

## ELECTROLYTICALLY STIMULATED COLD NUCLEAR SYNTHESIS OF STRONTIUM FROM RUBIDIUM

by

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### ABSTRACT

Two separate mass spectrometric analyses, SIMS and ICPMS of 1.0 amu discrimination with the latter preceded by an ion-exchange column separation of strontium and rubidium, performed by two independent laboratories on the pre-run and post-run cathode material from a light water based rubidium carbonate cell and a rubidium hydroxide cell provide strong evidence for the electrolytically induced transmutation of rubidium to strontium originally hypothesized by the author in connection with his CAF hypothesis ("Cold Alkali Fusion").

### INTRODUCTION

Analyses of the pre-run electrode material and post-run electrodes from two light water based rubidium salt electrolytic cells, cell 53 (rubidium carbonate) and cell 56 (rubidium hydroxide) having nickel mesh cathodes by two independent laboratories provide strong initial evidence in support of Bush's CAF Hypothesis [1,6] ("Cold Alkali Fusion") that strontium is being produced from rubidium via a cold nuclear reaction in which a proton is being added to  $\text{Rb}^{85}$  ( $\text{Rb}^{87}$ ) to produce  $\text{Sr}^{86}$  ( $\text{Sr}^{88}$ ). The post-run cathode material of cell 53 was analyzed via SIMS, while that for cell 53 and cell 56 was analyzed via Inductively Coupled Mass Spectrometry (1 amu discrimination) following an ion exchange column enhancement of the strontium relative to the rubidium [1,2,6] at WCAS ("West Coast Analytical Service, Inc.") of Santa Fe Springs, CA. This result combined with the earlier mass spectrometric evidence and its correlation with the excess heats measured via calorimetry also provides support for the author's LANT ("Lattice Assisted Nuclear Transmutation") hypothesis [3] according to which a cold nucleosynthetic chain extending beyond strontium is generated.

### CELL DESIGN AND CALORIMETRY

The cell and calorimeter design employed for the present series of experiments were of two types: (1) Cells 53 and 56 were essentially the same as that reported in Ref. 2. which was a modified Fleischmann-Pons electrolytic cell (Ref. 4) with the following principal modifications: (a) the use of a *platinum black recombiner* in the cell to allow for *closed-cell operation*, (b) a *magnetic stirrer* that provided for more uniform electrolyte mixing, and (c) *Teflon* coating of all nonelectrode materials to reduce electrolyte contamination. Additional details regarding the experimental setup provided in ref. 7.

Fig. 1 Cathode post-run mass spectrogram.

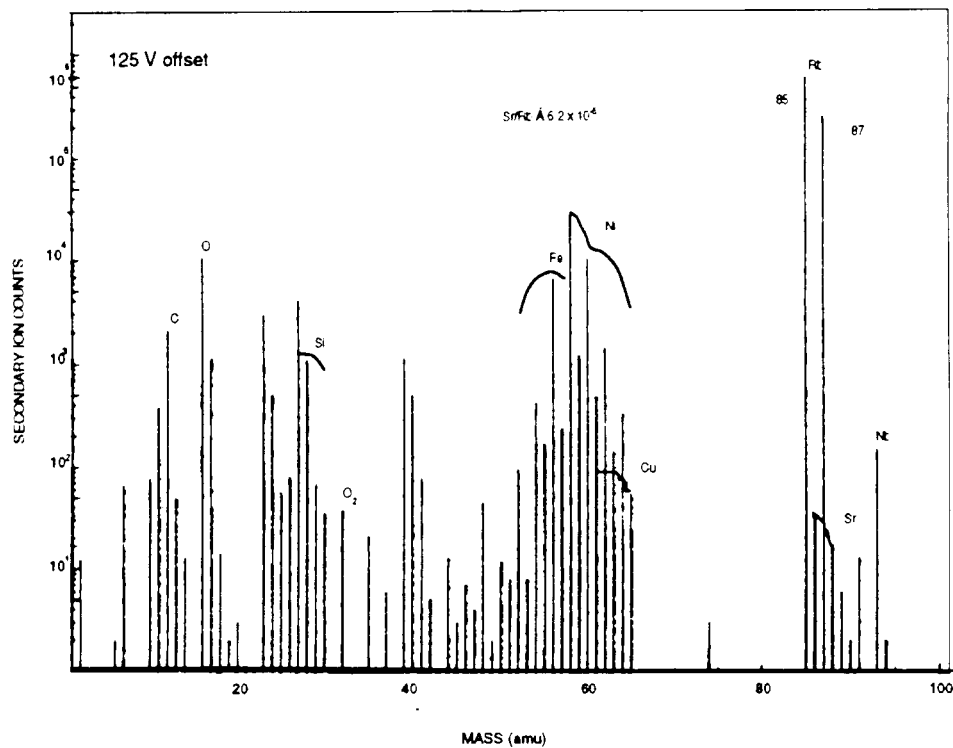


Fig. 2 Cathode pre-run mass spectrogram.

