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Cover Illustration: Multi-collector inductively-coupled plasma-mass spectrometer.

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High-Throughput Method for Strontium Isotope Analysis by Multi-Collector-Inductively Coupled Plasma-Mass Spectrometer

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Acronyms, Abbreviations, and Symbols

Term	Description
DOE	U.S. Department of Energy
MC-ICP-MS	Multi-collector-inductively coupled plasma-mass spectrometer
MVA	Monitoring, verification, and accounting
NETL	National Energy Technology Laboratory
SIS	Stable introduction system
Sr	Strontium
TIMS	Thermal ionization mass spectrometry
Rb	Rubidium

Acknowledgments

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EXECUTIVE SUMMARY

This technical report highlights a new method for high-throughput strontium (Sr) separation chemistry and isotopic analysis by multi-collector-inductively coupled plasma-mass spectrometer (MC-ICP-MS). This method was developed for the specific task of separating Sr from water with complex matrices from geologic settings, while taking advantage of the increased throughput of vacuum methods. This method is optimized for purposes of using Sr isotopes for monitoring, verification, and accounting (MVA) related to geologic CO_2 storage and for the long-term monitoring of brine migration and fluid/rock reactions related to oil/natural gas production. This technique potentially offers an order of magnitude improvement in speed compared to traditional methods. The benefits of this method over other separation protocols include:

1) *Cost savings* – the modifications of this method to current vacuum assisted Sr extraction techniques reduces the resin reservoir and reagents used for cost savings
2) *Disposability* – this design eliminates the concern for residual contaminants
3) *Ease of use* – column components consist of off-the-shelf, easy to obtain, parts
4) *Optimization for specific matrix effects* – specific interference elements have been accounted for that are common in formation waters and related fluids that could influence Sr yields (e.g. Ba, Ca, K, Fe)
5) *Optimization for MC-ICP-MS* – this method is designed for immediate isotopic analysis of Sr separated by MC-ICP-MS with no additional evaporation step

This technical report presents the details of the Sr column configuration and the high-throughput Sr separation protocol. Data showing the performance of the method as well as the best practices for optimizing Sr isotope analysis by MC-ICP-MS is presented. Lastly, this report offers tools for data handling and data reduction of Sr isotope results from the Thermo Scientific Neptune software to assist in data quality assurance, which help avoid issues of data glut associated with high sample throughput rapid analysis.

A concise version of this report has been published in a peer reviewed journal, *Journal of Analytical Atomic Spectrometry* (Wall et al., 2013).

1. INTRODUCTION

Strontium (Sr) isotopes have been proven to be a sensitive natural tracer useful for monitoring fluid-rock interactions and for tracking the origin of dissolved solids in surface and ground water systems (Banner, 2004). Because ^{87}Sr is a radiogenic, i.e. a relatively high-mass isotope produced by the decay of ^{87}Rb, variation in the isotopic ratio of $^{87}Sr/^{86}Sr$ due to natural fractionation processes (e.g., temperature, biological activity, and evaporation) can be neglected, in contrast to lower mass systems such as C, O, and H (Capo et al., 1998). The $^{87}Sr/^{86}Sr$ isotope ratio is useful for studying the migration of formation brines into surface and groundwater (Barnaby et al., 2004; Campbell et al., 2008; Chapman et al., 2012; Osborn et al., 2012), the interaction of coal fly ash with acid mine drainage (Hamel et al., 2010; Spivak-Birndorf et al., 2012), subsurface fluid flow in oil/natural gas reservoirs (Barnaby et al., 2004; Osborn et al., 2012), and fluid/rock reactions related to geologic storage of carbon dioxide (CO_2) (Quattrocchi et al., 2006).

Sr isotope analysis can be achieved by either using thermal ionization mass spectrometry (TIMS) or multi-collector-inductively coupled plasma-mass spectrometer (MC-ICP-MS) (Figure 1), which is a newly established method that allows for higher sample throughput (Fortunato et al., 2004; Vanhaecke et al., 2009). However, accurate and precise Sr isotope measurements by either technique require the separation of isobaric interferences (mainly Rb) and the removal of matrix elements (Balcaen et al., 2005; Becker, 2005; Pin et al., 2003). Strontium is routinely separated from sample matrices using Sr specific extraction resins loaded onto chromatographic columns (Horwitz et al., 1992; Horwitz et al., 1991). While these gravity flow methods are extremely effective at purifying aqueous samples for Sr, they can be time consuming.

Figure 1: NETL's Thermo Scientific NEPTUNE PLUS MC-ICP-MS at the University of Pittsburgh, Department of Geology and Planetary Science.

In order for Sr isotopes to serve as a useful tool for long-term monitoring of fluid migration related to oil and natural gas production or for monitoring, verification, and accounting (MVA) of CO_2 storage, rapid Sr separations methods are required. Improvements to gravity flow separation methods have come with the development of coupled chromatographic/MC-ICP-MS

techniques and vacuum assisted methods (EPA, 2010; Galler et al., 2008; Garcia-Ruiz et al., 2008; Maxwell, 2006; Maxwell et al., 2010). Coupled methods use ion chromatographs attached directly to mass spectrometers (Galler et al., 2008; Garcia-Ruiz et al., 2008). These methods result in high sample throughput, but their benefit can only be realized in the presence of a MC-ICP-MS, eliminating the option for TIMS analysis or offsite sample processing. Alternatively, vacuum assisted Sr separation can be carried out anywhere there is a clean laminar flow hood. However, these vacuum extraction techniques require large, expensive resin cartridges, and current vacuum-based techniques are designed specifically for evaluation of radioactive Sr in environmental samples and have not been optimized specifically for isotope ratio measurement of the eluted Sr in terms of procedural blanks and proper concentrations for analysis by MC-ICP-MS (Maxwell, 2006; Maxwell et al., 2010).

This technical report highlights a new method for high-throughput Sr separation chemistry and isotopic analysis by MC-ICP-MS. The method was developed for the specific task of separating Sr from water with complex matrices from geologic settings while taking advantage of the increased throughput of vacuum methods. This method is optimized for purposes of using Sr isotopes for MVA related to geologic CO_2 storage and for the long-term monitoring of brine migration and fluid/rock reactions related to oil/natural gas production. The benefits of this method over other separation protocols include:

1) *Cost savings* – the modifications of this method to current vacuum assisted Sr extraction techniques reduces the resin reservoir and reagents used for cost savings
2) *Disposability* – this design eliminates the concern for residual contaminants
3) *Ease of use* – column components consist of off-the-shelf, easy to obtain, parts
4) *Optimization for specific matrix effects* – specific interference elements have been accounted for that are common in formation waters and related fluids that could influence Sr yields (e.g. Ba, Ca, K, Fe)
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2. HIGH-THROUGHPUT STRONTIUM SEPARATION PROCEDURE

2.1 MATERIALS AND SAMPLE PREPARATION

During the development of this method all sample handing was done in Class 100 vertical laminar flow hoods. Ultrapure nitric acid (HNO_3) (e.g. *Optima,* Fisher Chemical, USA) is required for sample acidification, resin/column cleaning, and elutions to prevent Sr contamination. Ultrapure 18.2 MΩ·cm water (MQW) (e.g. Milli-Q, Millipore, USA) is also necessary for acid dilution, resin cleaning, and Sr elution. The Sr specific resin (Horwitz et al., 1991) (50–100 μm particle size) (Sr-resin®, Eichrom Technologies, Inc., USA) must be pre-cleaned prior to use with 8N HNO_3 and Milli-Q water (Smet et al., 2010). Before undertaking separation procedures, samples are to be filtered to <0.45 μm and then acidified with concentrated nitric acid to produce at 2% (v/v) nitric acid solution. Strontium concentrations of each sample must be obtained before proceeding to the separation procedure in order to calculate the proper volume of sample to evaporate in order to obtain 2 μg Sr. Lastly, in order to prevent contamination, samples should be evaporated in acid washed Teflon in a clean hood.

2.2 COLUMN CONFIGURATION

The column assembly (Figure 2) consists of a 3 mL syringe reservoir (National Scientific Co., part # S7515-3) attached via Luer Lock fitting to a 700 μL microcolumn (MoBiTec GmbH, part # M105010S). Sr-resin® is loaded into the microcolumn and fitted into the inner and outer tips (Eichrom Technologies, LLC, part #AC-1000-IT, OT) that are inserted into the vacuum box. All parts of the column assembly are acid cleaned before use. The polycarbonate vacuum box (Figure 3) (Eichrom Technologies, LLC) can accommodate 24 samples and is described in more detail (Maxwell, 2006). A vacuum pump that is capable of achieving a pressure of ~15 in. Hg is required for this protocol (e.g. Gast 1/6 hp Reciprocating Pump, #1HAB25M100X).

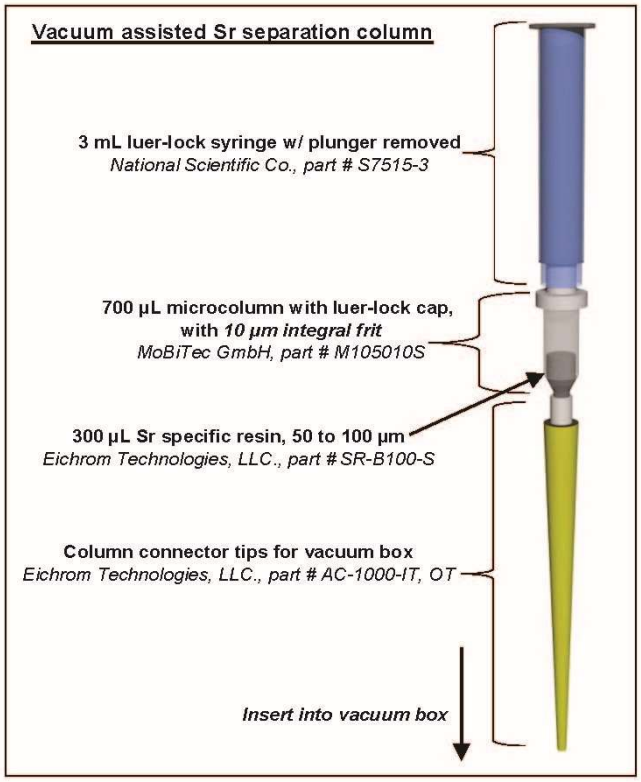

Figure 2: Sr separation column assembly for vacuum extraction (Wall et al., 2013).

Figure 3: Vacuum box for Sr separation chemistry. The box can accommodate up to 24 samples per batch.

2.3 MATERIALS PREP

2.3.1 Prior to using the vacuum box, rinse it with MQW and allow it to dry thoroughly.

2.3.2 Add 300 µL of MQW water to 700 µL microcolumn using a pipette; mark columns with a dot at the top of the 300 µL level. Discard the water.

2.3.3 Add 0.25 mL 8 N HNO_3 to the Teflon vials containing the evaporated samples (containing 2 µg Sr). Add additional 0.25 mL if necessary to dissolve dried residue. Another 0.25 mL can be added, but the total volume of 8N HNO_3 should NOT exceed 0.75 mL of 8 N HNO_3. If the sample cannot be taken up in 8 N HNO_3, exclude that sample from the procedure. Note the volume added to each sample in lab notes.

2.4 COLUMN CLEANING

2.4.1 Place waste container in vacuum box.

2.4.2 Attach microcolumn to the white and yellow vacuum box tips. Do not attach luer lock cap or reservoir at this time. Label samples on top of vacuum box and insert column assembly into the holes.

2.4.3 Add small amount of water to the microcolumn to wet frit and ensure that the column will flow. Turn on pump and keep at maximum pressure (~10–15 in. Hg).

2.4.4 Fill to the top of the microcolumn with MQW and pump through.

2.4.5 Turn off the pump. Fill to the top of the microcolumn with 8 N HNO_3 and let it sit for 60 s. Turn on pump and pump the acid through the microcolumn.

2.4.6 Fill column to the top of the microcolumn with MQW and pump through.

2.5 RESIN ADDITION AND CLEANING

2.5.1 Shake the resin bottle to make sure the resin is well mixed. WITH PUMP RUNNING AT MAXIMUM PRESSURE (~ 10–15 in. Hg), use a pipettor to load resin. Load the resin a few drops at a time until the resin bed reaches the 300 µL mark. The goal is to make a resin bed that is as compact as possible to prevent channeling.

2.5.2 With the pump running, connect the luer lock fitting and reservoir to each microcolumn.

2.5.3 With the pump running, add 3 mL of 8N HNO_3 to the reservoir and pump liquid through columns.

2.5.4 Add 3 mL of MQW in the same manner as in Step 2.5.3.

2.5.5 Repeat Step 2.5.3 once.

2.5.6 Repeat Step 2.5.4 once.

2.6 RESIN CONDITIONING

2.6.1 Add 3 mL of 8 N HNO_3 to the reservoir. Reduce pressure using the vacuum box valve and calibrate flow rate to ≤ 1 mL/min, typically between 4 and 5 in Hg. Add

an additional 2 mL of 8 N HNO_3 before the resin dries. Ensure that the flow rate is ≤ 1 mL/min. Note the pressure for this flow rate in lab notes.

2.6.2 Let the pump run until all of HNO_3 is out of the resin.

2.7 SAMPLE LOADING

2.7.1 Turn off the pump.

2.7.2 Inspect each sample to make sure it is fully dissolved in 8 N HNO_3.

2.7.3 Using a new, clean pipette tip for each sample, pipette the dissolved sample into the reservoir. DO THIS VERY SLOWLY, DOWN THE SIDE OF THE RESERVOIR AND AS CLOSE TO THE BOTTOM OF THE RESERVOIR AS POSSIBLE. Pipetting directly into the bottom will create channels.

2.7.4 Turn on pump and draw sample through the resin.

2.8 RINSING MATRIX

2.8.1 Use a squeeze bottle with 8 N HNO_3 for the following steps. To avoid sample contamination, make sure the tip of the bottle does not make contact with any of the reservoir sides. If the sample has low [Sr] or is a sensitive sample, collect these matrix rinses separately from the elutions.

