Isotopx

Neodymium isotope ratio analysis using the Phoenix TIMS

GEOLOGY

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Introduction

Neodymium together with strontium isotope ratio measurements are the benchmark analyses that define the ultimate precision and accuracy of isotope ratio measurements that Thermal Ionization mass spectrometers are capable of. The mass fractionation which occurs during thermal ionization can be compensated for using the exponential mass fractionation law. This can lead to single analysis precisions of better than 1ppm 1RSD given a sufficiently large ion beam and long analysis time. Reproducibility of measurement however, is governed by instrumental factors. These include:

- Amplifier gain stability
- Noise stability
- Ion focussing reproducibility
- Collector efficiency
- HT and magnetic field stability
- Size of peak flatness.
- Amplifier response

For the measurements presented here, a multidynamic analysis protocol was used. This cancels out the amplifier and collector efficiency variables (see below), but all other variables are possible sources of error. The analytical goal is to ensure that instrument effects are negligible, which would ultimately result in the reproducibility of the measurement being the same as the precision of an individual measurement.

Analytical Protocol

400ng of the JNd-i isotope standard was deposited onto the side filament of a degassed triple Re filament assembly. 30 analyses were made in two turrets, Turret 1, 10 samples, Turret 2 20 samples.

Collector	Cycle 1	Cycle 2	Cycle 3
H2	146	147	148
H1	145	146	147
Ax	144	145	146
L2	143	144	145
L3	142	143	144

Table 1. Multidynamic analysis sequence

A 3 mass-jump multidynamic sequence (Table 1) was used. The routine corrects for collector efficiency and gain variations, it does this by measuring the normalizing ratio (in this case $^{146}Nd/^{144}Nd$ = 0.7219) on the same collectors as the isotope ratio of interest. In this example the $^{143}Nd/^{144}Nd$ in cycle 1 and 2 are fractionation corrected using $^{146}Nd/^{144}Nd$ in cycle 3. $^{145}Nd/^{144}Nd$ in cycle 2 and 3 are fractionation corrected using $^{146}Nd/^{144}Nd$ in cycle 3. $^{142}Nd/^{144}Nd$ in cycle 1 is fractionation corrected using $^{146}Nd/^{144}Nd$ in cycle 3. $^{148}Nd/^{146}Nd$ in cycle 3 is fractionation corrected using $^{146}Nd/^{144}Nd$ in cycle 1. $^{148}Nd/^{144}Nd$ is simply derived by multiplying $^{148}Nd/^{146}Nd$ with $^{146}Nd/^{144}Nd$ = 0.7219

Analyses were made with a ^{144}Nd intensity of 4 Volts (4e-11 amps). Samples were not run to exhaustion. Data were collected in 8 blocks of 20 cycles. Each integration was for 10 seconds and so one complete cycle comprised 30 seconds of measurement. Mass fractionation was corrected using an exponential law using $^{146}Nd/^{144}Nd$ = 0.7219.

Results

Table 2 gives the Nd isotope ratio results for all 30 measurements. Figure 1 provides a graphical representation of the filament to filament variation in $^{143}Nd/^{144}Nd$.

The measured $^{143}Nd/^{144}Nd$ for the JNd-i standard is 0.5121031. The external precision (1σ) taken over all 30 measurements is 3.2ppm for $^{143}Nd/^{144}Nd$ internal precision is typically 1.5ppm (1RSE). No discernable trend can be seen in Figure 1 . Instrumental errors can be considered to have a contribution of about 1ppm, though this may also include a small contribution from non corrected mass fractionation.

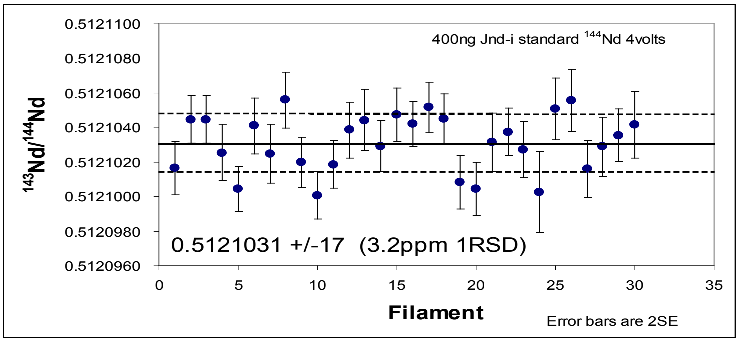

Figure 1. $^{143}Nd/^{144}Nd$ ratios for all 30 filaments.