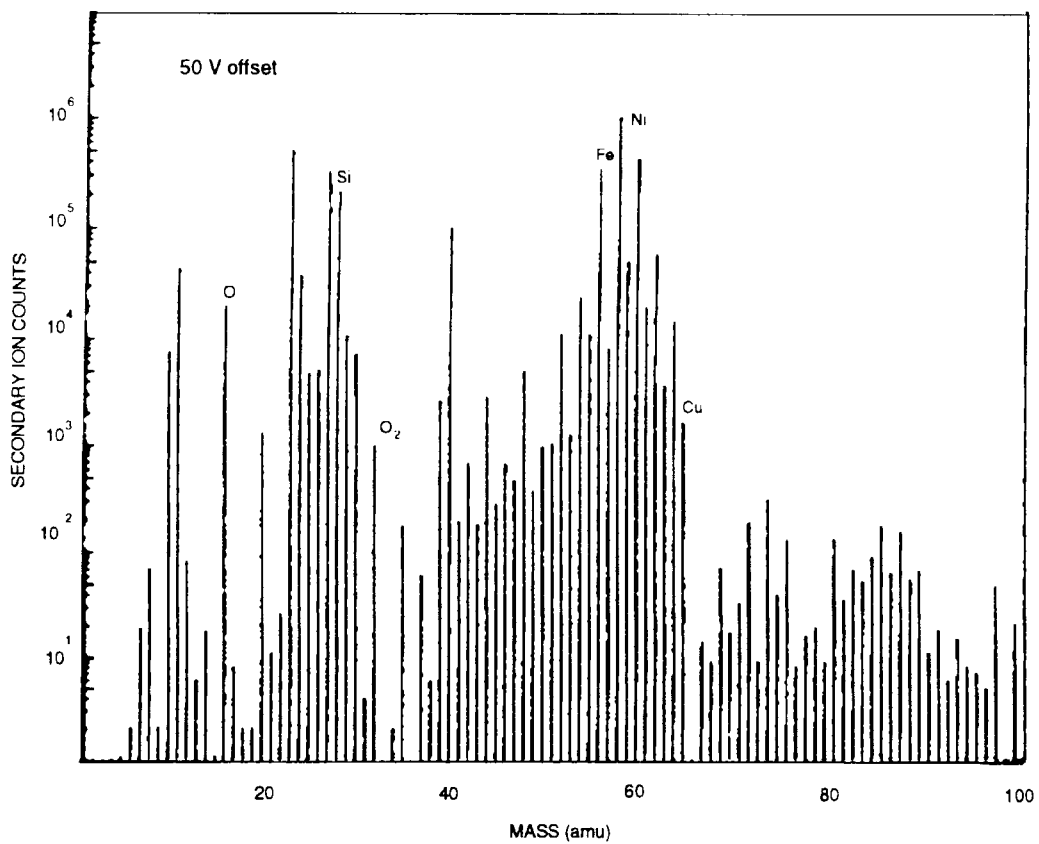


Fig. 3 Cathode post-run mass spectrogram.

