ESS 461 Homework Cosmic Ray Exposure Dating (Part 3)

Questions On Chemistry Lab Procedures

(1) Explain why we added precisely measured amounts of Be as a "carrier" to each sample before dissolving it. There are two main reasons, and at least one minor reason.

(2) Explain why one "blank" sample, containing no quartz, is included in the batch and processed through the chemical procedure along with the other samples.

(3) Mass spectrometry distinguishes charged atoms (ions) by their ratio of mass/charge. If a beam of singly charged carbon ions (C^+) is injected into a mass spectrometer, the ions will be split into two separate beams, each made up of one pure isotope of carbon; $^{12}C^+$ and $^{13}C^+$. However, if the beam also contains some $^{24}Mg^{2+}$ ions, these will follow the same path as the $^{12}C^+$ ions, because the ratio of mass to charge for $^{24}Mg^{2+}$ (24/2) is the same as the ratio for $^{12}C^+$ (12/1). Likewise, molecular $(^{12}C^{14}N)^{2+}$ ions, with mass/charge = (26/2) would follow the $^{13}C^+$ ions.

The ions injected into the accelerator for mass spectrometry are Al^-, for $^{26}Al/^{27}Al$ measurements, and BeO^- for $^{10}Be/^{9}Be$ measurements. In the case of Be isotope measurements, the BeO^- ions are broken up into atomic ions, and the $^{10}Be/^{9}Be$ ratio is ultimately measured on Be^{3+} ions. Any elements or molecules that follow the same paths as Al and Be ions through the accelerator interfere with the measurements. (they swamp the detector, which we have tuned to detect the very rare ^{10}Be or ^{26}Al ions). What elements must be carefully eliminated in the chemical purification to avoid interferences in the mass spectrometry? You will need to look at a chemistry text, or a chart of the nuclides (e.g. http://atom.kaeri.re.kr/) to get round-number masses for the common isotopes of potential contaminant elements (Hint: Notice that we avoided using pyrex glass in the chemistry - Pyrex is a "borosilicate" glass, containing ~10% B by weight).

(4) Work through an example calculation to show how we'll determine the concentration of ^{10}Be in a quartz sample once we've measured its $^{10}Be/^{9}Be$ ratio by accelerator mass spectrometry (AMS). The table below contains the bottle weighings, sample weights, solution weights and the concentration of Be in the carrier solution we added to the samples.

Now assume that we've carried out the AMS measurement on the first sample (10-PUG-043-GPT) , and found that $^{10}Be/^{9}Be = 7.7 \times 10^{-14}$. Using the weights listed for this sample below, set out a calculation showing how to determine the concentration of ^{10}Be in the original quartz. The final concentration will have units of atom ^{10}Be/gram quartz. You will need to convert grams of Be into atoms, for which you should assume that 1 mol of the ^{9}Be carrier weighs 9.012 g, and 1 mol = 6.022×10^{23} atoms (Avogaddro's number).

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Sample ID	Bottle ID	Wt empty bottle	Wt bottle plus quartz	Wt quartz sample	Wt of added carrier solution	Conc. of Be-9 in carrier solution	Wt Be-9 carrier added
		(g)	(g)	(g)	(g)	(microgram Be-9/g carrier sol'n)	(micrograms)
BLANK-171	250-6	59.8489	59.8489		0.6227	404.7	
08-PUG-043-GPT	250-7	61.3040	80.1593		0.6233	404.7	
08-PUG-044-GPT	250-8	60.7683	79.9088		0.6225	404.7	