2.8.2 Add 0.5 mL of 8 N HNO_3 to each reservoir and pump through at ≤ 1 mL/min.

2.8.3 Next add 1 mL of 8 N HNO_3.

2.8.4 Next add 2 ml of 8 N HNO_3.

2.8.5 Near end of the rinse, increase the pressure to around 10 in Hg to ensure that all of HNO_3 has passed through the columns.

2.8.6 Turn off the pump and remove the waste container.

2.9 STRONTIUM ELUTIONS

2.9.1 Label 15 mL centrifuge tubes with sample name and place each one in the corresponding spot in the centrifuge rack.

2.9.2 Install centrifuge rack for sample collection.

2.9.3 Using the MQW squeeze bottle, add 2 mL of MQW to each reservoir as precisely as possible. Turn on pump so flow through column is ≤ 1 mL/min.

2.9.4 Add an additional 2 mL of MQW as precisely as possible.

2.9.5 Once elution is complete, increase the pressure to ensure that all of MQW has passed through the columns and you have collected the totality of the sample.

2.10 PREPARATION FOR STRONTIUM ANALYSIS

2.10.1 Spike the eluted sample (4 mL MQW) with 80 µL of UP conc HNO_3 to make a 2% solution for analysis by MC-ICP-MS.

3. STRONTIUM SEPARATION PERFORMANCE

3.1 STRONTIUM SEPARATION FROM RUBIDIUM

To ensure that this method can adequately separate Rb from Sr, 2 µg Sr and 1µg Rb were loaded onto the column and the eluted fractions were collected and analyzed for Rb and Sr. Rubidium was ~100% eluted after 2 mL of 8 N HNO_3. An additional 2 mL of 8 N HNO_3 was added to ensure that the tail of the Rb elution curve returned to background. Maximum recovery of Sr was achieved with the addition of 4 mL of Milli-Q H_2O. Figure 4 shows the elution curves for one experiment with an 88% Sr yield. Less than 100% Sr yields are not atypical and recoveries as low as 70% have been reported (Charlier et al., 2006). Even if Sr isotopes are fractionated on the column, the exponential correction for mass bias that was employed when the data was reduced eliminates the influence of any variations in $^{88}Sr/^{86}Sr$. While it is important to have high Sr yields in order to maintain proper signal strength for MC-ICP-MS measurements, the exponential correction precludes the need for 100% recovery Sr to achieve accurate $^{88}Sr/^{86}Sr$ ratios.

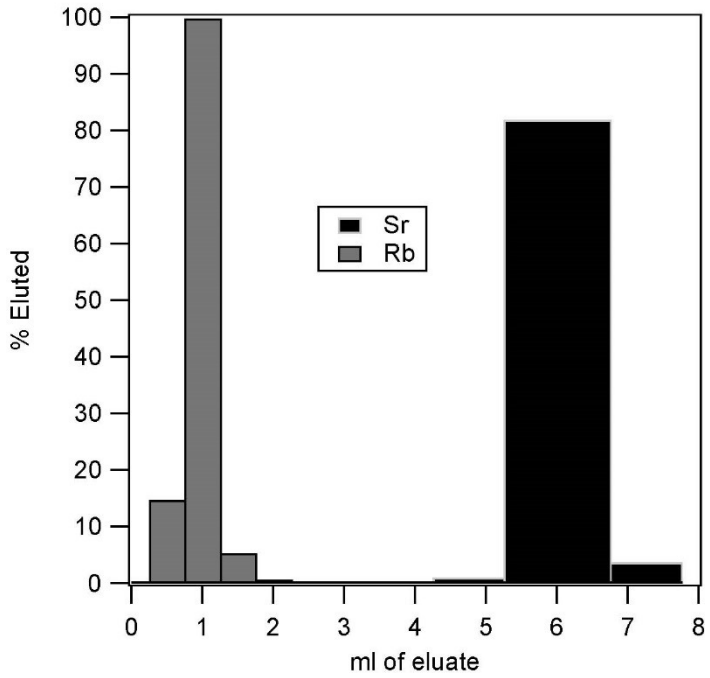

Figure 4: Elution curves showing the typical separation of Rb from Sr in a clean matrix (Wall et al., 2013).

3.2 STRONTIUM SEPARATION FROM MATRIX ELEMENTS

To demonstrate that the Sr separation procedure can effectively isolate Sr from matrix elements known to interfere with column yield (Horwitz et al., 1992; Horwitz et al., 1991) or MC-ICP-MS analysis (Rb), columns were loaded with 2 µg Sr, 1µg Rb, and a range of Ca, K, Ba, and Fe at molar ratios equivalent to what is observed for a variety of energy related geofluids (Table 1). These fluids include fly ash impoundment waters, acid mine drainage, formation brines, Marcellus shale produced waters, and fluids associated with geologic analogs for carbon storage.

For the elution experiment shown in Figure 5, the Sr and Rb mixture was spiked with 442 µg Ca, 4 µg K, 4 µg Ba, and 830 µg Fe which represent the highest *X* element/Sr ratio in the samples from Table 1. Even with a complex matrix, Rb and Sr were separated effectively, with nearly all the Rb removed after addition of 2 mL of 8 N HNO_3. Ca, K, and Fe behaved similarly to Rb and were rinsed from the resin with 2 mL of 8 N HNO_3. Barium, on the other hand, is retained longer on the resin even when as much as 4 mL of 8 N HNO_3 is added. However, this behavior does not affect the elution of Rb or Sr. In fact, the Sr yield is similar (87% recovery) to the simple elution curve shown in Figure 4.

Table 1: Geochemistry and Sr isotope ratios of energy related fluids (Wall et al., 2013)

	(M/M)					TIMS*		MC-ICP-MS		TIMS) - (MC-ICP-MS)
Source	µS/cm	Ca/Sr	Ba/Sr	K/Sr	Fe/Sr	$^{87}Sr/^{86}Sr$ **	± 2(SE)	$^{87}Sr/^{86}Sr$ **	± 2(SE)	$^{87}Sr/^{86}Sr$
Coal ash storage impoundment	533	267	--	53.0	3.20	0.712927 [12]	07	0.712942	15	-0.000015
Coal ash storage impoundment	561	301	--	45.0	--	0.712771 [12]	08	0.712766	09	0.000005
Abandoned natural gas well	1,275	633	0.08	38.0	913.00	0.715864 [11]	10	0.715861	13	0.000003
Coal mine drainage (acidic)	1,441	953	0.11	37.0	20.00	0.714503 [11]	11	0.714516	13	-0.000013
Coal mine drainage (net alkaline)	--	136	0.04	3.6	31.18	0.712056 [30]	10	0.712057	11	-0.000001
Formation brine	173,438	154	0.02	2.0	0.03	0.717022 [11]	16	0.717017	11	0.000005
Hydraulic fracturing produced water	240,625	7	5.13	0.1	0.04	0.710742 [5]	06	0.710733	14	0.000009
Hydraulic fracturing produced water	294,063	9	2.23	0.3	0.02	0.711173 [5]	09	0.711165	13	0.000008
High CO_2 natural analog	1,868	147	0.02	14.0	0.07	0.709566	10	0.709557	12	0.000009
High CO_2 natural analog	1,692	152	0.02	14.0	0.01	0.709544	07	0.709536	13	0.000008

*Source of TIMS data indicated by reference superscript

** TIMS and MC-ICP-MS values are normalized to SRM 987 = 0.71024

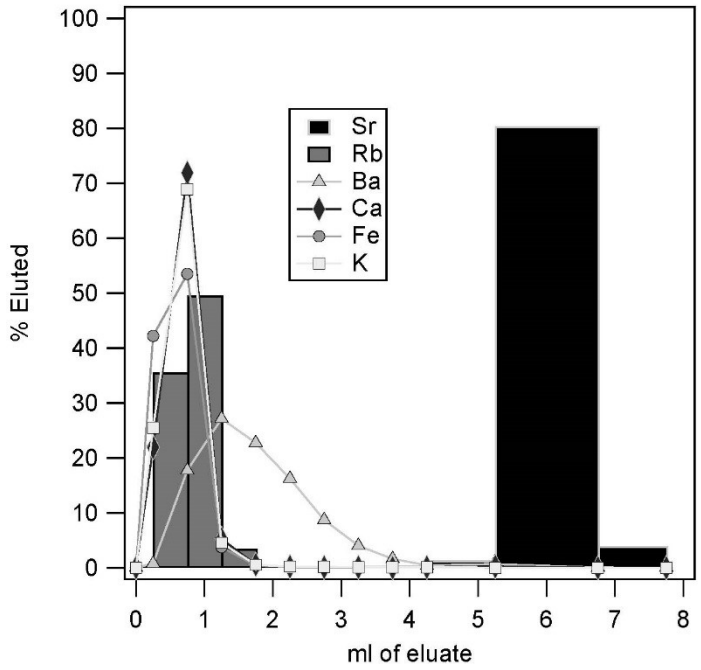

Figure 5: Elution curves showing the separation of Sr (2 µg) from Rb (1 µg) with a complex matrix of Ca, K, Ba, and Fe (at 871, 47, 4.7 and 1,147 µg, respectively) (Wall et al., 2013).

3.3 MATRIX EFFECTS ON STRONTIUM YIELDS

In order to better assess the influence of matrix elements on Sr recovery from the Sr-Resin®, columns were loaded with a solution containing 2 µg Sr, 1µg Rb, and varying amounts of a single matrix element, including Ca (200–75,000 µg), K (10–4,000 µg), Ba (2–400 µg), and Fe (300–50,000 µg). The highest matrix element:Sr ratio of these solutions greatly exceed ratios measured in typical brine and produced water samples, in order to demonstrate the range of effectiveness of the column procedure to adequately separate Sr from a complex matrix, including brines.

Strontium yields using this method appear generally unaffected by increasing amounts of Fe and K (Figure 6). The result of the Fe experiment is not surprising as the binding efficiency of Fe on the resin is relatively low (Horwitz et al., 1992). However, high concentrations of K and Ca have been shown to reduce Sr retention (Horwitz et al., 1992). This study hypothesized that the higher nitric acid concentration, 8N compared to 3N used in Horwitz et al. (1992), in this method allows for better retention of Sr in the presence of these two elements. The Sr yield does begin to decrease with excessive amounts of Ca. However, this effect is observed when the Ca:Sr exceeds 20,000, roughly 20 times the ratio observed in these samples.

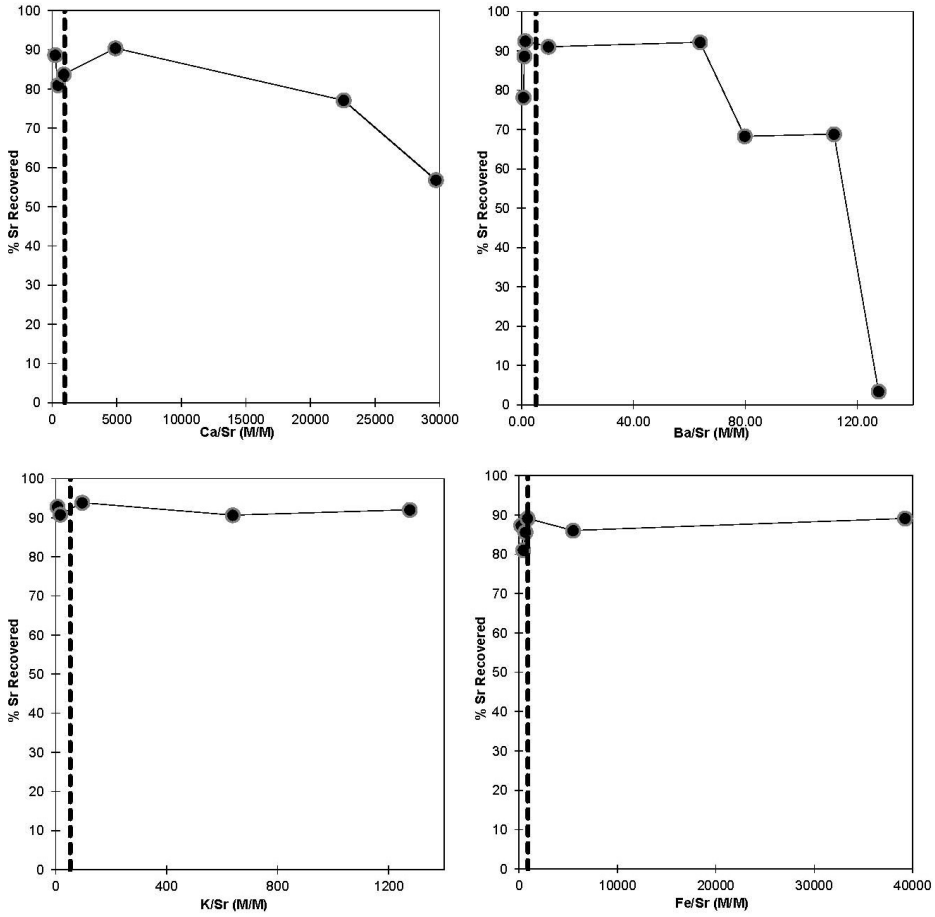

Figure 6: Sr recoveries from columns loaded with Ca, K, Ba, and Fe. 2 µg Sr, 1 µg Rb, and the matrix element were added to the column and Sr yields were measured in the water elution step. The vertical dashed line represents a typical ratio for produced water samples.

An increased amount of Ba in the matrix does apparently result in a reduction in Sr retention (Figure 6). The effect of Ba, however, occurs on these columns when the Ba:Sr is > 100:1. Even though produced waters from the Marcellus Shale have high Ba content (Table 1), the Ba:Sr ratio is < 6:1 indicating that this column method can effectively separate typical geological samples.