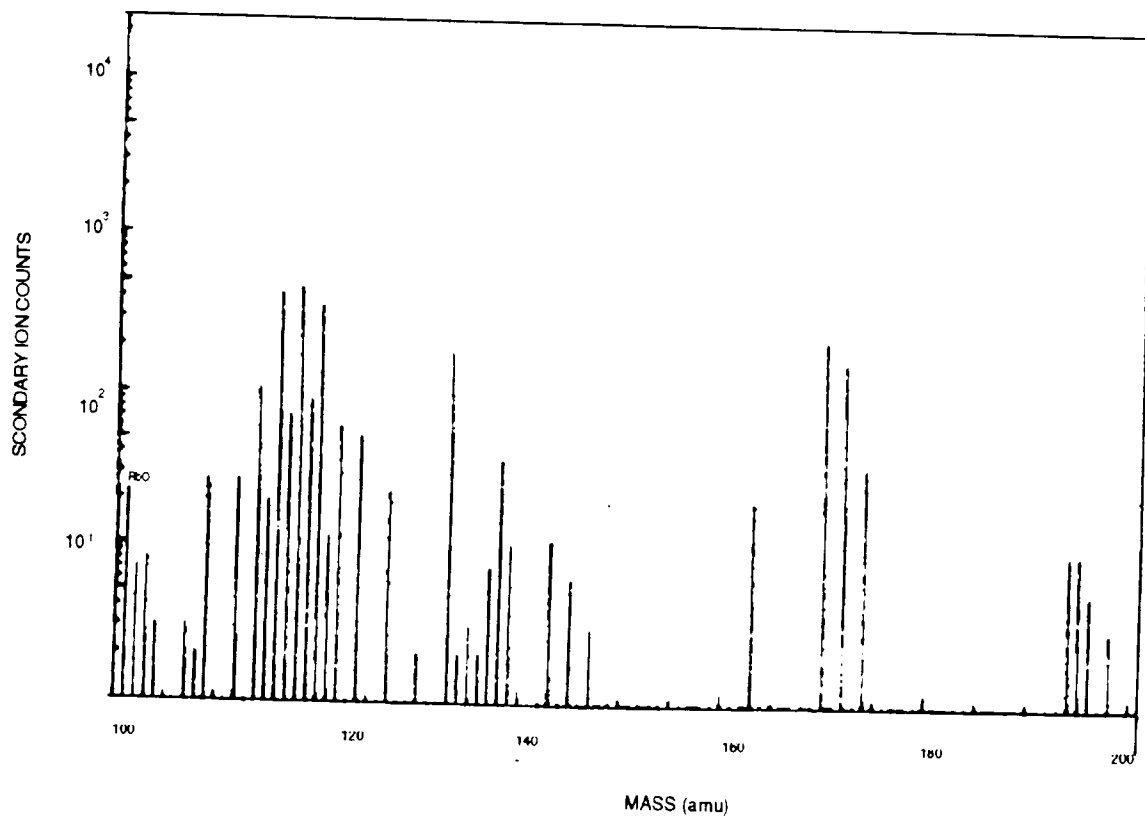
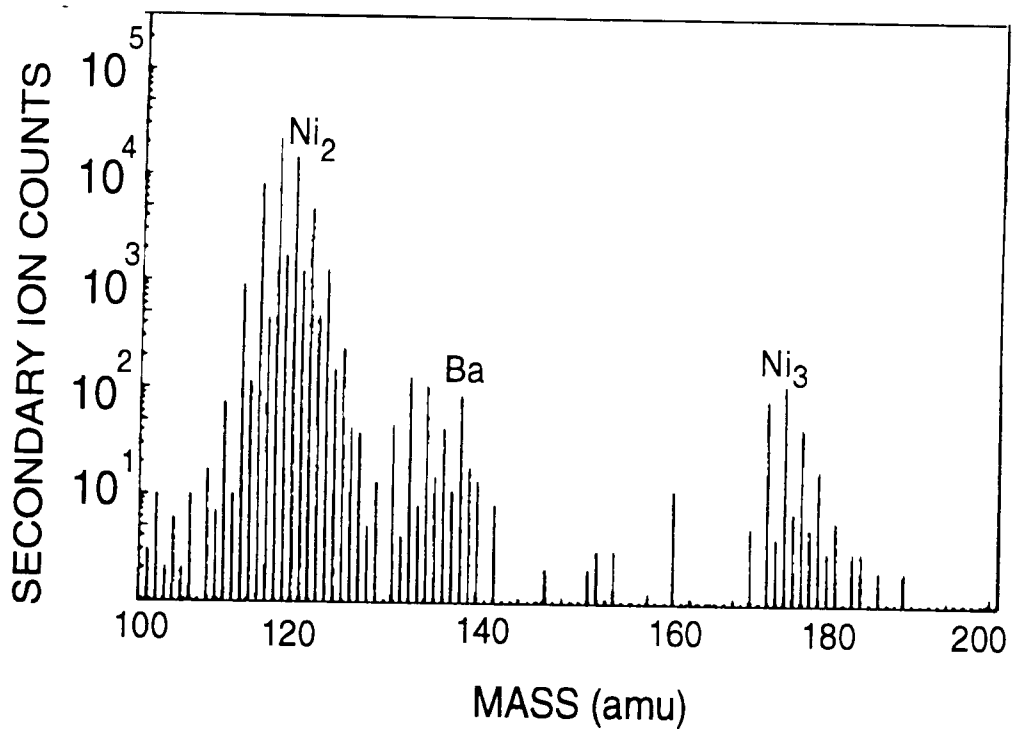


Fig. 4 Cathode pre-run mass spectrogram.