Bead	$^{142}Nd/^{144}Nd$	ppm 1RSE	$^{143}Nd/^{144}Nd$	ppm 1RSE	$^{145}Nd/^{144}Nd$	ppm 1RSE	$^{148}Nd/^{144}Nd$	ppm 1RSE	ratios
1	1.1418383	1.7	0.5121016	1.5	0.3484046	1.4	0.2415749	3.2	160
2	1.1418479	2.2	0.5121045	1.3	0.3484045	1.3	0.2415795	2.8	160
3	1.1418445	2.5	0.5121045	1.3	0.3484064	1.3	0.2415756	2.8	160
4	1.1418301	2.2	0.5121025	1.6	0.3484058	1.5	0.2415754	3.4	160
5	1.1418459	1.9	0.5121004	1.3	0.3484052	1.3	0.2415756	3.2	160
6	1.1418489	2.4	0.5121041	1.6	0.3484046	1.6	0.2415778	3.0	160
7	1.1418370	2.8	0.5121025	1.7	0.3484045	1.5	0.2415744	3.1	160
8	1.1418337	2.2	0.5121056	1.6	0.3484059	1.4	0.2415757	3.6	160
9	1.1418275	2.1	0.5121020	1.4	0.3484055	1.7	0.2415767	2.7	160
10	1.1418304	1.9	0.5121001	1.3	0.3484041	1.3	0.2415770	2.7	160
11	1.1418353	2.4	0.5121019	1.3	0.3484039	1.4	0.2415771	3.0	160
12	1.1418459	2.5	0.5121039	1.6	0.3484057	1.5	0.2415740	2.8	160
13	1.1418442	2.2	0.5121044	1.7	0.3484065	1.4	0.2415753	3.5	160
14	1.1418423	2.1	0.5121029	1.4	0.3484051	1.2	0.2415774	2.9	160
15	1.1418537	2.0	0.5121047	1.5	0.3484038	1.5	0.2415791	3.0	160
16	1.1418482	2.1	0.5121042	1.3	0.3484050	1.3	0.2415766	2.8	160
17	1.1418430	2.0	0.5121052	1.4	0.3484053	1.5	0.2415781	3.1	160
18	1.1418487	1.9	0.5121045	1.4	0.3484059	1.4	0.2415791	2.7	160
19	1.1418410	2.1	0.5121008	1.5	0.3484057	1.5	0.2415777	3.0	160
20	1.1418329	1.8	0.5121004	1.5	0.3484028	1.3	0.2415772	3.1	160
21	1.1418407	2.3	0.5121031	1.7	0.3484045	1.4	0.2415775	3.2	160
22	1.1418527	2.1	0.5121037	1.3	0.3484049	1.3	0.2415770	2.8	160
23	1.1418372	2.2	0.5121027	1.6	0.3484059	1.5	0.2415758	2.8	160
24	1.1418397	3.0	0.5121003	2.3	0.3484010	1.7	0.2415783	4.1	160
25	1.1418506	2.5	0.5121051	1.7	0.3484047	1.3	0.2415783	3.2	160
26	1.1418497	2.1	0.5121056	1.7	0.3484024	1.7	0.2415805	2.8	160
27	1.1418383	2.8	0.5121016	1.6	0.3484049	1.7	0.2415773	3.1	160
28	1.1418475	2.5	0.5121029	1.7	0.3484038	1.5	0.2415798	2.6	160
29	1.1418537	2.7	0.5121036	1.5	0.3484035	1.3	0.2415789	3.5	160
30	1.1418503	2.0	0.5121042	1.9	0.3484049	1.5	0.2415754	3.1	160

MEAN	**1.1418427**	**2.2**	**0.5121031**	**1.5**	**0.3484047**	**1.4**	**0.2415771**	**3.1**
1SD	**0.0000074**		**0.0000017**		**0.0000012**		**0.0000017**	
1RSD (ppm)	**6.5**		**3.2**		**3.5**		**6.9**	

Table 2. Tabulated results for all 30 filaments.

Instrument to Instrument performance

Table 3 presents the results of $^{143}Nd/^{144}Nd$ measurements on four instruments during installation in 2011, together with the data in this report (red). The mean reproducibility for each instrument is typically 3 to 4ppm. The mean isotopic composition for all 5 instruments is 0.5121057 +/- 4.9ppm. This is comparable to that on any one instrument. The data show that each instrument is set-up in the same way and that there are no significant biases between each instrument.

Instrument	$^{143}Nd/^{144}Nd$	ppm 1RSD	2sd
1	0.5121053	5	5.1E-06
2	0.5121065	4.4	4.5E-06
3	0.5121095	2.3	2.4E-06
4	0.5121040	4	4.1E-06
5	0.5121031	3.2	3.3E-06
Mean	**0.5121057**	Instrument to Instrument performance	
1SD	**0.0000025**		
1RSD	**4.9**		

Table 3 Tabulated results for five different instruments

Summary

Phoenix analyses $^{143}Nd/^{144}Nd$ at 3 to 4 ppm reproducibility 1RSD. Instrument to instrument performance is extremely consistent.