4. MC-ICP-MS OPTIMIZATION FOR STRONTIUM ISOTOPE MEASUREMENTS

Strontium isotope ratios were analyzed using a Thermo Scientific Neptune Plus double-focusing MC-ICP-MS (Thermo Scientific, Bremen, Germany) (Figure 1). Acidified solutions were introduced into a stable introduction system (SIS) spray chamber via a 100 µL/min PFA-nebulizer. Instrument parameters and cup configuration for Sr isotope ratio determination are summarized in Table 2. Operating conditions for Sr analysis by MC-ICP-MS were optimized to achieve a balance between precise and accurate isotope ratio measurements and high sample throughput. The goal in the column procedure was to obtain samples that were preserved and ready for immediate isotopic analysis, without an evaporation step. With that this study set out to determine the lowest Sr concentration necessary to achieve accurate and precise Sr isotope measurements using standard instrument settings.

Table 2: MC-ICP-MS running parameters

Thermo Scientific Neptune Plus MC-ICP-MS	
Running Parameter	**Typical Setting**
RF power	1,200 W
Cooling gas flow rate	15 L/min
Auxiliary gas flow rate	0.7 L/min
Sample gas flow rate	1.0 to 1.1 L/min
Extraction voltage	2,000 V
Focus voltage	725 V
Sample cone	Standard, Ni
Skimmer cone	Standard, Ni
Spray chamber	SIS
Nebulizer	PFA-ST, 100 µL/min
Sample uptake rate	65 µL/min
Uptake mode	Free aspiration
Instrument Resolution	400 (Low)
Analyzer pressure mbar	1×10^{-8} mbar
Minimum sensitivity for ^{88}Sr (10^{11} Ω resistors)	16 V/ppm
Blocks	1
Cycles/block	45
Integration time	8.41 sec
Baseline on peak, 2% HNO_3	60 sec
Cup Configuration	
Collection Mode	**Static**
L3	$^{82}Kr^+$
L2	$^{84}Sr^+/^{84}Kr^+$
L1	$^{85}Rb^+$
C	$^{86}Sr^+/^{86}Kr^+$
H1	$^{87}Sr^+/^{87}Rb^+$
H2	$^{88}Sr^+$

The concentration of the NIST 987 Sr standard (100–500 ppb) was varied to assess the effect of signal strength (monitored by ^{88}Sr) on accuracy and precision (Figure 7). When instrument parameters remained constant and only the solution concentration varied, a clear decrease in measurement precision and a deviation in the accuracy of the measurement were observed with the 100 ppb solution (run at approximately 1 V ^{88}Sr). This result is consistent with a previous study that showed similar deviation in the accuracy with low signal strength during MC-ICP-MS analysis (Neptune) (De Muynck et al., 2009).

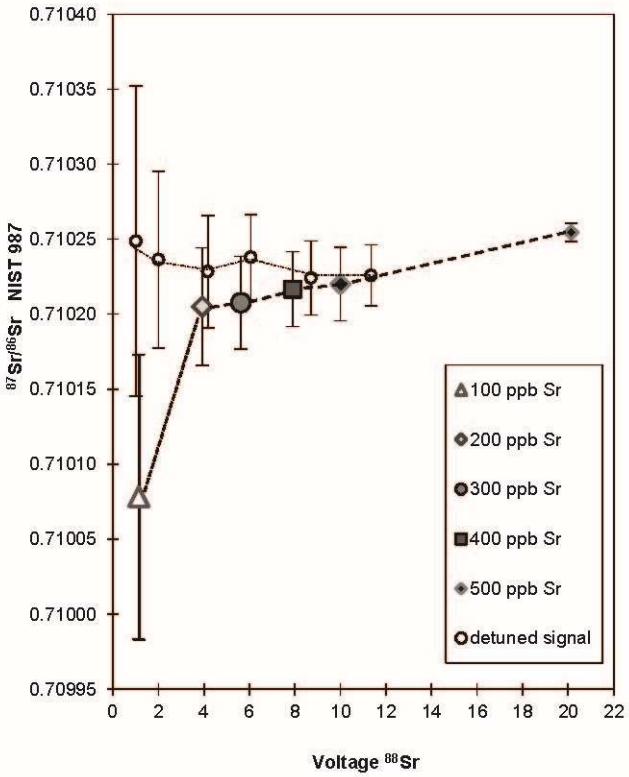

Figure 7: Measured value of NIST SRM 987 plotted against the voltage of ^{88}Sr. Error bars indicate the in-run standard error of NIST 987 $^{87}Sr/^{86}Sr$ at various solution concentrations and instrument settings. Solution of NIST 987 with [Sr] of 100 ppb, 200 ppb, 300 ppb, 400 ppb, and 500 ppb were run using the same instrument settings. NIST 987 solutions of 400 and 500 ppb were run while detuning the instrument (lowered sample gas) (from Wall et al., 2013).

Overall, these results suggest that in order to achieve accurate and precise Sr isotope ratio measurements with the Neptune MC-ICPMS, the ^{88}Sr signal should be ≥ 8 V (and < 50 V with 10^{11} Ω resistors). This can be achieved with 400 to 500 ppb Sr solutions using standard operating procedures. Optimal tuning of the instrument usually produces a higher ^{88}Sr signal strength (~15 to 30 volts). This indicates that solutions taken directly from the Sr separation protocol described here, even if Sr yields are as low as 50%, have adequate concentrations of Sr to achieve good accuracy and precision.

Similar tests of accuracy and precision of the NIST 987 Sr standard were conducted using various data acquisition methods (e.g. varied signal integration time, number of sampling blocks, and number of cycles per block). The ideal balance between precision and sample throughput occurred with signal integration times of ~8 sec and 1 block of 45 measurements (or cycles per block). Table 2 describes the optimal instrument parameters for the Neptune MC-ICPMS based on these experiments.

To assess long term variability of the $^{87}Sr/^{86}Sr$ ratio, the NIST 987 Sr standard was analyzed over the course of a month using the instrument parameters shown in Table 2 (Figure 8). The average $^{87}Sr/^{86}Sr$ value (n=99) is 0.710265 ± 14 (2σ). These values are consistent with other measurements of NIST 987 by MC-ICP-MS (De Muynck et al., 2009; Rich et al., 2012).

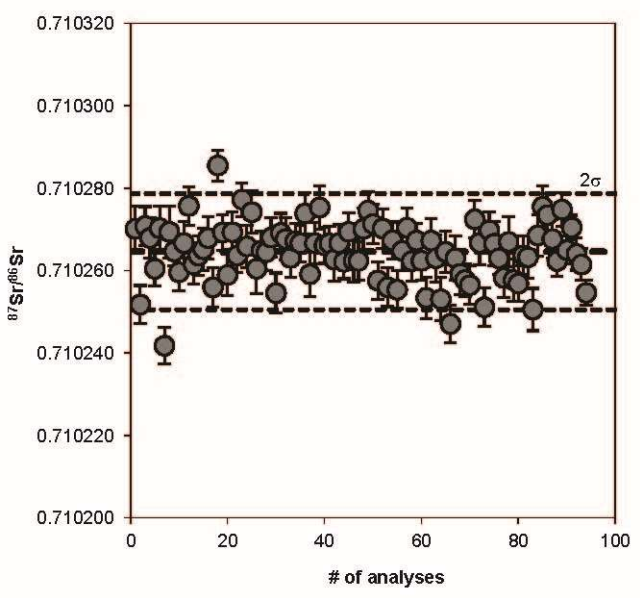

Figure 8: $^{87}Sr/^{86}Sr$ values of repeat measurement of NIST 987 over 2 weeks. The average value is 0.710265 ± 14 (2σ).

5. COMPARISON OF MC-ICP-MS AND THERMAL IONIZATION MASS SPECTROMETRY

For comparison of Sr isotope results with standard TIMS analysis of samples, the method described here was used to chemically separate and analyze by MC-ICP-MS samples that were previously measured using a multidynamic method on a Finnigan-MAT 262 thermal ionization mass spectrometer (Table 1). Details of sample preparation and analysis of those samples are discussed elsewhere (Brubaker et al., 2013; Chapman et al., 2012; Chapman et al., 2013; Sharma et al., 2013).

Sr isotope measurements performed by MC-ICP-MS were compared to TIMS on a variety of samples with a wide range of $^{87}Sr/^{86}Sr$ (Table 1). All of these samples had been previously processed through gravity-fed Sr-Resin® columns and analyzed by TIMS (Brubaker et al., 2013; Chapman et al., 2012; Chapman et al., 2013; Sharma et al., 2013). Unseparated aliquots of the same samples were obtained and processed through the entire chemical separation and MC-ICP-MS procedure described in this paper. Even when measured by TIMS, the $^{87}Sr/^{86}Sr$ ratio of the NIST SRM 987 standard on different instruments can vary significantly, depending on the instrument geometry and measurement algorithm. The measured value of this standard is routinely reported to allow inter-laboratory comparison of $^{87}Sr/^{86}Sr$ ratios. Therefore, all measured ratios were normalized to a common value of 0.710240 for the NIST SRM 987 standard by applying the offset between the standard measurements and this value to all measured ratios. To assess the agreement of the $^{87}Sr/^{86}Sr$ ratios measured by TIMS and MC-ICP-MS, a Bland-Altman plot (Figure 8) was used (Bland and Altman, 1986). The average difference of the $^{87}Sr/^{86}Sr$ ratios measured by TIMS and MC-ICP-MS is $1.7x10^{-6}$. While this indicates that, for the ten samples that were measured, $^{87}Sr/^{86}Sr$ ratios were measured to be slightly higher using TIMS, this value is smaller than the average standard error of sample measurements by TIMS ($8.0x10^{-6}$). Therefore, this can conclude that any bias related to the average difference $^{87}Sr/^{86}Sr$ ratios measured by TIMS and MC-ICP-MS is within the error of the measurement. Furthermore, difference between $^{87}Sr/^{86}Sr$ ratios measured TIMS and MC-ICP-MS is no greater than $1.8x10^{-5}$ as indicated by the 95% confidence levels (2σ, dark dashes) in Figure 9. This variability is close to the long term precision (2σ) of standard measurements by TIMS ($1.7x10^{-5}$). These results suggest that Sr isotopic measurements with a precision and accuracy comparable to routine measurements made by TIMS are achievable using this method.

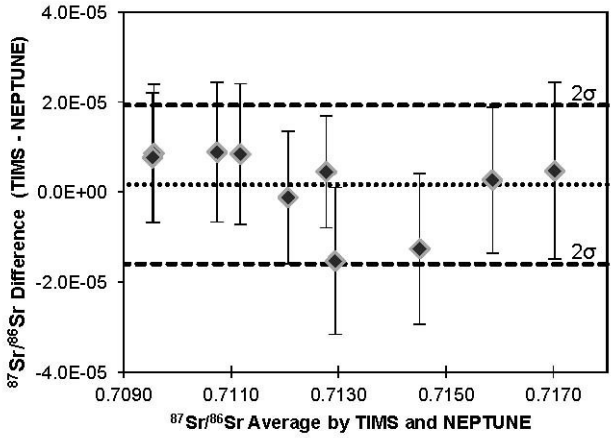

Figure 9: Differences in $^{87}Sr/^{86}Sr$ values measured by the University of Pittsburgh TIMS and MC-ICP-MS vs. the average $^{87}Sr/^{86}Sr$ values normalized to a common value for SRM 987 of 0.710240. The error bars represent the propagated error of both measurements. The bold dashed line represents the 2σ error (±0.000018, n = 10) and the light dashed line is the average difference of the $^{87}Sr/^{86}Sr$ values ($1.7x10^{-6}$).

6. DATA HANDLING AND REDUCTION

6.1 INSTRUMENTAL MASS BIAS CORRECTIONS

Data acquisition was carried out using 1 block of 45 measurements with 8-s integration times. Raw data (voltages) were first corrected for signal contributions using voltages from the analytical blank (2% HNO_3). The $^{87}Sr/^{86}Sr$ ratio was corrected for instrumental mass discrimination using an exponential law (Russell et al., 1978; Wasserburg et al., 1981) assuming a normal $^{86}Sr/^{88}Sr$ ratio of 0.1194 (De Laeter et al., 2003). The $^{87}Sr^+$ signal was corrected for any contribution from $^{87}Rb^+$ by measuring $^{85}Rb^+$ and assuming a $^{87}Rb/^{85}Rb$ ratio of 0.3858 (De Laeter et al., 2003). Additionally, the $^{86}Sr^+$ signal was corrected to account for any $^{86}Kr^+$ contamination present with the Ar source by measuring $^{83}Kr^+$ and using a value of 1.5044 for the $^{86}Kr/^{83}Kr$ ratio (De Laeter et al., 2003). Calcium argide and dimer corrections were not carried out because these interferences have not been observed with the Neptune MC-ICP-MS (Ramos et al., 2004; Yang et al., 2012). After all corrections were applied, any of the 45 measured ratios that fell outside of the 95% (2σ) confidence test were edited out as outliers. Typically fewer than 3 ratios were removed.

6.2 DATA REDUCTION AND QUALITY ASSURANCE

Since these methods allow for high sample throughput resulting in a potential completion of ~120 samples per day, data management is important. The data output from the Thermo Scientific Neptune software can be cumbersome however, especially when dealing with multiple samples. It is important to not only collect the $^{87}Sr/^{86}Sr$ ratio, but also monitor other quality assurance parameters such as the ^{88}Sr signal intensity, the ^{88}Sr signal from the blank, the magnitude of the Rb and Kr interference correction, and the stability of the measured signals over time. To do this however, the data must be organized by the user. Microsoft Excel macros have been developed that reduce the data to a final user friendly output that appears in Appendix A. This output displays sample information, the isotope ratios, signal intensities, measurement errors, and signal variability over time. An important feature of the data output highlights the normalized $^{87}Sr/^{86}Sr$ ratio. In order to compare ratios measured across long time periods it is necessary to correct for normal long term instrument drifting. To do this three to five (or more) NIST 978 standard solutions are measured over the course of the run. The average of these standard runs is then compared to 0.710240 and an offset is calculated. This offset is then applied to the $^{87}Sr/^{86}Sr$ ratio of the sample and the normalized ratio is displayed.