## SIMS RESULTS FOR POST-RUN CATHODE OF CELL 53

A SIMS analysis for the pre- and post-run cathode material of cell #53 showed strong signals at mass numbers 86 and 88 that were not present in the pre-run spectrum [1,2,6]. Fig. 1, Fig. 2, Fig. 3, and Fig. 4 portray the four mass spectrograms, respectively: Post-run cathode material: 0-100 amu, Pre-run: 0-100 amu, Post-run: 100-200 amu, and Pre-run: 0-100 amu. Appendix A provides an interpretation of these from the standpoint of hypothetical strontium production. An interesting finding from the standpoint of the CAF Hypothesis [1,3,6] is the fact that, within experimental error, the ratio of the line height for mass number 86 to that for 88 was the same as that for the ratio of the rubidium signals at masses 85 and 87. (The SIMS tests were performed under the auspices of a well known U.S. National Laboratory, which because of the present political atmosphere for cold fusion work, prefers not to have their name revealed at this time.)

A disadvantage of these SIMS tests was that the mass spectrometer employed was unable to discriminate between rubidium hydride and strontium; i.e.  $\text{Rb}^{85}\text{H}$  would be indistinguishable from  $\text{Sr}^{86}$ . So, even though there was strong evidence pointing to the noninvolvement of rubidium hydride, such as the relative instability of that compound and the fact that the rubidium oxide line, which should have been higher than those for  $\text{RbH}$  because of the greater stability of  $\text{RbO}$ , were shorter than those for the putative  $\text{RbH}$ , it was decided to pursue additional tests in which a chemical separation of the rubidium and strontium would be performed prior to the mass spectrometric analysis. These analyses were carried out by West Coast Analytical Services, Inc., of Santa Fe Springs, CA.

### Ion Column Exchange Separation of the Rubidium and Strontium Followed by ICPMS ("Inductively-Coupled Plasma Mass Spectroscopy") (Cells 53, 56)

Since, at least in principle, criticism could be levelled at the SIMS results by suggesting the formation of  $\text{RbH}$  to account for an apparent strong enhancement of  $\text{Sr}^{86}$  to  $\text{Sr}^{88}$  it was decided to have an ICPMS ("Inductively Coupled Plasma Mass Spectrometry") analysis performed at an independent laboratory, West Coast Analytical Service, Inc. [1,2] (Hereafter: WCAS) of Santa Fe Springs, CA. Two pages of their final report are included as Appendix B. Because the mass discrimination of the spectrometer was limited to one amu, an ion-exchange column separation was first performed to concentrate the divalent strontium relative to the monovalent rubidium, which was washed selectively out of the column.

A summary of the WCAS results is included in the Table of Fig. 5. Previously WCAS had found that the virgin cathode material gave readings for the relative percentages of the two strontium isotopes of interest essentially the same as that of the Strontium Standard average given in the data table of Fig. 5 as follows:  $\text{Sr } 86: (10.51 \pm 0.04)\%$  and  $\text{Sr } 88: (89.49 \pm 0.04)\%$ . This gives a ratio of  $\text{Sr } 88$  to  $\text{Sr } 86$  for the standard (and virgin cathode material) of  $(8.515 \pm 0.004)$  to which the ratios for the post-run cathode material will next be compared. From the data summary in Fig. 5, the following results are seen for the post-run cathode material of cell 53 (Sample A#53) for the test date of (4/9/93):  $\text{Sr } 86: (22.20 \pm 0.05)\%$  and  $\text{Sr } 88 (77.80 \pm 0.05)\%$ . The ratio of  $\text{Sr } 88$  to  $\text{Sr } 86$  is thus  $(3.504 \pm 0.002)$ , which is lower than the ratio for the virgin material by about 716 standard deviations as seen by the following:  $(8.515 - 3.504) / (0.007) = 715.8$ . Since the ratio was reduced significantly from that of the standard (pre-run cathode material), this provides good evidence for an enhancement of  $\text{Sr } 86$  relative to  $\text{Sr } 88$  for the post-run cathode of cell 53, a light water based rubidium carbonate cell.

