The noble gas budget of the Kamchatkan mantle wedge

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The Kamchatka peninsula in far-eastern Russia is the site of the most active arc volcanoes worldwide. We performed a stepwise crushing noble gas study on a suite of mantle xenoliths (spinel harzburgites) from the andesitic Avacha volcano in southern Kamchatka to investigate the impact of slab devolatilization on the noble gas budget of the mantle wedge. Only very fresh mantle xenoliths were selected for analysis to ensure negligible late-stage contamination with atmospheric gases. Furthermore, olivine separates had been prepared only from cores of the xenoliths to further prevent contamination by alteration processes during surface exposure.

^{3}He/^{4}He ratios range from 6 to 8 R$_{A}$, indistinguishable from most lithospheric mantle samples and at the lower end of typical MORB compositions. There is no evidence for a significant radiogenic ^{4}He* contribution, i.e. the ca. 80 Ma-old Pacific crust currently subducting under Kamchatka appears to have lost most of its radiogenic ^{4}He* before the onset of the main dehydration events within the slab. All other noble gases show an atmospheric isotopic composition (Ne, Xe indistinguishable from air values, ^{40}Ar/^{36}Ar ratios <400) and high concentrations in Ar, Kr, Xe when compared with xenolith data from non-arc settings (e.g. ^{36}Ar: 1-6·10^{-9} cm^{3} STP/g). Again, there is no evidence for a significant radiogenic contribution of the subducted oceanic crust. Accepting a slab origin of the sampled atmospheric noble gases these must have entered the oceanic crust lately, shortly before or during the subduction process.

^{36}Ar/^{22}Ne ratios (up to 100) are strongly fractionated, with higher values than those in seawater. ^{84}Kr/^{36}Ar and ^{132}Xe/^{36}Ar ratios show a linear correlation and are slightly fractionated relative to air composition. The latter two ratios appear to be also correlated with the relative proportion of mantle Ar (i.e. ^{40}Ar/^{36}Ar ratios). In general, explaining the complex elemental pattern may require multi-stage fractionation and mixing processes e.g. during ocean floor alteration, during the subduction process itself and in the course of magmatic processes within the mantle wedge.

SiC grains from supernovae and the solar Si-isotopic ratios

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Introduction

GCE models fail to account for the solar Si isotope abundances; specifically ^{29}Si is too low [1]. SNeII are the most important suppliers of ^{29}Si to the ISM. By con-sidering 1.5x enhanced SNII ^{29}Si yields, [2] achieved a good match between Si-isotopic ratios of SiC mainstream grains and predictions from incomplete mixing of SN ejecta in the ISM. To account for the Si-isotopic ratios of low-density graphite and SiC X grains in SNII mixing calculations, an 2x enhanced ^{29}Si yield in the C- and Ne-burning shells was proposed [3]. Recently, we identified a SN grain with unusual Si-isotopic ratios in a NanoSIMS survey of >1000 presolar SiC grains [4] which strongly supports the suggestion by [3]. Here, we discuss the implications for the production of ^{29}Si in SNeII and for GCE models of Si.

Results and Discussion

SiC grain KJB2-11-17-1 has ^{29}Si/^{28}Si = 1.63x solar, ^{30}Si/^{28}Si = 0.82x solar, ^{12}C/^{13}C = 265, and evidence for the initial presence of radioactive ^{44}Ti [4]. With an 2x enhanced ^{29}Si yield in the O/Ne and O/Si shells of a 15 M$_{\odot}$ SNII [5] we find a perfect match between the grain data and predictions from SN mixing calculations. We have explored the impact of various reaction rates on the ^{29}Si abundance in these shells using a computer code built on the nuclear reaction toolkit libnucnet. The ^{29}Si yield is most sensitive to changes in the ^{26}Mg(α,n)^{29}Si and, to a lesser extent, ^{29}Si(n,γ)^{30}Si rates. To increase the ^{29}Si yield by a factor of ~2, the currently used ^{26}Mg(α,n)^{29}Si rate must be increased by 3x, which is compatible with experimental uncertainties. Since the O/Ne and O/Si zones contribute ~90% of ^{29}Si in SNII ejecta, the twofold increase in the ^{29}Si yield will heavily influence GCE predictions. Considering IMF-weighted ejecta from 15, 19, and 25 M$_{\odot}$ SNeII [5] gives δ^{29}Si = -475‰ (unmodified ^{29}Si yield) and +5‰ (2x enhanced ^{29}Si yield in O/Ne and O/Si zones). The latter value appears a promising starting point for improved GCE models.

[1] Timmes & Clayton (1996) *ApJ* **472**, 723. [2] Lugaro *et al.* (1999) *ApJ* **527**, 369. [3] Travaglio *et al.* (1998) *Nuclei in the Cosmos* **V**, 567. [4] Hoppe *et al.* (2009) *ApJ* **691**, L20. [5] Rauscher *et al.* (2002) *ApJ* **576**, 323.