Instructions listed in Appendix B allow data from the entire run to be reduced into easily managed PDF files and a stand-alone Microsoft Excel spreadsheet. The macros are part of files Sr_template.xlsm and appear in Appendix C.

7. CONCLUSIONS

A high-throughput Sr separation procedure for $^{87}Sr/^{86}Sr$ isotope analysis by MC-ICP-MS was developed, based in part on previously existing vacuum box methods. This procedure is optimized for accurate and precise $^{87}Sr/^{86}Sr$ measurements of fluids related oil/gas production and geologic storage of carbon. The chemical separation procedure can effectively isolate Sr from complex sample matrices and from solutions that have excess Ca, K, Ba, and Fe. This separation procedure uses off-the-shelf parts, and is designed with the option to be carried out offsite without the direct need for a dedicated clean lab and mass spectrometry facility. The low cost of the column and resin assembly allows use of a new column and fresh resin for each sample to minimize contamination. This report also describes optimal parameters for MC-ICPMS analysis to achieve routine accuracy with precision of $\pm$ 1.4 x 10^{-5}. After sample evaporation, processing time for 24 samples is approximately 1 hr and a maximum of 120 samples per day can be analyzed using an autosampler by MC-ICP-MS. This is approximately an order of magnitude faster than traditional methods using standard columns combined with TIMS analysis. The results of this high-throughput method demonstrate that Sr isotopes analysis could be a viable tool for MVA and long-term geochemical monitoring of oil/gas reservoirs.

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APPENDIX A: DATA MANAGEMENT EXAMPLE OUTPUT

Neptune Sr Data Reduction

Sample Name: **NIST987**

Run Date:	3/11/2013	*Sample ID:*	NIST987
Time:	11:29:33:628	*Operator:*	ajw
Run number:	002.	*Valid Values:*	43(45)

File: C:\Neptune\User\NEPTUNE\Data\example_folder\NIST987_002.dat

Method Name: C:\Neptune\User\NEPTUNE\Methods\example_folder\120510_ajw_8_1_45_Sr.met

RESULTS

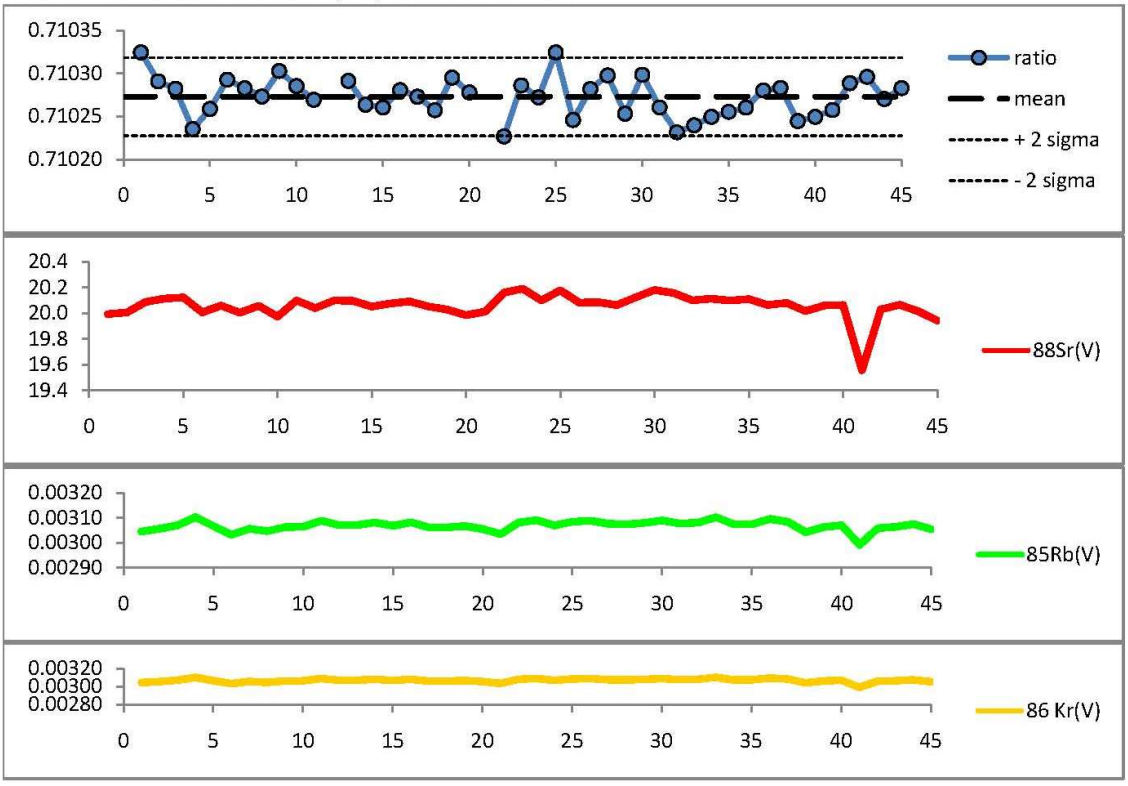
$^{87}Sr/^{86}Sr$ normilized to 0.71024: **0.710245 ± 1.4E-05** 2SD, see standard results on back

$^{87}Sr/^{86}Sr$ as reported NEPTUNE: 0.710273 ± 3.5E-06 SE

$^{87}Sr/^{86}Sr$ calc, no correction:	0.710797	*Rb correction*	709.4 ppm
$^{87}Sr/^{86}Sr$ calc, Rb + Kr corr.:	0.710294	*Kr correction*	2.20 ppm
$^{87}Sr/^{86}Sr$ calc, Rb corr. only:	0.710293		

^{88}Sr (V):	20.06	*^{88}Sr max/min (V):*	20.2 / 19.6
^{88}Sr background:	0.004	*^{88}Rb max/min (V):*	0.003102 / 0.002992
signal to bckgrnd	5198.	*$^{86}Sr/^{88}Sr$ max/min:*	0.114676 / 0.114662

Corrected for mass fractionation, Rb, and Kr interference

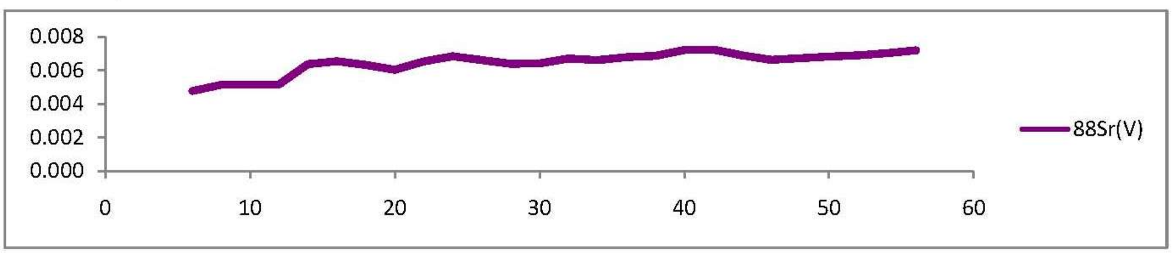


Standard Results (Neptune results, corrected for Rb, Kr, and mass bias)

Analysis Date	Time	Sample ID	run #	87Sr/86Sr	Std Err (ab)	valid values	88Sr
3/11/2013	11:29:33:628	NIST987	2	0.710273	3.5E-06	43(45)	20.1
3/11/2013	11:43:27:628	NIST987	4	0.710264	4.4E-06	45(45)	20.0
3/11/2013	14:16:21:621	NIST987	26	0.710278	3.6E-06	44(45)	20.1
3/11/2013	16:49:12:615	NIST987	48	0.710262	3.8E-06	42(45)	20.0
3/11/2013	17:58:41:611	NIST987	58	0.710263	3.6E-06	44(45)	19.8
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0
0	0	0	0	0.000000	0.0E+00	0	0.0

Avg Standard	2 Stdev Stnds	offset from (0.710240)
0.710268	1.4E-05	-2.82E-05

88Sr background over entire analytical run



APPENDIX B: SR ISOTOPE DATA REDUCTION FOR THERMO NEPTUNE

The NEPTUNE software creates a folder in which it saves .DAT, .EXP, .TDT, and .LOG files of your analytical run. The .DAT files contain the raw signals from each faraday cup and calculations for any ratios or mass bias corrections that have been selected. These files can be opened by NEPTUNE software (EVALUATION) and are used for reprocessing of the data if adjustments to any ratio calculation are needed. The .LOG files can be read in a text editor and they record some of the instrument conditions from the run. The .EXP files are simply .DAT files that can be read by EXCEL.

To reduce Sr isotope data from the NEPTUNE output files (.EXP) follow this procedure:

1) Open the folder containing your data and verify that there are .EXP files
2) **Open Sr_data_reduction** folder on the desktop , select "**Sr_template.xlsm**", **copy,** and **paste** a copy of the template **into your data folder** (a copy of Sr_template is located in the copy folder in case the original files in corrupted)
3) **Close Sr_data_reduction** folder
4) Change .exp files to .xls files as follows:
    a. Click "start" menu on the Windows desktop
    b. Select "run" program
    c. Type "cmd" and then OK (this opens Windows command prompt)
    d. Type "cd" then SPACE and without hitting return go to the next step
    e. Select the address from your open data folder and COPY
    f. PASTE into command prompt by right clicking and selected PASTE
    g. Hit RETURN
    h. Type "ren<SPACE> *.exp<SPACE> *.xls" (note the spaces)
    i. Hit RETURN
    j. Go back to your data folder and verify that the .EXP files are now .XLS files
    k. Close command prompt
5) Open EXCEL from the "start" menu
6) On the "**Data**" tab click "**RDBMerge Add-in**" to compile all the .XLS files into one
    a. Folder Location → click **Browse and navigate to your folder**, click **OK**
    b. Which Files → pull down "**XLS**", default: select "Merge All files from the folder…"
    c. Which worksheet(s)→ default: "Use the sheet index 1"
    d. Which range → **change to First cell A1**
    e. Check Add file name, Check Paste as values
    f. Click "**MERGE**"
    g. Once it is finished click **OK**

h. Close Book1 without saving

7) In the new spreadsheet, **SELECT ALL** (Ctrl + A) and **COPY** all the data in the "Combine Sheet" worksheet
8) **Open** the copy of "**Sr_template.xlsm**" from **your data folder**
9) **PASTE** the copied data into "**Combine Sheet**"
10) To start the data processing, **Click the blue, red, and yellow circle** at the top of the spreadsheet (next to the save button).
11) **Once processing is done (~1 min),** navigate to **print menu**, select **PRINT**, and select the "Adobe **PDF**" printer, printing "Active sheets"
12) A "save as" prompt will appear, name your file and **save** it **to the desired location**
13) **PDF will be generated** giving a report for each sample. This can be printed using two sided printing so each sample will have a standard summary on the back.
14) **IMPORTANT:** Save the **Sr_template.xlsm** of your newly compiled data by **SAVE AS**, select **file type *.xlsx**, rename the file and save it to the desired location. **Click SAVE**, then **click YES to save as a macro-free workbook**.
15) **CLOSE** the workbook called **Sheet 1 without saving** (the file that was created using RDBMerge)
16) **Delete the Sr_template.xlsm from your data folder** (this prevents having multiple templates scatter across the computer)

The compiled spreadsheet has a tab marked Samples and Standards (scroll all the way to the left). These summarize the data in the order in which they were run and applies the normalization to 0.71024.