Fig. 5

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Table 1				
Date	Sample ID	Total Sr 86	Sr 88	Strontium
4-8-93	0.01ppm Sr Std	10.48	89.52	10ppb
4-9-93	0.01ppm Sr Std	10.48	89.52	10ppb
4-13-93	0.01ppm Sr Std	10.56	89.44	10ppb
4-14-93	0.01ppm Sr Std	10.53	89.47	10ppb
		10.51±0.04	89.49±0.04	
Date	Sample ID	Sr 86	Sr 88	Strontium
4-13-93	100ppm Rb/0.01ppm Sr.	10.47	89.53	10ppb
4-15-93	100ppm Rb/0.01ppm Sr.	10.55	89.45	10ppb
		10.51±0.06	89.49±0.06	
Date	Sample ID	Sr 86	Sr 88	Strontium
4-8-93	A#53	ND	ND	ND
4-9-93	A#53	22.2	77.8	1400ppb
4-15-93	A#53	12.05	87.95	NC
Date	Sample ID	Sr 86	Sr 88	Strontium
4-8-93	#56PR	22.3	77.7	NC
4-9-93	#56PR	26.8	73.2	1500ppb

NC - not calculated

For cell 56 (light water based rubidium hydroxide), which had evidenced about five times as much excess heat as cell 53 based upon calorimetry, the data table of Fig. 5 gives results for the analysis of sample #56PR on (4/9/93) as follows: Sr 86:  $(26.80 \pm 0.05)\%$  and Sr 88  $(73.20 \pm 0.05)\%$ . The following ratio of Sr 88 to Sr 86 for these numbers implies an even greater electrolytically induced enhancement of Sr 86 relative to Sr 88, which could be anticipated based upon the greater excess heat exhibited by cell 56:  $(2.731 \pm 0.003)$ . Again, as dramatic evidence for this enhancement of Sr 86 relative to Sr 88 this ratio is less than the standard by about 826 standard deviations as seen by the following:  $(8.515 - 2.731)/(0.007) = 826.3$ . Thus these ICPMS results of WCAS obtained by first achieving a chromatographic concentration of the strontium relative to the rubidium provide strong independent support for the SIMS results.

SUPPORT FOR THE LANT HYPOTHESIS

According to the author's LANT hypothesis [3] ("Lattice Assisted Nuclear Transmutation") strontium production would not necessarily be the end of the transmutation line. Rather, the Sr atoms formed in the lattice would themselves now become targets for the lattice assisted addition of a proton. This would produce an entire cold nucleosynthetic series, the Rubidium Series [3], shown in Fig. 6 taken from reference 3. A comparison of the SIMS spectrographs of the cathode material of Cell 53 (rubidium carbonate) before and after running provides evidence for the synthesis of such nuclides as shown in the Table of Fig. 7 entitled "Isotope Production via Cold Nucleosynthesis: Rubidium Series [3]." In this respect it is interesting to note from the Table in Fig. 7 that the total excess heat (based upon Q values) produced in connection with this synthesis should be  $(3.8 \pm 0.4) \times 10^{19}$  MeV, whereas the actual excess heat for cell 53 as determined from calorimetry [3] was approximately  $(4.0 \pm 0.8) \times 10^{19}$  MeV. This is rather good agreement and provides initial support for the LANT hypothesis.

