Europlanet TNA Report

PROJECT LEADER

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Date of TNA visit:	21-26 November 2010
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Host laboratory:	CRPG, Nancy
Reimbursed	Yes/No

Project Title –

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database)

Ne and Ar isotope ratios were measured in vesicles from Tonga Arc basaltic glasses. All samples are massively contaminated by atmosphere-derived gases acquired when the rock was still molten and stored in, or in transit through, the crust. Noble gases diffused into the melt during contamination by fluids or rocks rich in atmospheric noble gases. Noble gases subsequently diffused out of the melt, probably during eruption, producing mass-dependent isotope fractionation.

Full Scientific Report on the outcome of your TNA visit
Approx. 1 page

Background

At the outset, the aim of this work was to investigate the noble gas systematics of submarine basaltic glasses from the North Tonga arc, with two primary objectives:

1 determine noble gas characteristics of subduction-related magmatism, and,
2 identify the extent to which Samoan plume mantle penetrated the North Tonga Arc.

An inherent challenge for all noble gas studies in determining original magmatic signatures is identification of atmosphere-derived contaminants (which might include rocks rich in atmospheric gases, such as clay minerals, or deep percolating ground waters) that might have been added during transport through the crust or during and after eruption onto the seafloor. This challenge is all the greater for subduction-related magma because high intrinsic H_2O content promotes the loss of other volatiles. Since most studies, like this one, target mantle sources and processes, samples dominated by contaminant contributions are usually avoided.

North Tonga was identified as a suitable target for our aim because the samples were erupted underwater from intra-arc rifts; the rationale being that this setting would minimise contamination and so increase the probability of preserving primary, magmatic volatiles. We recognised that our samples were more vesicular than would normally be used for noble gas measurements but North Tonga appeared to offer a high chance of sampling magmatic Ne and Ar.

Visit

Dr. John Caulfied visited CRPG Nancy from 21-26 November 2010. He had no prior experience of conducting noble gas analyses so received suitable training from CRPG staff. Five samples were analysed by crushing to recover gas from vesicles contained in the glasses.

Results

Results all show that instead of retaining mantle derived noble gases, there has been strong contamination by non radiogenic noble gases isotopically similar to atmospheric gas. These data mean that we were unable to achieve our primary objectives of constraining the noble gas characteristics of the mantle beneath the North Tonga Arc.

However, on closer inspection, the data show some significant differences to air that cannot be accounted for by mixing between air and mantle sources. Such mixing would result in $^{40}Ar/^{36}Ar$ ratios > $^{40}Ar/^{36}Ar_{air}$ (=296.5), whereas these samples have $^{40}Ar/^{36}Ar$ as low as 280. Some other process or processes have fractionated Ne and Ar isotopes of the gases trapped in these vesicles. Furthermore, there are strong correlations between $^{40}Ar/^{36}Ar$ and both $^{38}Ar/^{36}Ar$ and $^{20}Ne/^{22}Ne$ (Fig. 1a), in each case showing enrichment in the heavier isotope. Fractionation of Ar from Ne is also apparent and demonstrates that the enrichment of heavier isotopes is associated with a decrease in the gas content of the rocks (Fig. 1b).

Variations of $^{40}Ar/^{36}Ar$ with $^{38}Ar/^{36}Ar$ and $^{20}Ne/^{22}Ne$ with $^{21}Ne/^{22}Ne$ (not shown) lie very close to mass fractionation curves. This leads us to interpret the variation in noble gas isotope ratios within the suite as kinetic mass dependent fractionation: equilibrium processes cannot significantly fractionate noble gas isotopes. The correlation with gas content (Fig. 1b) suggests that the vesicle components are recording progressive enrichment in heavy isotopes as noble gases diffused out of the melt. This is the final stage of gas evolution and would most probably have occurred during eruption, but possibly after eruption when the melt was emplaced onto the seafloor.

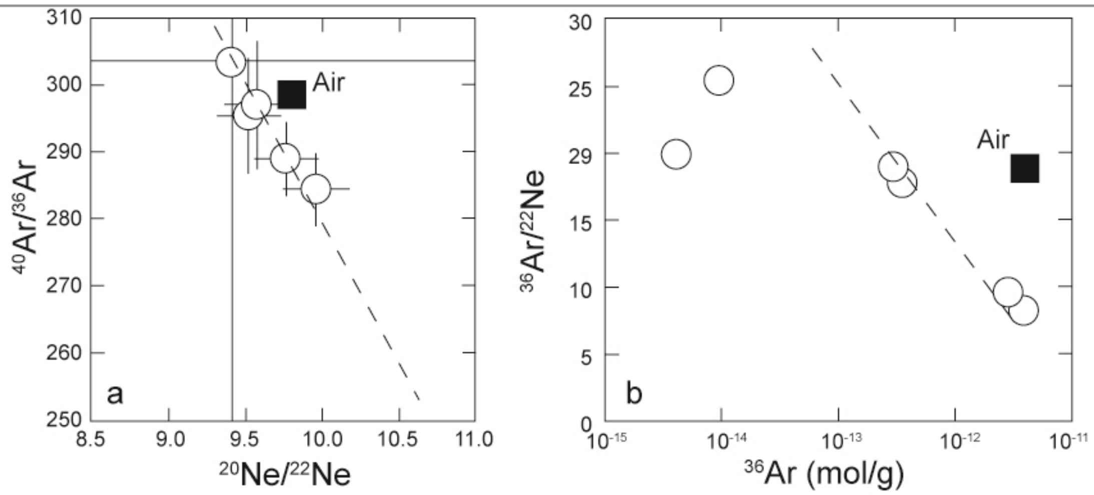

Figure 1. (a) $^{40}Ar/^{36}Ar$ versus $^{20}Ne/^{22}Ne$, and (b) $^{36}Ar/^{22}Ne$ versus ^{36}Ar in North Tonga Arc basalt glasses. Basalts describe a mass fractionation array (dashed line) probably as a result of preferential loss of lighter isotopes during diffusion-controlled degassing i.e. towards lower ^{36}Ar contents. This requires that the magma was already enriched in lighter isotopes (with respect to air) prior to degassing, probably as a result of diffusion of atmospheric (air or seawater) contaminant into the melt phase.

Intriguingly, the lowest $^{40}Ar/^{36}Ar$ occur in the most Ar-rich samples (Fig. 1b). Therefore, the glasses had $^{40}Ar/^{36}Ar$ less than air prior to the process that produced the mass fractionation shown in Fig. 1. We interpret this to reflect the melt becoming enriched in light isotopes during <u>noble gas diffusion into the melt</u>. The source of these gases could be air, although it is more likely to be either atmospheric gases hosted in altered crustal rocks or fluids that are liberated in the proximity of stored or migrating magma.

Actions

We are currently producing quantitative models of the diffusive processes, described above in a qualitative sense. Our intention is to prepare a manuscript describing the results and discussing the implications for noble gas systematics and volatile budgets in basaltic magmatic systems. This will be submitted to an international journal. The article will also discuss the implications for correcting noble gas isotope ratios, particularly of Ne, of oceanic basalts for the presence of atmospheric contamination. Such corrections do not currently recognise a role for mass fractionation when atmospheric components are introduced to the rocks. These samples have yielded a previously unrecognised source of information about melt - crust interaction.

Please include:

- <u>Publications arising/planned</u> (include conference abstracts etc)
- <u>Host approval</u> The host is required to approve the report agreeing it is an accurate account of the research performed.