APPENDIX C: EXCEL MACRO

```
Sub main()
Call standardMove
Call cleanupStandards
Call sampleMove
Call cleanupSamples
Call assembleSamples
Call assembleStandards
Call removeEmpty
Call SortSheets
Call activateSheets
'Call printToPDF
End Sub
```

```
Sub standardMove()
Const sampletype1 = "SampleType: STD"
Dim wsSource As Worksheet
Dim wsDest As Worksheet
Dim NoRows As Long
Dim DestNoRows As Long
Dim i As Long
Dim rngCells As Range
Dim rngFind As Range

    Set wsSource = Worksheets("Combine sheet")

    NoRows = wsSource.Range("A65536").End(xlUp).Row
    DestNoRows = 5
    Set wsDest = ActiveWorkbook.Worksheets.Add

    For i = 1 To NoRows

        Set rngCells = wsSource.Range("B" & i)
        '84
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 4).Copy wsDest.Range("q" & DestNoRows)
        End If
        '86
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 6).Copy wsDest.Range("p" & DestNoRows)
        End If
        '87
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 7).Copy wsDest.Range("o" & DestNoRows)
        End If
        '82
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 2).Copy wsDest.Range("n" & DestNoRows)
        End If
        '83
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 3).Copy wsDest.Range("m" & DestNoRows)
        End If
        '85
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 5).Copy wsDest.Range("l" & DestNoRows)
        End If
        'background
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(50, 8).Copy wsDest.Range("j" & DestNoRows)
        End If
        '88
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(51, 8).Copy wsDest.Range("i" & DestNoRows)
        End If
```

```
        'valid values
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(56, 10).Copy wsDest.Range("h" & DestNoRows)
        End If
        'standard error (ab)
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(53, 10).Copy wsDest.Range("g" & DestNoRows)
        End If
        '87/86
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(51, 10).Copy wsDest.Range("f" & DestNoRows)
        End If
        'run number
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(-8, 0).Copy wsDest.Range("e" & DestNoRows)
        End If
        'sample id
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(-11, 0).Copy wsDest.Range("d" & DestNoRows)
        End If
        'time
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(47, 1).Copy wsDest.Range("c" & DestNoRows)
        End If
        'date
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
           rngCells.Offset(-5, 0).Copy wsDest.Range("b" & DestNoRows)


           DestNoRows = DestNoRows + 1
        End If

    Next i

    ActiveSheet.Name = "Standards"
End Sub
```

```
Sub cleanupStandards()
'add headers
    Worksheets("Standards").Range("b4") = "Analysis Date"
    Worksheets("Standards").Range("c4") = "Time"
    Worksheets("Standards").Range("d4") = "Sample ID"
    Worksheets("Standards").Range("e4") = "Run Number"
    Worksheets("Standards").Range("f4") = "87Sr/86Sr"
    Worksheets("Standards").Range("g4") = "Std Err (ab)"
    Worksheets("Standards").Range("h4") = "Valid Values"
    Worksheets("Standards").Range("i4") = "88Sr"
    Worksheets("Standards").Range("j4") = "88Sr bckgrnd"
    Worksheets("Standards").Range("l4") = "85Rb"
    Worksheets("Standards").Range("m4") = "83Kr"
    Worksheets("Standards").Range("n4") = "82Kr"
    Worksheets("Standards").Range("o4") = "87Sr"
    Worksheets("Standards").Range("p4") = "86Sr"
    Worksheets("Standards").Range("q4") = "84Sr"
    Worksheets("Standards").Range("s4") = "Avg Standard"
    Worksheets("Standards").Range("t4") = "2 Stdev Stnds"
    Worksheets("Standards").Range("u4") = "offset from (0.710240)"
'a1
Range("a1").Select
    With Selection
        .HorizontalAlignment = xlLeft
    End With
  Worksheets("Standards").Range("a1") = "NEPTUNE Sr Isotope Data: Standards"
  Range("a1").EntireRow.Font.Bold = True

'bold
   Range("A4").EntireRow.Font.Bold = True
'average standards
   Range("S5").Select
```

```
    ActiveCell.FormulaR1C1 = "=AVERAGE(RC[-13]:R[1000]C[-13])"
'2 Stdev of standards
   Range("t5").Select
    ActiveCell.FormulaR1C1 = "=2*STDEV(RC[-14]:R[1000]C[-14])"
'offset
   Range("u5").Select
   ActiveCell.FormulaR1C1 = "=0.71024-RC[-2]"
'remove Analysis date:
   Columns("B:B").Select
    Selection.Replace What:="Analysis date:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
'remove Sample ID:
   Columns("D:D").Select
    Selection.Replace What:="Sample ID:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
'remove Run number:
   Columns("E:E").Select
    Selection.Replace What:="Run number:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
'center text
    Cells.Select
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = False
        .Orientation = 0
        .AddIndent = False
        .IndentLevel = 0
        .ShrinkToFit = False
        .ReadingOrder = xlContext
        .MergeCells = False
    End With
'format
    Columns("F:F").Select
    Selection.NumberFormat = "0.000000"
    Columns("G:G").Select
    Selection.NumberFormat = "0.0E+00"
    Columns("I:I").Select
    Selection.NumberFormat = "0.0"
    Columns("J:J").Select
    Selection.NumberFormat = "0.0000"
    Columns("L:N").Select
    Selection.NumberFormat = "0.0E+00"
    Columns("O:Q").Select
    Selection.NumberFormat = "0.00"
    Columns("S:S").Select
    Selection.NumberFormat = "0.000000"
    Columns("T:T").Select
    Selection.NumberFormat = "0.0E+00"
    Columns("u:u").Select
    Selection.NumberFormat = "0.0E+00"
    Cells.Select
    Selection.Columns.AutoFit

'sort
    Cells.Select
    ActiveWorkbook.Worksheets("Standards").Sort.SortFields.Clear
    ActiveWorkbook.Worksheets("Standards").Sort.SortFields.Add Key:=Range("E5:E1000" _
        ), SortOn:=xlSortOnValues, Order:=xlAscending, DataOption:=xlSortNormal
    With ActiveWorkbook.Worksheets("Standards").Sort
        .SetRange Range("B4:U1000")
        .Header = xlYes
        .MatchCase = False
        .Orientation = xlTopToBottom
        .SortMethod = xlPinYin
        .Apply
    End With
```

```
Range("A1").Select
End Sub
```

```
Sub sampleMove()
Const sampletype1 = "SampleType: SMP"
Dim wsSource As Worksheet
Dim wsDest As Worksheet
Dim NoRows As Long
Dim DestNoRows As Long
Dim i As Long
Dim rngCells As Range
Dim rngFind As Range

    Set wsSource = Worksheets("Combine sheet")

    NoRows = wsSource.Range("A65536").End(xlUp).Row
    DestNoRows = 5
    Set wsDest = ActiveWorkbook.Worksheets.Add

    For i = 1 To NoRows

        Set rngCells = wsSource.Range("B" & i)
        '84
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 4).Copy wsDest.Range("s" & DestNoRows)
        End If
        '86
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 6).Copy wsDest.Range("r" & DestNoRows)
        End If
        '87
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 7).Copy wsDest.Range("q" & DestNoRows)
        End If
        '82
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 2).Copy wsDest.Range("p" & DestNoRows)
        End If
        '83
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 3).Copy wsDest.Range("o" & DestNoRows)
        End If
        '85
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 5).Copy wsDest.Range("n" & DestNoRows)
        End If
        'background
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(50, 8).Copy wsDest.Range("l" & DestNoRows)
        End If
        '88
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 8).Copy wsDest.Range("k" & DestNoRows)
        End If
        'valid values
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(57, 10).Copy wsDest.Range("j" & DestNoRows)
        End If
        'standard error (ab)
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(54, 10).Copy wsDest.Range("i" & DestNoRows)
        End If
        '87/86
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(52, 10).Copy wsDest.Range("h" & DestNoRows)
        End If
        'run number
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
```

```
            rngCells.Offset(-8, 0).Copy wsDest.Range("e" & DestNoRows)
        End If
        'sample id
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-11, 0).Copy wsDest.Range("d" & DestNoRows)
        End If
        'time
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(47, 1).Copy wsDest.Range("c" & DestNoRows)
        End If
        'date
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-5, 0).Copy wsDest.Range("b" & DestNoRows)


            DestNoRows = DestNoRows + 1
        End If

    Next i

   ActiveSheet.Name = "Samples"
End Sub
```

```
Sub cleanupSamples()
'add headers
    Worksheets("Samples").Range("b4") = "Analysis Date"
    Worksheets("Samples").Range("c4") = "Time"
    Worksheets("Samples").Range("d4") = "Sample ID"
    Worksheets("Samples").Range("e4") = "Run Number"
    Worksheets("Samples").Range("f4") = "87Sr/86Sr normalized"
    Worksheets("Samples").Range("g4") = "2SD standards"
    Worksheets("Samples").Range("h4") = "87Sr/86Sr"
    Worksheets("Samples").Range("i4") = "Std Err (ab)"
    Worksheets("Samples").Range("j4") = "Valid Values"
    Worksheets("Samples").Range("k4") = "88Sr"
    Worksheets("Samples").Range("l4") = "88Sr bckgrnd"
    Worksheets("Samples").Range("n4") = "85Rb"
    Worksheets("Samples").Range("o4") = "83Kr"
    Worksheets("Samples").Range("p4") = "82Kr"
    Worksheets("Samples").Range("q4") = "87Sr"
    Worksheets("Samples").Range("r4") = "86Sr"
    Worksheets("Samples").Range("s4") = "84Sr"

'a1
Range("a1").Select
    With Selection
        .HorizontalAlignment = xlLeft
    End With
  Worksheets("Samples").Range("a1") = "NEPTUNE Sr Isotope Data: Samples"
  Range("a1").EntireRow.Font.Bold = True
'bold
   Range("A1").EntireRow.Font.Bold = True
'remove Analysis date:
   Columns("B:B").Select
    Selection.Replace What:="Analysis date:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
'remove Sample ID:
   Columns("D:D").Select
    Selection.Replace What:="Sample ID:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
'remove Run number:
   Columns("E:E").Select
    Selection.Replace What:="Run number:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
'center text
    Cells.Select
```

```
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = False
        .Orientation = 0
        .AddIndent = False
        .IndentLevel = 0
        .ShrinkToFit = False
        .ReadingOrder = xlContext
        .MergeCells = False
    End With
'format
    Columns("F:F").Select
    Selection.NumberFormat = "0.000000"
    Columns("G:G").Select
    Selection.NumberFormat = "0.0E+00"
    Columns("H:H").Select
    Selection.NumberFormat = "0.000000"
    Columns("I:I").Select
    Selection.NumberFormat = "0.0E+00"
    Columns("J:J").Select
    Selection.NumberFormat = "0"
    Columns("K:K").Select
    Selection.NumberFormat = "0.000000"
    Columns("L:L").Select
    Selection.NumberFormat = "0.0000"
    Columns("N:P").Select
    Selection.NumberFormat = "0.0E+00"
    Columns("Q:S").Select
    Selection.NumberFormat = "0.00"
    Cells.Select
    Selection.Columns.AutoFit

'sort
   Cells.Select
    ActiveWorkbook.Worksheets("Samples").Sort.SortFields.Clear
    ActiveWorkbook.Worksheets("Samples").Sort.SortFields.Add Key:=Range("E5:E1000" _
      ), SortOn:=xlSortOnValues, Order:=xlAscending, DataOption:=xlSortNormal
    With ActiveWorkbook.Worksheets("Samples").Sort
        .SetRange Range("B4:U1000")
        .Header = xlYes
        .MatchCase = False
        .Orientation = xlTopToBottom
        .SortMethod = xlPinYin
        .Apply
    End With
'normalized ratio
    Range("F5").Select
    ActiveCell.FormulaR1C1 = "=IF(RC[2]>0,RC[2]+Standards!R5C21)"
    Range("F5").Select
    Selection.AutoFill Destination:=Range("F5:F500"), Type:=xlFillDefault
    Range("F5:F182").Select
'inserts 2SD standards
    Range("G5").Select
    ActiveCell.FormulaR1C1 = "=IF(RC[1]>0,Standards!R5C20,)"
    Range("G5").Select
    Selection.Copy
    Range("G5:G500").Select
        Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
            :=False, Transpose:=False
        Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
            SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
            ReplaceFormat:=False

Range("A1").Select
End Sub
```

```
Sub assembleSamples()
Const sampletype1 = "SampleType: SMP"
```

```
Dim wsSource As Worksheet
Dim wsDest As Worksheet
Dim NoRows As Long
Dim DestNoRows As Long
Dim i As Long
Dim rngCells As Range
Dim rngFind As Range

    Set wsSource = Worksheets("Combine sheet")

    NoRows = wsSource.Range("A65536").End(xlUp).Row
    DestNoRows = 5
    Set wsDest = ActiveWorkbook.Worksheets.Add

    For i = 1 To NoRows

        Set rngCells = wsSource.Range("B" & i)


        'sample id
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-11, 0).Copy wsDest.Range("c" & 2)
                'remove Sample ID:
                Columns("c:c").Select
                Selection.Replace What:="Sample ID:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'date
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-5, 0).Copy wsDest.Range("b" & 4)
                'remove Analysis date:
                Columns("b:b").Select
                Selection.Replace What:="Analysis date:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'time
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(47, 1).Copy wsDest.Range("b" & 5)
        End If
        'run number
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-8, 0).Copy wsDest.Range("b" & 6)
                'remove Run number:
                Columns("b:b").Select
                Selection.Replace What:="Run number:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'File location
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-13, 0).Copy wsDest.Range("b" & 7)
            'remove file location:
                Columns("b:b").Select
                Selection.Replace What:="Filename:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'method name
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-10, 0).Copy wsDest.Range("b" & 8)
            'remove method name:
                Columns("b:b").Select
                Selection.Replace What:="Method Name:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'sample id
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
```

```
    rngCells.Offset(-11, 0).Copy wsDest.Range("f" & 4)
    'remove Sample ID: again
        Columns("f:f").Select
        Selection.Replace What:="Sample ID:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
End If
'operator
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(-3, 0).Copy wsDest.Range("f" & 5)
    'remove operator:
        Columns("f:f").Select
        Selection.Replace What:="Operator:", Replacement:="", LookAt:=xlPart _
        , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