Fig. 6

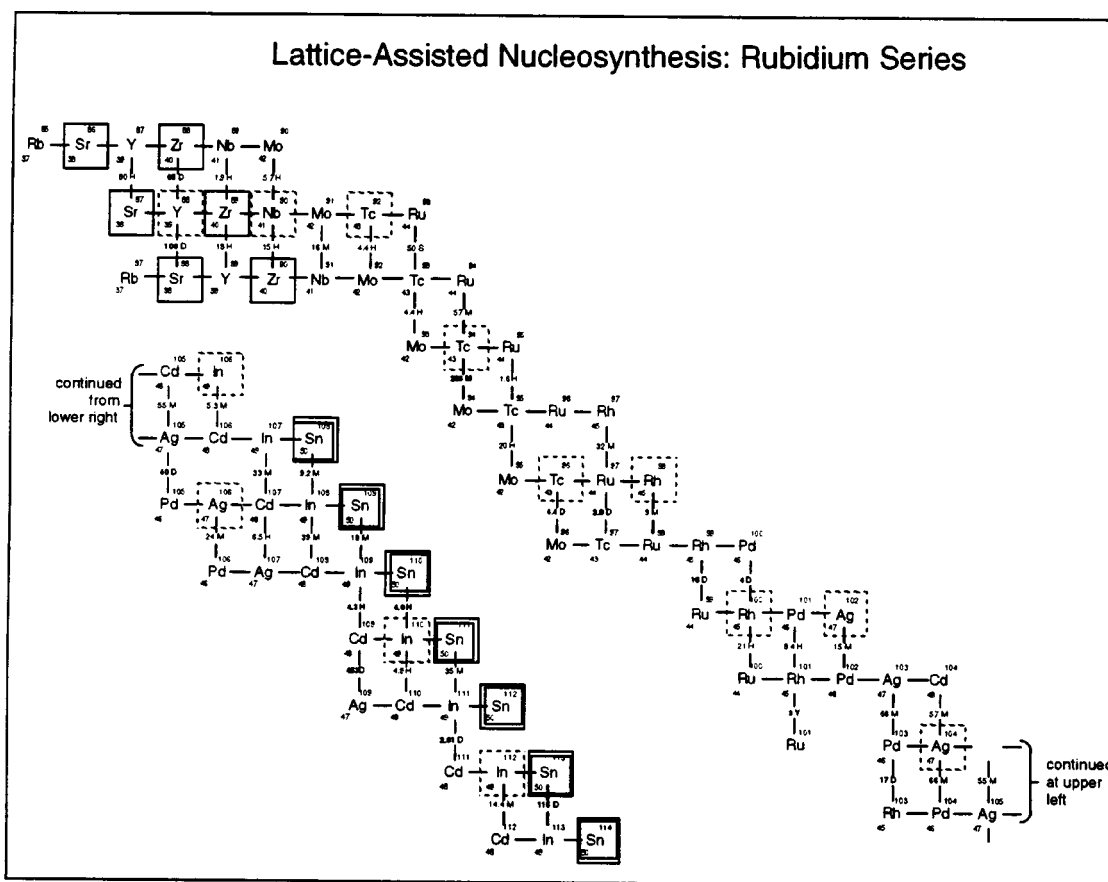


Fig. 7

Isotope Production via Cold Nucleosynthesis: Rubidium Series  
(Cell 53)

Mass Number (A)	Nuclides Synthesized	Net number of Nuclei Synthesized x 10 <sup>16</sup>	Total Energy Released (MeV x 10 <sup>17</sup> )
86	<sup>38</sup> Sr <sup>86</sup>	1.34	1.29
87	<sup>38</sup> Sr <sup>87</sup>	19.25	33.30
88	<sup>38</sup> Sr <sup>88</sup> , <sup>39</sup> Y <sup>88</sup> <sub>(108D)</sub> , <sup>40</sup> Zr <sup>88</sup> <sub>(88D)</sub>	0.52	0.55
89	<sup>39</sup> Y <sup>89</sup>	1.66	4.6
90	<sup>40</sup> Zr <sup>90</sup>	0.28	1.1
91	<sup>41</sup> Nb <sup>91</sup>	3.00	12.1
92	<sup>42</sup> Mo <sup>92</sup>	(small)	(small)
93	<sup>42</sup> Mo <sup>93</sup>	27.03	148.10
94	<sup>42</sup> Mo <sup>94</sup>	0.23	1.43
95	<sup>42</sup> Mo <sup>95</sup>	(small)	(small)
96	<sup>44</sup> Ru <sup>96</sup> , <sup>43</sup> Tc <sup>96</sup> <sub>(4.35D)</sub>	(small)	(small)
97	<sup>43</sup> Tc <sup>97</sup> , <sup>44</sup> Ru <sup>97</sup> <sub>(2.9D)</sub>	(small)	(small)
98	<sup>44</sup> Ru <sup>98</sup>	(small)	(small)
99	<sup>44</sup> Ru <sup>99</sup> , <sup>45</sup> Rh <sup>99</sup> <sub>(16.1D)</sub>	(small)	(small)
100	<sup>45</sup> Rh <sup>100</sup> , <sup>46</sup> Pd <sup>100</sup> <sub>(4D)</sub>	0.30	3.90
101	<sup>44</sup> Ru <sup>101</sup> , <sup>45</sup> Rh <sup>101</sup> <sub>(3y)</sub>	3.70	41.30
102	<sup>45</sup> Rh <sup>102</sup> , <sup>46</sup> Pd <sup>102</sup>	1.21	14.50
103	<sup>45</sup> Rh <sup>103</sup> , <sup>46</sup> Pd <sup>103</sup> <sub>(17D)</sub>	1.40	17.80
104	<sup>46</sup> Pd <sup>104</sup>	0.54	7.30
105	<sup>46</sup> Pd <sup>105</sup> , <sup>47</sup> Ag <sup>105</sup> <sub>(40D)</sub>	(small)	(small)
106	<sup>46</sup> Pd <sup>106</sup> , <sup>48</sup> Cd <sup>106</sup>	(small)	(small)
107	<sup>47</sup> Ag <sup>107</sup>	0.54	7.30
108	<sup>48</sup> Cd <sup>108</sup>	0.23	3.90
109	<sup>47</sup> Ag <sup>109</sup> , <sup>48</sup> Cd <sup>109</sup> <sub>(453D)</sub>	2.25	39.70
110	<sup>48</sup> Cd <sup>110</sup>	(small)	(small)
111	<sup>48</sup> Cd <sup>111</sup> , <sup>49</sup> In <sup>111</sup> <sub>(2.8D)</sub>	(small)	(small)
112	<sup>50</sup> Sn <sup>112</sup>	2.25	44.60
	Sums:	65.73 x 10 <sup>16</sup>	384.17 x 10 <sup>16</sup> MeV

