the Franciscan Complex. The circle represents the average of the Group 2 samples (i.e. MgO = 36.0 wt% and δ^{26}Mg = −0.20). Curved lines depict release of Mg from meteperidotites into the fluid via Rayleigh distillation during the antigorite dehydration reaction that forms talc. The Group 3 samples are plotted between the fractionation factors [$\alpha_{\text{talc-fluid}} = (^{26}Mg/^{24}Mg)_{\text{talc}}/(^{26}Mg/^{24}Mg)_{\text{fluid}}$] varying from 1.0003 to 1.0012. Error bars represent the 2SD uncertainties of individual samples.

5.4. Implications on Mg isotopic heterogeneity in arc lavas through fluid metasomatism

Fluid metasomatism within the subduction channel will lead to modification of element and isotopic compositions of the hybrid mélange rocks. The occurrence of exhumed mélange zones kilometers wide in some high-pressure terranes and the geophysical observations of a low seismic velocity zone at tops of many subducting slabs indicate that the subduction channel and related fluid activity could be up to several kilometers thick (Bebout and Penniston-Dorland, 2016 and references therein). Kilometer-scale fluid activity at the slab-mantle interface may exert a significant influence on the slab signature being transferred to the subarc mantle wedge (Spandler and Pirard, 2013). Therefore, the significant Mg isotopic variations observed in mélange metaperidotites may shed light on the Mg isotopic heterogeneity in arc lavas.

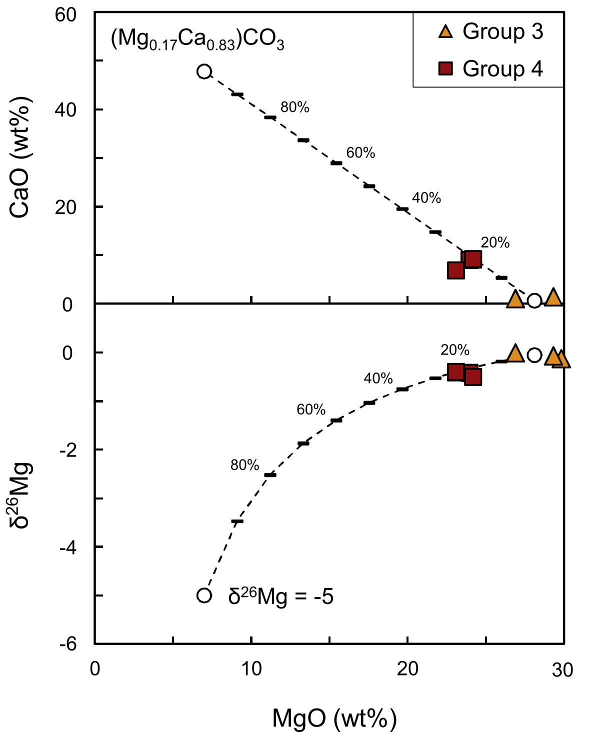

Fig. 4. MgO (wt%), CaO (wt%) and δ^{26}Mg of the Groups 3 and 4 metaperidotites from the Franciscan Complex, together with binary mixing curves. The circles represent two end-members of the mixing curves: one is the average of the Group 3 samples (i.e. MgO = 28.1 wt%, CaO = 0.62 wt% and δ^{26}Mg = −0.06) and the other is a Mg-calcite component with the formula of $(Mg_{0.17}Ca_{0.83})CO_3$ (i.e. MgO = 7.0 wt%, CaO = 47.8 wt%) and δ^{26}Mg = −5. The percentages next to the small bars denote the mass mixing ratios of the Mg-calcite component.

Dehydration of serpentinite at subduction zones is believed to play a major role in triggering arc volcanism as it can explain the geochemical characteristics of many arc lavas (e.g., Hattori and Guillot, 2003; Evans et al., 2013). Talc of metasomatic origin has been found in some mélange zones (Bebout and Penniston-Dorland, 2016), suggesting that the transformation of serpentine into talc following the reactions (1) and (3) may occur frequently. As ^{26}Mg is preferentially incorporated in talc (Fig. 3), the fluids with dissolved Mg released from the dehydration reaction (3) would be correspondingly enriched in ^{24}Mg. These low-δ^{26}Mg fluids may shift some part of the mantle wedge toward light Mg isotopic compositions, which may account for the slightly lower δ^{26}Mg values of some arc basalts (down to -0.35; Li et al., 2017) compared to the convecting mantle. On the other hand, although talc was further replaced by tremolite within the Franciscan subduction channel, for the more general case, talc will remain stable until its breakdown at ~700–800 °C at sub-arc depths (e.g., Spandler et al., 2008). Recent studies on whiteschists from Alps and eclogites from Tianshan suggested that the breakdown of talc may release high-Mg and high-δ^{26}Mg fluids (Chen et al., 2016; Wang et al., 2017). Metasomatism of the sub-arc mantle wedge by such fluids may account for the high δ^{26}Mg values of some arc lavas (up to +0.06; Teng et al., 2016; Li et al., 2017). Therefore, the significant Mg isotope fractionation between talc and fluid (Fig. 3) during the dehydration reaction (3) and the subsequent breakdown of talc at sub-arc depths could introduce both light and heavy Mg isotopes into the overlying mantle wedge, though the precursor serpentinites have mantle-like Mg isotopic compositions.

Light Mg isotopes may also be transported into the mantle wedge by metasomatic fluids derived from dissolution of subducted Mg-calcite, as documented by the isotopically light tremolite-dominated metaperidotites from the Franciscan Complex (Fig. 4). The light Mg isotopes will be released into arc magma sources when tremolite breaks down at ~800–900 °C at sub-arc depths (e.g., Chernosky et al., 1998), or alternatively, be retained in carbonated peridotites and transported into the deep mantle. Since the light Mg isotopes ultimately originate from subducted carbonates, these processes need to be considered in subduction zone carbon cycle. Contribution of recycled carbonates into the mantle has been suggested to account for the low δ^{26}Mg values of some continental basalts from eastern China (down to −0.60; Li et al., 2017 and references therein). Hence, Mg isotopes are a potential tracer of the interactions between recycled carbonates and mantle wedge peridotites.

6. CONCLUSIONS

This study presents Mg isotopic data for the well-characterized metaperidotites from the Franciscan Complex of California. The partially serpentinized and completely serpentinized peridotites have δ^{26}Mg values (from −0.26 to −0.14) similar to the mantle value, indicating small Mg isotope fractionation during peridotite serpentinization. By contrast, the samples with serpentine completely replaced by talc have heavier Mg isotopic compositions (δ^{26}Mg of −0.13 to −0.01), whereas samples with talc further completely replaced by tremolite have lighter Mg isotopic compositions (δ^{26}Mg of −0.50 to −0.41). These observations suggest the non-conservative behaviour of Mg and large Mg isotope fractionation during the antigorite dehydration reaction forming talc and during the carbonate-added reaction forming tremolite from talc. Collectively, significant Mg isotopic variations may occur during fluid metasomatism along the slab-mantle interface, making Mg isotopes a potentially useful tracer of crust-mantle interactions at subduction zones. Such a mechanism provides a possible explanation for the observed Mg isotopic heterogeneity in arc lavas.

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