End If
'valid values
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(57, 10).Copy wsDest.Range("f" & 6)
End If



'83Kr over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(2, 3).Resize(46, 1).Copy wsDest.Range("p" & 5)
End If
'85Rb over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(2, 5).Resize(46, 1).Copy wsDest.Range("o" & 5)
End If
'88Sr/86Sr over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(2, 11).Resize(46, 1).Copy wsDest.Range("m" & 5)

'CALC FOR 86/88
    Range("N6").Select
    ActiveCell.FormulaR1C1 = "=IF(RC[-1]>0,1/RC[-1],)"
    Range("N6").Select
    Selection.AutoFill Destination:=Range("N6:N50"), Type:=xlFillDefault
    Range("N6:N50").Select
    Selection.Copy
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
        SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
        ReplaceFormat:=False
End If
'88Sr over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(2, 8).Resize(46, 1).Copy wsDest.Range("l" & 5)
End If
'87/86 over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(2, 10).Resize(46, 1).Copy wsDest.Range("k" & 5)
End If
'cycle number
If Not (rngCells.Find(sampletype1) Is Nothing) Then
    rngCells.Offset(2, 0).Resize(46, 1).Copy wsDest.Range("j" & 5)

'entire sample set, run number
Range("Q6").Select
    ActiveCell.FormulaR1C1 = "=Samples!R[-1]C[-12]"
     Range("Q6").Select
    Selection.AutoFill Destination:=Range("Q6:Q500"), Type:=xlFillDefault
    Range("Q6:Q500").Select
    Selection.Copy
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
     :=False, Transpose:=False
    Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
```

```
            SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
              ReplaceFormat:=False
        'entire sample set, run number
        Range("R6").Select
          ActiveCell.FormulaR1C1 = "=Samples!R[-1]C[-6]"
           Range("R6").Select
          Selection.AutoFill Destination:=Range("R6:R500"), Type:=xlFillDefault
          Range("R6:R500").Select
          Selection.Copy
          Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
           :=False, Transpose:=False
          Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
           SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
             ReplaceFormat:=False
        End If
        '84
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 4).Copy wsDest.Range("o" & 2)
        End If
        '86
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 6).Copy wsDest.Range("n" & 2)
        End If
        '87
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 7).Copy wsDest.Range("m" & 2)
        End If
        '82
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 2).Copy wsDest.Range("l" & 2)
        End If
        '83
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 3).Copy wsDest.Range("k" & 2)
        End If
        '85
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 5).Copy wsDest.Range("j" & 2)
        End If


        '87/86
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 10).Copy wsDest.Range("c" & 13)
        End If
        'standard error (ab)
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(54, 10).Copy wsDest.Range("e" & 13)

    'calculations
        'Standard normalization
          Range("C11").Select
          ActiveCell.FormulaR1C1 = "=R[2]C+Standards!R[-6]C[18]"
          Range("E11").Select
        'pull 2SD of Standard measurement
          ActiveCell.FormulaR1C1 = "=Standards!R[-6]C[15]"
          Range("E12").Select

        End If
        '88
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(52, 8).Copy wsDest.Range("b" & 19)
        End If
        'background
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
          rngCells.Offset(50, 8).Copy wsDest.Range("b" & 20)

    'calculations
        '87/86 calc, no correction
        Range("C15").Select
```

```
        ActiveCell.FormulaR1C1 = "=(R[-13]C[10]/R[-13]C[11])/POWER(86.9089/85.9094,(LN((R[4]C[-1]/R[-
13]C[11])/8.375209)/LN(87.9056/85.9094)))"
        Range("C15").Select
    '87Sr Rb corr.
    Range("P2").Select
        ActiveCell.FormulaR1C1 = "=RC[-3]-(RC[-6]*(0.3857563))"
        Range("P2").Select
    '86Sr Kr corr.
    Range("Q2").Select
        ActiveCell.FormulaR1C1 = "=RC[-3]-(RC[-6]*(1.50434756))"
        Range("Q2").Select
    '87/86 calc, Rb+Kr corr:
    Range("C16").Select
        ActiveCell.FormulaR1C1 = "=(R[-14]C[13]/R[-14]C[14])/POWER(86.9089/85.9094,(LN((R[3]C[-1]/R[-
14]C[14])/8.375209)/LN(87.9056/85.9094)))"
        Range("C16").Select
    '87/86 calc, Rb only corr:
    Range("C17").Select
        ActiveCell.FormulaR1C1 = "=(R[-15]C[13]/R[-15]C[11])/POWER(86.9089/85.9094,(LN((R[2]C[-1]/R[-
15]C[11])/8.375209)/LN(87.9056/85.9094)))"
        Range("C17").Select
    'Rb correction ppm
    Range("G15").Select
        ActiveCell.FormulaR1C1 = "=ABS(R[2]C[-4]-RC[-4])/RC[-4]*1000000"
        Range("G15").Select
    'Kr correction ppm
    Range("G16").Select
        ActiveCell.FormulaR1C1 = "=(ABS(R[1]C[-4]-R[-1]C[-4])/R[1]C[-4]*1000000)-(ABS(RC[-4]-R[-1]C[-4])/RC[-4]*1000000)"
        Range("G15").Select
    'Signal to Background
    Range("B21").Select
        ActiveCell.FormulaR1C1 = "=R[-2]C/R[-1]C"
        Range("B21").Select
    '88 max
    Range("F19").Select
        ActiveCell.FormulaR1C1 = "=MAX(R[-13]C[6]:R[31]C[6])"
        Range("F19").Select
    '88 min
    Range("h19").Select
        ActiveCell.FormulaR1C1 = "=MIN(R[-13]C[4]:R[31]C[4])"
        Range("h19").Select
    '85 max
    Range("f20").Select
        ActiveCell.FormulaR1C1 = "=MAX(R[-14]C[9]:R[30]C[9])"
        Range("f20").Select
    '85 min
    Range("h20").Select
        ActiveCell.FormulaR1C1 = "=MIN(R[-14]C[7]:R[30]C[7])"
        Range("h20").Select
    '86/88 max
    Range("f21").Select
        ActiveCell.FormulaR1C1 = "=MAX(R[-15]C[8]:R[29]C[8])"
        Range("f21").Select
    '86/88 min
    Range("h21").Select
        ActiveCell.FormulaR1C1 = "=MIN(R[-15]C[6]:R[29]C[6])"
        Range("h21").Select
    '87/86 ave plot left
    Range("k51").Select
        ActiveCell.FormulaR1C1 = "=Average(R[-45]C:R[-1]C)"
        Range("k51").Select
    '87/86 ave plot right
    Range("k52").Select
        ActiveCell.FormulaR1C1 = "=Average(R[-46]C:R[-2]C)"
        Range("k52").Select
    '87/86 2sd left
    Range("k53").Select
        ActiveCell.FormulaR1C1 = "=2*STDEV(R[-47]C:R[-3]C)+R[-2]C"
        Range("k53").Select
    '87/86 2sd right
```

```
        Range("k54").Select
            ActiveCell.FormulaR1C1 = "=2*STDEV(R[-48]C:R[-4]C)+R[-3]C"
            Range("k54").Select
        '87/86 - 2sd left
        Range("k55").Select
            ActiveCell.FormulaR1C1 = "=R[-4]C-(2*STDEV(R[-49]C:R[-5]C))"
            Range("k55").Select
        '87/86 - 2sd right
        Range("k56").Select
            ActiveCell.FormulaR1C1 = "=R[-5]C-(2*STDEV(R[-50]C:R[-6]C))"
            Range("k56").Select

'Standard info for printout
    Range("A52").Select
    ActiveCell.FormulaR1C1 = "=Standards!R[-48]C[1]"
    Range("A52").Select
    Selection.AutoFill Destination:=Range("A52:G52"), Type:=xlFillDefault
    Range("A52:G52").Select
    Selection.AutoFill Destination:=Range("A52:G74"), Type:=xlFillDefault
    Range("A52:G74").Select
    Range("H52").Select
    ActiveCell.FormulaR1C1 = "=Standards!R[-48]C[1]"
    Range("H52").Select
    Selection.AutoFill Destination:=Range("H52:H74"), Type:=xlFillDefault
    Range("H52:H74").Select

        Range("a76").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("a76").Select
        Range("a77").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("a77").Select
        Range("b76").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("b76").Select
        Range("b77").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("b77").Select
        Range("c76").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("c76").Select
        Range("c77").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("c77").Select

'column row widths
Columns("a:a").Select
    Selection.columnWidth = 16.14
Columns("b:b").Select
    Selection.columnWidth = 12.43
Columns("c:c").Select
    Selection.columnWidth = 12.29
Columns("d:d").Select
    Selection.columnWidth = 5.57
Columns("e:e").Select
    Selection.columnWidth = 9
Columns("f:f").Select
    Selection.columnWidth = 12.71
Columns("g:g").Select
    Selection.columnWidth = 5.86
Columns("h:h").Select
    Selection.columnWidth = 8.71
Columns("i:i").Select
    Selection.columnWidth = 1.71
Columns("j:j").Select
    Selection.columnWidth = 14
Columns("k:k").Select
    Selection.columnWidth = 14
Columns("l:l").Select
    Selection.columnWidth = 14
```

```
Columns("m:m").Select
    Selection.columnWidth = 14
Columns("n:n").Select
    Selection.columnWidth = 14
Columns("o:o").Select
    Selection.columnWidth = 14
Columns("p:p").Select
    Selection.columnWidth = 14
Columns("q:q").Select
    Selection.columnWidth = 14
Columns("r:r").Select
    Selection.columnWidth = 14

Rows("1:1").Select
    Selection.rowHeight = 15.75
Rows("2:2").Select
    Selection.rowHeight = 15.75
Rows("3:3").Select
    Selection.rowHeight = 7.5
Rows("4:4").Select
    Selection.rowHeight = 15.75
Rows("11:11").Select
    Selection.rowHeight = 19
Rows("13:13").Select
    Selection.rowHeight = 17.25
Rows("22:22").Select
    Selection.rowHeight = 8.25

'add headers and lines
Cells.Select
With Selection
    .HorizontalAlignment = xlCenter
End With
'TOP
    'a1
    ActiveSheet.Range("a1") = "Neptune Sr Data Reduction"
    Range("a1").Select
    With Selection.Font
        .FontStyle = "Bold"
        .Size = 12
    End With
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    'a2
    ActiveSheet.Range("a2") = "Sample Name:"
    Range("a2").Select
    With Selection.Font
        .FontStyle = "Italic"
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    'b2 underline
    Range("B2:G2").Select
    With Selection.Borders(xlEdgeBottom)
        .LineStyle = xlContinuous
        .Weight = xlThin
    End With
    'c2
    Range("c2").Select
    With Selection.Font
        .FontStyle = "Bold"
        .Size = 12
    End With
   'a4
    ActiveSheet.Range("a4") = "Run Date:"
    Range("a4").Select
    With Selection.Font
        .FontStyle = "Italic"
```

```
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'b4 underline
Range("B4").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a5
ActiveSheet.Range("a5") = "Time:"
Range("a5").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'b5 underline
Range("B5").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a6
ActiveSheet.Range("a6") = "Run number:"
Range("a6").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'b6 underline
Range("B6").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'e4
ActiveSheet.Range("e4") = "Sample ID:"
Range("e4").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'f4 underline
Range("f4").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'e5
ActiveSheet.Range("e5") = "Operator:"
Range("e5").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'f5 underline
Range("f5").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
```

```
    'e6
    ActiveSheet.Range("e6") = "Valid Values:"
    Range("e6").Select
    With Selection.Font
       .FontStyle = "Italic"
    End With
    With Selection
       .HorizontalAlignment = xlRight
    End With
    'f6 underline
    Range("f6").Select
    With Selection.Borders(xlEdgeBottom)
       .LineStyle = xlContinuous
       .Weight = xlThin
    End With
   'a7
    ActiveSheet.Range("a7") = "File:"
    Range("a7").Select
    With Selection.Font
       .FontStyle = "Italic"
    End With
    With Selection
       .HorizontalAlignment = xlRight
    End With
    'a8
    ActiveSheet.Range("a8") = "Method Name:"
    Range("a8").Select
    With Selection.Font
       .FontStyle = "Italic"
    End With
    With Selection
       .HorizontalAlignment = xlRight
    End With
    'b7
    Range("b7").Select
    With Selection.Font
       .Size = 8
    End With
    With Selection
       .HorizontalAlignment = xlLeft
    End With
    'b8
    Range("b8").Select
    With Selection.Font
       .Size = 8
    End With
    With Selection
       .HorizontalAlignment = xlLeft
    End With
    'a9:a9 underline
    Range("a9:i9").Select
    With Selection.Borders(xlEdgeBottom)
       .LineStyle = xlContinuous
       .Weight = xlMedium
    End With
'RESULTS
    'a10
    ActiveSheet.Range("a10") = "RESULTS"
    Range("a10").Select
    With Selection.Font
       .FontStyle = "Bold"
       .Size = 11
    End With
    With Selection
       .HorizontalAlignment = xlLeft
    End With
    'b11
    ActiveSheet.Range("b11") = "87Sr/86Sr normilized to 0.71024:"
    Range("b11").Select
    With Selection.Font
```

```
    .FontStyle = "Bold Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'box
Range("C11:E11").Select
With Selection.Borders(xlEdgeLeft)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
With Selection.Borders(xlEdgeTop)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
With Selection.Borders(xlEdgeRight)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
'c11
Range("c11").Select
Selection.NumberFormat = "0.000000"
With Selection.Font
    .FontStyle = "Bold"
    .Size = 14
End With
'e11
Range("e11").Select
Selection.NumberFormat = "0.0E+00"
With Selection.Font
    .FontStyle = "Bold"
    .Size = 14
End With
'd11
ActiveSheet.Range("d11") = "±"
Range("d11").Select
'f11
ActiveSheet.Range("f11") = "2SD, see standard results on back"
Range("f11").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'b13
ActiveSheet.Range("b13") = "87Sr/86Sr as reported NEPTUNE:"
Range("b13").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
```

```
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c13
Range("c13").Select
Selection.NumberFormat = "0.000000"
'd13
ActiveSheet.Range("d13") = "±"
Range("d13").Select
'e13
Range("e13").Select
Selection.NumberFormat = "0.0E+00"
'f13
ActiveSheet.Range("f13") = "SE"
Range("f13").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'c13 underline
Range("c13:e13").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'b15
ActiveSheet.Range("b15") = "87Sr/86Sr calc, no correction:"
Range("b15").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c15 number and underline
Range("c15").Select
Selection.NumberFormat = "0.000000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'b16
ActiveSheet.Range("b16") = "87Sr/86Sr calc, Rb + Kr corr.:"
Range("b16").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
```

```
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c16 number and underline
Range("c16").Select
Selection.NumberFormat = "0.000000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'b17
ActiveSheet.Range("b17") = "87Sr/86Sr calc, Rb corr. only:"
Range("b17").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c17 number and underline