Estimating a ten percent error, then, the total energy to produce the above based upon the LANT Model is approximately  $(3.8 \pm 0.4) \times 10^{19}$  MeV versus the total excess heat determined from calorimetry for Cell 53 of  $(4.0 \pm 0.8) \times 10^{19}$  MeV.

## CONCLUSIONS

With the corroborative independent mass spectrographic results of the two separate laboratories the evidence supporting the electrolytically induced transmutation of rubidium to strontium, as evidenced by the shift in the abundance ratio of Sr-86 to Sr-88, must be considered to be significant. These results add support to the author's CAF and LANT hypotheses. Note that any strontium contamination would only tend to shift this ratio back to the natural abundance ratio for the two strontium isotopes.

## ACKNOWLEDGMENTS

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## APPENDIX A: Interpretation of the SIMS Mass Spectrograms

The mass spectrograms of Fig. 2 and Fig. 3 were carried out by SIMS analysis, respectively, for the post-run cathode material and for the pre-run cathode. (Earlier mass spectrometry established an upper limit on the strontium in the post-run solution from cell 53 of 5 ppb.) Note the following from Fig. 3 (Pre-run):

Fig. 3 (Pre-run): Mass 86: The height of this signal is about 3.6 cm corresponding on the log-scale to an ordinate of 190 counts.



3.5 cm signal height: 150 counts

Nickel 58: 10.0 cm signal height: 1,250,000 counts

Fig. 2 (Post-run): Note that the signal height discrimination for this spectrogram is greater than that for the one of Fig. 3. Thus, the spectrogram of Fig. 3 is associated with only a 50 V offset, whereas that of Fig. 2 is associated with a 125 V offset. Thus, in comparing signal heights from Fig. 2 to those on Fig. 3 we must multiply the numbers of counts in Fig. 2 by the ratio of the Nickel 58 signal in Fig. 3 to that in Fig. 2:

Mass 86: 3.25 signal height: 36 counts

Mass 88: 2.6 cm signal height: 16 counts

Nickel 58: 9.5 cm signal height: 31,000 counts

Ratio of Nickel 58 signal in Fig.3 to that in Fig.2:  $(1,250,000/ 31,000)= 40.32.$

Corrected counts from Fig. 2 to compare with those in Fig. 3:

Mass 86:  $36 \times 40.32 =$  1,452 counts

Mass 88:  $16 \times 40.32 =$  645

Ratio of Sr-86 to Sr-88: (Corrected for background in Fig. 3):

$$(1,452 - 190) / (645 - 150) = \underline{2.55}. \quad (1)$$

Note that the ratio of the natural abundances of Sr-86 and Sr-88 is approximately:

$$\underline{0.12} \quad (2)$$

Thus, we have an isotopic abundance ratio shift by a factor of

$$\underline{2.55 / 0.12 = 21}. \quad (3)$$

Note, also, that the ratio of the natural abundances of Rb-85 and Rb-86 is about

$$\underline{2.59}. \quad (4)$$

The fact that the ratio in (1) so closely matches that in (4) is strong support for Bush's hypothesis that the strontium arises from the rubidium via the addition of a proton at the surface of the nickel.