Range("c17").Select
Selection.NumberFormat = "0.000000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'f15
ActiveSheet.Range("f15") = "Rb correction"
Range("f15").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'g15 number and underline
Range("g15").Select
Selection.NumberFormat = "0.0"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'h15
ActiveSheet.Range("h15") = "ppm"
Range("h15").Select
With Selection
```

```
    .HorizontalAlignment = xlLeft
End With
'f16
ActiveSheet.Range("f16") = "Kr correction"
Range("f16").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'g16 number and underline
Range("g16").Select
Selection.NumberFormat = "0.00"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'h16
ActiveSheet.Range("h16") = "ppm"
Range("h16").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'a19
ActiveSheet.Range("a19") = "88Sr (V):"
Range("a19").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
'b19 number and underline
Range("b19").Select
Selection.NumberFormat = "0.00"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a20
ActiveSheet.Range("a20") = "88Sr background:"
Range("a20").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
'b20 number and underline
Range("b20").Select
Selection.NumberFormat = "0.000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
```

```
    End With
    'a21
    ActiveSheet.Range("a21") = "signal to bckgrnd"
    Range("a21").Select
    With Selection.Font
        .FontStyle = "Italic"
        .Size = 11
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
   'b21 number and underline
    Range("b21").Select
    Selection.NumberFormat = "0."
    With Selection.Borders(xlEdgeBottom)
        .LineStyle = xlContinuous
        .Weight = xlThin
    End With
    'e19
    ActiveSheet.Range("e19") = "88Sr max/min (V):"
    Range("e19").Select
    With Selection.Font
        .FontStyle = "Italic"
        .Size = 11
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    With ActiveCell.Characters(Start:=1, Length:=2).Font
        .Superscript = True
    End With
    With ActiveCell.Characters(Start:=3, Length:=3).Font
        .Superscript = False
    End With
    'f19 number and underline
    Range("f19").Select
    Selection.NumberFormat = "0.0"
    With Selection
        .HorizontalAlignment = xlRight
    End With
    Range("f19:h19").Select
    With Selection.Borders(xlEdgeBottom)
        .LineStyle = xlContinuous
        .Weight = xlThin
    End With
    Range("h19").Select
    Selection.NumberFormat = "0.0"
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    ActiveSheet.Range("g19") = "/"
    Range("g19").Select
    'e20
    ActiveSheet.Range("e20") = "88Rb max/min (V):"
    Range("e20").Select
    With Selection.Font
        .FontStyle = "Italic"
        .Size = 11
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    With ActiveCell.Characters(Start:=1, Length:=2).Font
        .Superscript = True
    End With
    With ActiveCell.Characters(Start:=3, Length:=3).Font
        .Superscript = False
    End With
    'f20 number and underline
    Range("f20").Select
```

```
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlRight
End With
Range("f20:h20").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
Range("h20").Select
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlLeft
End With
ActiveSheet.Range("g20") = "/"
Range("g20").Select
'e21
ActiveSheet.Range("e21") = "86Sr/88Sr max/min:"
Range("e21").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
 With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'f21 number and underline
Range("f21").Select
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlRight
End With
Range("f21:h21").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
Range("h21").Select
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlLeft
End With
ActiveSheet.Range("g21") = "/"
Range("g21").Select
'line
Range("a21:i21").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
'data labels
 ActiveSheet.Range("j1") = "85Rb"
 Range("j1").Select
 ActiveSheet.Range("k1") = "83Kr"
 Range("k1").Select
 ActiveSheet.Range("l1") = "82Kr"
 Range("l1").Select
 ActiveSheet.Range("m1") = "87Sr"
```

```
 Range("m1").Select
 ActiveSheet.Range("m1") = "87Sr"
 Range("m1").Select
 ActiveSheet.Range("n1") = "86Sr"
 Range("n1").Select
 ActiveSheet.Range("o1") = "84Sr"
 Range("o1").Select
 ActiveSheet.Range("p1") = "87Sr Rb corr."
 Range("p1").Select
 ActiveSheet.Range("q1") = "86Sr Kr corr."
 Range("q1").Select
 ActiveSheet.Range("n5") = "86/88"
 Range("n5").Select
 ActiveSheet.Range("q5") = "run number"
 Range("q5").Select
 ActiveSheet.Range("r5") = "88Sr background"
 Range("r5").Select
 ActiveSheet.Range("j51") = "0"
 Range("j51").Select
 ActiveSheet.Range("j52") = "45"
 Range("j52").Select
 ActiveSheet.Range("j53") = "0"
 Range("j53").Select
 ActiveSheet.Range("j54") = "45"
 Range("j54").Select
 ActiveSheet.Range("j55") = "0"
 Range("j55").Select
 ActiveSheet.Range("j56") = "45"
 Range("j56").Select
 ActiveSheet.Range("d51") = "run"
 Range("d51").Select
 ActiveSheet.Range("d52") = "#"
 Range("d52").Select
 ActiveSheet.Range("g51") = "valid"
 Range("d51").Select
 ActiveSheet.Range("g52") = "values"
 Range("d52").Select
 'a50
ActiveSheet.Range("a50") = "Standard Results"
Range("a50").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlLeft
End With
 ActiveSheet.Range("b50") = "(Neptune results, corrected for Rb, Kr, and mass bias)"
 Range("b50").Select
Range("a52:h52").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
Range("a76:c76").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
Range("d51:g51").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
Range("c76").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
Range("b50").Select
With Selection
```

```
        .HorizontalAlignment = xlLeft
    End With
    Range("e53:e74").Select
    Selection.NumberFormat = "0.000000"
    Range("f53:f74").Select
    Selection.NumberFormat = "0.0E+00"
    Range("h53:h74").Select
    Selection.NumberFormat = "0.0"
    Range("a77").Select
    Selection.NumberFormat = "0.000000"
    Range("b77").Select
    Selection.NumberFormat = "0.0E+00"
    Range("c77").Select
    Selection.NumberFormat = "0.00E+00"
    'a79
    ActiveSheet.Range("a79") = "88Sr background over entire analytical run"
    Range("a79").Select
    With Selection.Font
        .FontStyle = "Bold"
        .Size = 11
    End With
    With Selection
        .HorizontalAlignment = xlLeft
    End With
     'a23
    ActiveSheet.Range("a23") = "Corrected for mass fractionation, Rb, and Kr interference"
    Range("a23").Select
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    'b6 number format
    Range("b6").Select
    Selection.NumberFormat = "000."
'
'
'
'
'
Call Chart8786
Call ChartSr88V
Call ChartRb85V
Call ChartKr86V
Call ChartBckgrnd
ActiveSheet.PageSetup.PrintArea = "$A$1:$i$93"
Range("A1").Select
'rename

ActiveSheet.Name = Range("f4").Value & " " & Range("b6").Value


'add new worksheet and loop to top
        Set wsDest = ActiveWorkbook.Worksheets.Add
        DestNoRows = DestNoRows + 1

    End If


     Next i

End Sub
```

```
Sub assembleStandards()
Const sampletype1 = "SampleType: STD"
Dim wsSource As Worksheet
Dim wsDest As Worksheet
Dim NoRows As Long
Dim DestNoRows As Long
Dim i As Long
Dim rngCells As Range
```

```
Dim rngFind As Range

    Set wsSource = Worksheets("Combine sheet")

    NoRows = wsSource.Range("A65536").End(xlUp).Row
    DestNoRows = 5
    Set wsDest = ActiveWorkbook.Worksheets.Add

    For i = 1 To NoRows

        Set rngCells = wsSource.Range("B" & i)


        'sample id
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-11, 0).Copy wsDest.Range("c" & 2)
                'remove Sample ID:
                Columns("c:c").Select
                Selection.Replace What:="Sample ID:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'date
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-5, 0).Copy wsDest.Range("b" & 4)
                'remove Analysis date:
                Columns("b:b").Select
                Selection.Replace What:="Analysis date:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'time
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(47, 1).Copy wsDest.Range("b" & 5)
        End If
        'run number
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-8, 0).Copy wsDest.Range("b" & 6)
                'remove Run number:
                Columns("b:b").Select
                Selection.Replace What:="Run number:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'File location
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-13, 0).Copy wsDest.Range("b" & 7)
            'remove file location:
                Columns("b:b").Select
                Selection.Replace What:="Filename:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'method name
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-10, 0).Copy wsDest.Range("b" & 8)
            'remove method name:
                Columns("b:b").Select
                Selection.Replace What:="Method Name:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
        End If
        'sample id
        If Not (rngCells.Find(sampletype1) Is Nothing) Then
            rngCells.Offset(-11, 0).Copy wsDest.Range("f" & 4)
            'remove Sample ID: again
                Columns("f:f").Select
                Selection.Replace What:="Sample ID:", Replacement:="", LookAt:=xlPart _
                , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
                ReplaceFormat:=False
```

```
End If
'operator
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(-3, 0).Copy wsDest.Range("f" & 5)
   'remove operator:
      Columns("f:f").Select
      Selection.Replace What:="Operator:", Replacement:="", LookAt:=xlPart _
      , SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
      ReplaceFormat:=False
End If
'valid values
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(56, 10).Copy wsDest.Range("f" & 6)
End If



'83Kr over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(2, 3).Resize(46, 1).Copy wsDest.Range("p" & 5)
End If
'85Rb over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(2, 5).Resize(46, 1).Copy wsDest.Range("o" & 5)
End If
'88Sr/86Sr over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(2, 11).Resize(46, 1).Copy wsDest.Range("m" & 5)

'CALC FOR 86/88
   Range("N6").Select
   ActiveCell.FormulaR1C1 = "=IF(RC[-1]>0,1/RC[-1],)"
   Range("N6").Select
   Selection.AutoFill Destination:=Range("N6:N50"), Type:=xlFillDefault
   Range("N6:N50").Select
   Selection.Copy
   Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
      :=False, Transpose:=False
   Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
      SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
      ReplaceFormat:=False
End If
'88Sr over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(2, 8).Resize(46, 1).Copy wsDest.Range("l" & 5)
End If
'87/86 over time
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(2, 10).Resize(46, 1).Copy wsDest.Range("k" & 5)
End If
'cycle number
If Not (rngCells.Find(sampletype1) Is Nothing) Then
   rngCells.Offset(2, 0).Resize(46, 1).Copy wsDest.Range("j" & 5)

'entire sample set, run number
Range("Q6").Select
   ActiveCell.FormulaR1C1 = "=Samples!R[-1]C[-12]"
    Range("Q6").Select
   Selection.AutoFill Destination:=Range("Q6:Q500"), Type:=xlFillDefault
   Range("Q6:Q500").Select
   Selection.Copy
   Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
    :=False, Transpose:=False
   Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
    SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
      ReplaceFormat:=False
'entire sample set, run number
Range("R6").Select
   ActiveCell.FormulaR1C1 = "=Samples!R[-1]C[-6]"
    Range("R6").Select
```

```
        Selection.AutoFill Destination:=Range("R6:R500"), Type:=xlFillDefault
        Range("R6:R500").Select
        Selection.Copy
        Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
         :=False, Transpose:=False
        Selection.Replace What:="0", Replacement:="", LookAt:=xlWhole, _
         SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
           ReplaceFormat:=False
    End If
    '84
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 4).Copy wsDest.Range("o" & 2)
    End If
    '86
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 6).Copy wsDest.Range("n" & 2)
    End If
    '87
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 7).Copy wsDest.Range("m" & 2)
    End If
    '82
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 2).Copy wsDest.Range("l" & 2)
    End If
    '83
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 3).Copy wsDest.Range("k" & 2)
    End If
    '85
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 5).Copy wsDest.Range("j" & 2)
    End If


    '87/86
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 10).Copy wsDest.Range("c" & 13)
    End If
    'standard error (ab)
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(53, 10).Copy wsDest.Range("e" & 13)

'calculations
    'Standard normalization
        Range("C11").Select
        ActiveCell.FormulaR1C1 = "=R[2]C+Standards!R[-6]C[18]"
        Range("E11").Select
    'pull 2SD of Standard measurement
        ActiveCell.FormulaR1C1 = "=Standards!R[-6]C[15]"
        Range("E12").Select

    End If
    '88
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(51, 8).Copy wsDest.Range("b" & 19)
    End If
    'background
    If Not (rngCells.Find(sampletype1) Is Nothing) Then
        rngCells.Offset(50, 8).Copy wsDest.Range("b" & 20)

'calculations
    '87/86 calc, no correction
    Range("C15").Select
        ActiveCell.FormulaR1C1 = "=(R[-13]C[10]/R[-13]C[11])/POWER(86.9089/85.9094,(LN((R[4]C[-1]/R[-
13]C[11])/8.375209)/LN(87.9056/85.9094)))"
        Range("C15").Select
    '87Sr Rb corr.
    Range("P2").Select
        ActiveCell.FormulaR1C1 = "=RC[-3]-(RC[-6]*(0.3857563))"
```

```
        Range("P2").Select
    '86Sr Kr corr.
    Range("Q2").Select
        ActiveCell.FormulaR1C1 = "=RC[-3]-(RC[-6]*(1.50434756))"
        Range("Q2").Select
    '87/86 calc, Rb+Kr corr:
    Range("C16").Select
        ActiveCell.FormulaR1C1 = "=(R[-14]C[13]/R[-14]C[14])/POWER(86.9089/85.9094,(LN((R[3]C[-1]/R[-
14]C[14])/8.375209)/LN(87.9056/85.9094)))"
        Range("C16").Select
    '87/86 calc, Rb only corr:
    Range("C17").Select
        ActiveCell.FormulaR1C1 = "=(R[-15]C[13]/R[-15]C[11])/POWER(86.9089/85.9094,(LN((R[2]C[-1]/R[-
15]C[11])/8.375209)/LN(87.9056/85.9094)))"
        Range("C17").Select
    'Rb correction ppm
    Range("G15").Select
        ActiveCell.FormulaR1C1 = "=ABS(R[2]C[-4]-RC[-4])/RC[-4]*1000000"
        Range("G15").Select
    'Kr correction ppm
    Range("G16").Select
        ActiveCell.FormulaR1C1 = "=(ABS(R[1]C[-4]-R[-1]C[-4])/R[1]C[-4]*1000000)-(ABS(RC[-4]-R[-1]C[-4])/RC[-4]*1000000)"