Finally, how do we know that masses 86 and 88 in B correspond to strontium and not, say, to rubidium hydride. Quite aside from the well-known instability of rubidium hydride is the fact that a second mass spectrometric study in which the rubidium and strontium are first chemically separated via an ion exchange column shows a strong enhancement of Sr-86 over Sr-88 both for the post-run cathode material of cell 53 and for a new light water rubidium hydroxide (0.57 M) cell (cell 56).

## APPENDIX B

(WCAS)  
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April 22, 1993

## LABORATORY REPORT

## STRONTIUM ISOTOPE RATIO DETERMINATION

## SUMMARY

The results obtained and listed in Table 1 (Fig. 6 ) show that the method works as designed, using single and mixed standards. For sample A#53, some enhancement was determined, particularly on 4-9-93 when sequence 2 was performed,  $Sr86 = 22.2 \pm 0.05$ . Sequence 2 has been producing the most consistent results. Sample #56PR demonstrated verifiable enhancement,  $Sr86 = 26.8 \pm 0.05$ .

On 4-14-93, we decided to run A#53W1 from the first sequence just to have similar batch results as obtained for #56PR. The strontium standard looks great; not much strontium detected in the sample. (Pages 50 and 9)

The next experiment was designed to improve the chromatography. The amount of rubidium in solution exceeds the capacity of one column, so two columns were hooked together and a series of solutions run through them. The results for the standard are very consistent with single column values; however, for a real sample such as A#53, the strontium is still coming out early in W1 instead of DP-2 where we would like it to. (See pages 51 and 52, also results pages 10 and 11, 4-15-93.)

To demonstrate adequate resolution of the mass spectrometer, an experiment was devised on 4-16-93 (page 53). The idea is to use the scanning mode on the ICPMS instead of the peak jumping mode used when measuring isotope ratios. In the scanning mode, the resolution between peaks would be more obvious because many more data points are taken as the mass spec scans through the mass ranges. This test was run twice because the detector tripped off due to the high rubidium counts. For the second scan, the autotrip function was overridden. Page 12 shows the trip results while page 13 shows the scan with the trip switched off. The results are most vividly shown in the two mass spectra, page 14 and 15. Page 14 shows excellent base-line resolution and demonstrates the difference in magnitude of the rubidium/strontium concentrations.

Page 15 shows what would happen to the spectrum and the results if no chromatography was used on the samples to reduce the rubidium levels. Notice peak saturation for both rubidium isotopes as indicated by pitch-fork shaped peaks. Also notice the peak widths and how they spread out into the mass 84 and 87 to some extent.

Page 16 is a mass spectrum of the peak jumping mode, and it shows the resolution, peak width also.

## EXPERIMENTAL

Rubidium carbonate impregnated nickel matte electrodes from WCAS Job number 22542 were subjected to ultrasonic cleaning and acid etching to solubilize any strontium isotopes present so isotope ratio measurements using ICPMS could be made. Results are summarized in Table 1. Total Strontium levels were calculated and are reported in Table 1.

Ion Chromatography/cation exchange was used to separate the monovalent rubidium from the divalent strontium. Ten milliliter fractions were collected from the end of the column and analyzed in batches by ICPMS.

A two-step sample preparation scheme was used. The first step was eight hours of sonication in 2M HCl. The second step was 24 hours of sonication in 10% HCl, followed by 4 days of room temperature etching with the end point being a light green color from the nickel matrix. Each of the two samples was then washed with DI water three times and set aside to dry. The solutions of 10% HCl were then brought to approximately thirty milliliters (see page 43).

The first analytical sequence (Ion Chromatography, fraction collection, Isotope ratio ICPMS) of the two samples and a strontium only standard is recorded on pages 44 & 45. The actual instrument printouts are on unruled paper, pages 1-3. The results indicate possible enhancement for A#53 and substantial enhancement for #56, data Table 1, 4-8-93.

The second analytical sequence (pages 46 & 47, results pages 4-6) is from sending the fractions collected in sequence one, back through the column to try to get better separation between the rubidium and strontium. The results indicate enhancement for both samples. See results Table 1 data for 4-9-93.

The third sequence came out of our concern for demonstrating that the rubidium levels in the samples were not artificially enhancing the strontium isotopes, resulting in false ratios. (Pages 48 & 49 on 4-13-93 and pages 7 & 8 from printouts contain test information.) The conclusion is that the chromatography is providing enough separation and the resolution of the mass spectrometer is such that no artificial ratio enhancement is being induced by the high rubidium levels. Isotope ratio values are listed in Table 1 for 4-13-93.