        Range("G15").Select
    'Signal to Background
    Range("B21").Select
        ActiveCell.FormulaR1C1 = "=R[-2]C/R[-1]C"
        Range("B21").Select
    '88 max
    Range("F19").Select
        ActiveCell.FormulaR1C1 = "=MAX(R[-13]C[6]:R[31]C[6])"
        Range("F19").Select
    '88 min
    Range("h19").Select
        ActiveCell.FormulaR1C1 = "=MIN(R[-13]C[4]:R[31]C[4])"
        Range("h19").Select
    '85 max
    Range("f20").Select
        ActiveCell.FormulaR1C1 = "=MAX(R[-14]C[9]:R[30]C[9])"
        Range("f20").Select
    '85 min
    Range("h20").Select
        ActiveCell.FormulaR1C1 = "=MIN(R[-14]C[7]:R[30]C[7])"
        Range("h20").Select
    '86/88 max
    Range("f21").Select
        ActiveCell.FormulaR1C1 = "=MAX(R[-15]C[8]:R[29]C[8])"
        Range("f21").Select
    '86/88 min
    Range("h21").Select
        ActiveCell.FormulaR1C1 = "=MIN(R[-15]C[6]:R[29]C[6])"
        Range("h21").Select
    '87/86 ave plot left
    Range("k51").Select
        ActiveCell.FormulaR1C1 = "=Average(R[-45]C:R[-1]C)"
        Range("k51").Select
    '87/86 ave plot right
    Range("k52").Select
        ActiveCell.FormulaR1C1 = "=Average(R[-46]C:R[-2]C)"
        Range("k52").Select
    '87/86 2sd left
    Range("k53").Select
        ActiveCell.FormulaR1C1 = "=2*STDEV(R[-47]C:R[-3]C)+R[-2]C"
        Range("k53").Select
    '87/86 2sd right
    Range("k54").Select
        ActiveCell.FormulaR1C1 = "=2*STDEV(R[-48]C:R[-4]C)+R[-3]C"
        Range("k54").Select
    '87/86 - 2sd left
    Range("k55").Select
        ActiveCell.FormulaR1C1 = "=R[-4]C-(2*STDEV(R[-49]C:R[-5]C))"
```

```
        Range("k55").Select
    '87/86 - 2sd right
    Range("k56").Select
        ActiveCell.FormulaR1C1 = "=R[-5]C-(2*STDEV(R[-50]C:R[-6]C))"
        Range("k56").Select

'Standard info for printout
    Range("A52").Select
    ActiveCell.FormulaR1C1 = "=Standards!R[-48]C[1]"
    Range("A52").Select
    Selection.AutoFill Destination:=Range("A52:G52"), Type:=xlFillDefault
    Range("A52:G52").Select
    Selection.AutoFill Destination:=Range("A52:G74"), Type:=xlFillDefault
    Range("A52:G74").Select
    Range("H52").Select
    ActiveCell.FormulaR1C1 = "=Standards!R[-48]C[1]"
    Range("H52").Select
    Selection.AutoFill Destination:=Range("H52:H74"), Type:=xlFillDefault
    Range("H52:H74").Select

        Range("a76").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("a76").Select
        Range("a77").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("a77").Select
        Range("b76").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("b76").Select
        Range("b77").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("b77").Select
        Range("c76").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("c76").Select
        Range("c77").Select
            ActiveCell.FormulaR1C1 = "=Standards!R[-72]C[18]"
            Range("c77").Select

'column row widths
Columns("a:a").Select
    Selection.columnWidth = 16.14
Columns("b:b").Select
    Selection.columnWidth = 12.43
Columns("c:c").Select
    Selection.columnWidth = 12.29
Columns("d:d").Select
    Selection.columnWidth = 5.57
Columns("e:e").Select
    Selection.columnWidth = 9
Columns("f:f").Select
    Selection.columnWidth = 12.71
Columns("g:g").Select
    Selection.columnWidth = 5.86
Columns("h:h").Select
    Selection.columnWidth = 8.71
Columns("i:i").Select
    Selection.columnWidth = 1.71
Columns("j:j").Select
    Selection.columnWidth = 14
Columns("k:k").Select
    Selection.columnWidth = 14
Columns("l:l").Select
    Selection.columnWidth = 14
Columns("m:m").Select
    Selection.columnWidth = 14
Columns("n:n").Select
    Selection.columnWidth = 14
Columns("o:o").Select
    Selection.columnWidth = 14
```

```
Columns("p:p").Select
    Selection.columnWidth = 14
Columns("q:q").Select
    Selection.columnWidth = 14
Columns("r:r").Select
    Selection.columnWidth = 14

Rows("1:1").Select
    Selection.rowHeight = 15.75
Rows("2:2").Select
    Selection.rowHeight = 15.75
Rows("3:3").Select
    Selection.rowHeight = 7.5
Rows("4:4").Select
    Selection.rowHeight = 15.75
Rows("11:11").Select
    Selection.rowHeight = 19
Rows("13:13").Select
    Selection.rowHeight = 17.25
Rows("22:22").Select
    Selection.rowHeight = 8.25

'add headers and lines
Cells.Select
With Selection
    .HorizontalAlignment = xlCenter
End With
'TOP
    'a1
    ActiveSheet.Range("a1") = "Neptune Sr Data Reduction"
    Range("a1").Select
    With Selection.Font
        .FontStyle = "Bold"
        .Size = 12
    End With
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    'a2
    ActiveSheet.Range("a2") = "Sample Name:"
    Range("a2").Select
    With Selection.Font
        .FontStyle = "Italic"
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    'b2 underline
    Range("B2:G2").Select
    With Selection.Borders(xlEdgeBottom)
        .LineStyle = xlContinuous
        .Weight = xlThin
    End With
    'c2
    Range("c2").Select
    With Selection.Font
        .FontStyle = "Bold"
        .Size = 12
    End With
   'a4
    ActiveSheet.Range("a4") = "Run Date:"
    Range("a4").Select
    With Selection.Font
        .FontStyle = "Italic"
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    'b4 underline
    Range("B4").Select
```

```
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a5
ActiveSheet.Range("a5") = "Time:"
Range("a5").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'b5 underline
Range("B5").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a6
ActiveSheet.Range("a6") = "Run number:"
Range("a6").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'b6 underline
Range("B6").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'e4
ActiveSheet.Range("e4") = "Sample ID:"
Range("e4").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'f4 underline
Range("f4").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'e5
ActiveSheet.Range("e5") = "Operator:"
Range("e5").Select
With Selection.Font
    .FontStyle = "Italic"
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'f5 underline
Range("f5").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'e6
ActiveSheet.Range("e6") = "Valid Values:"
Range("e6").Select
With Selection.Font
    .FontStyle = "Italic"
End With
```

```
    With Selection
        .HorizontalAlignment = xlRight
    End With
    'f6 underline
    Range("f6").Select
    With Selection.Borders(xlEdgeBottom)
        .LineStyle = xlContinuous
        .Weight = xlThin
    End With
   'a7
    ActiveSheet.Range("a7") = "File:"
    Range("a7").Select
    With Selection.Font
        .FontStyle = "Italic"
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    'a8
    ActiveSheet.Range("a8") = "Method Name:"
    Range("a8").Select
    With Selection.Font
        .FontStyle = "Italic"
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
    'b7
    Range("b7").Select
    With Selection.Font
        .Size = 8
    End With
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    'b8
    Range("b8").Select
    With Selection.Font
        .Size = 8
    End With
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    'a9:a9 underline
    Range("a9:i9").Select
    With Selection.Borders(xlEdgeBottom)
        .LineStyle = xlContinuous
        .Weight = xlMedium
    End With
'RESULTS
    'a10
    ActiveSheet.Range("a10") = "RESULTS"
    Range("a10").Select
    With Selection.Font
        .FontStyle = "Bold"
        .Size = 11
    End With
    With Selection
        .HorizontalAlignment = xlLeft
    End With
    'b11
    ActiveSheet.Range("b11") = "87Sr/86Sr normilized to 0.71024:"
    Range("b11").Select
    With Selection.Font
        .FontStyle = "Bold Italic"
        .Size = 11
    End With
    With Selection
        .HorizontalAlignment = xlRight
    End With
```

```
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'box
Range("C11:E11").Select
With Selection.Borders(xlEdgeLeft)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
With Selection.Borders(xlEdgeTop)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
With Selection.Borders(xlEdgeRight)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
'c11
Range("c11").Select
Selection.NumberFormat = "0.000000"
With Selection.Font
    .FontStyle = "Bold"
    .Size = 14
End With
'e11
Range("e11").Select
Selection.NumberFormat = "0.0E+00"
With Selection.Font
    .FontStyle = "Bold"
    .Size = 14
End With
'd11
ActiveSheet.Range("d11") = "±"
Range("d11").Select
'f11
ActiveSheet.Range("f11") = "2SD, see standard results on back"
Range("f11").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'b13
ActiveSheet.Range("b13") = "87Sr/86Sr as reported NEPTUNE:"
Range("b13").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
```

```
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c13
Range("c13").Select
Selection.NumberFormat = "0.000000"
'd13
ActiveSheet.Range("d13") = "±"
Range("d13").Select
'e13
Range("e13").Select
Selection.NumberFormat = "0.0E+00"
'f13
ActiveSheet.Range("f13") = "SE"
Range("f13").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'c13 underline
Range("c13:e13").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'b15
ActiveSheet.Range("b15") = "87Sr/86Sr calc, no correction:"
Range("b15").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c15 number and underline
Range("c15").Select
Selection.NumberFormat = "0.000000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'b16
ActiveSheet.Range("b16") = "87Sr/86Sr calc, Rb + Kr corr.:"
Range("b16").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
```

```
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c16 number and underline
Range("c16").Select
Selection.NumberFormat = "0.000000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'b17
ActiveSheet.Range("b17") = "87Sr/86Sr calc, Rb corr. only:"
Range("b17").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'c17 number and underline
Range("c17").Select
Selection.NumberFormat = "0.000000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'f15
ActiveSheet.Range("f15") = "Rb correction"
Range("f15").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'g15 number and underline
Range("g15").Select
Selection.NumberFormat = "0.0"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'h15
ActiveSheet.Range("h15") = "ppm"
Range("h15").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'f16
ActiveSheet.Range("f16") = "Kr correction"
Range("f16").Select
With Selection.Font
```

```
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
'g16 number and underline
Range("g16").Select
Selection.NumberFormat = "0.00"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'h16
ActiveSheet.Range("h16") = "ppm"
Range("h16").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
'a19
ActiveSheet.Range("a19") = "88Sr (V):"
Range("a19").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
'b19 number and underline
Range("b19").Select
Selection.NumberFormat = "0.00"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a20
ActiveSheet.Range("a20") = "88Sr background:"
Range("a20").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
'b20 number and underline
Range("b20").Select
Selection.NumberFormat = "0.000"
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
'a21
ActiveSheet.Range("a21") = "signal to bckgrnd"
Range("a21").Select
With Selection.Font
    .FontStyle = "Italic"
```

```
    .Size = 11
  End With
  With Selection
    .HorizontalAlignment = xlRight
  End With
 'b21 number and underline
  Range("b21").Select
  Selection.NumberFormat = "0."
  With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
  End With
  'e19
  ActiveSheet.Range("e19") = "88Sr max/min (V):"
  Range("e19").Select
  With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
  End With
  With Selection
    .HorizontalAlignment = xlRight
  End With
  With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
  End With
  With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
  End With
  'f19 number and underline
  Range("f19").Select
  Selection.NumberFormat = "0.0"
  With Selection
    .HorizontalAlignment = xlRight
  End With
  Range("f19:h19").Select
  With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
  End With
  Range("h19").Select
  Selection.NumberFormat = "0.0"
  With Selection
    .HorizontalAlignment = xlLeft
  End With
  ActiveSheet.Range("g19") = "/"
  Range("g19").Select
  'e20
  ActiveSheet.Range("e20") = "88Rb max/min (V):"
  Range("e20").Select
  With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
  End With
  With Selection
    .HorizontalAlignment = xlRight
  End With
  With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
  End With
  With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
  End With
  'f20 number and underline
  Range("f20").Select
  Selection.NumberFormat = "0.000000"
  With Selection
    .HorizontalAlignment = xlRight
  End With
  Range("f20:h20").Select
  With Selection.Borders(xlEdgeBottom)
```

```
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
Range("h20").Select
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlLeft
End With
ActiveSheet.Range("g20") = "/"
Range("g20").Select
'e21
ActiveSheet.Range("e21") = "86Sr/88Sr max/min:"
Range("e21").Select
With Selection.Font
    .FontStyle = "Italic"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlRight
End With
 With ActiveCell.Characters(Start:=1, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=3, Length:=3).Font
    .Superscript = False
End With
With ActiveCell.Characters(Start:=6, Length:=2).Font
    .Superscript = True
End With
With ActiveCell.Characters(Start:=8, Length:=3).Font
    .Superscript = False
End With
'f21 number and underline
Range("f21").Select
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlRight
End With
Range("f21:h21").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlThin
End With
Range("h21").Select
Selection.NumberFormat = "0.000000"
With Selection
    .HorizontalAlignment = xlLeft
End With
ActiveSheet.Range("g21") = "/"
Range("g21").Select
'line
Range("a21:i21").Select
With Selection.Borders(xlEdgeBottom)
    .LineStyle = xlContinuous
    .Weight = xlMedium
End With
'data labels
 ActiveSheet.Range("j1") = "85Rb"
 Range("j1").Select
 ActiveSheet.Range("k1") = "83Kr"
 Range("k1").Select
 ActiveSheet.Range("l1") = "82Kr"
 Range("l1").Select
 ActiveSheet.Range("m1") = "87Sr"
 Range("m1").Select
 ActiveSheet.Range("m1") = "87Sr"
 Range("m1").Select
 ActiveSheet.Range("n1") = "86Sr"
 Range("n1").Select
 ActiveSheet.Range("o1") = "84Sr"
```

```
 Range("o1").Select
 ActiveSheet.Range("p1") = "87Sr Rb corr."
 Range("p1").Select
 ActiveSheet.Range("q1") = "86Sr Kr corr."
 Range("q1").Select
 ActiveSheet.Range("n5") = "86/88"
 Range("n5").Select
 ActiveSheet.Range("q5") = "run number"
 Range("q5").Select
 ActiveSheet.Range("r5") = "88Sr background"
 Range("r5").Select
 ActiveSheet.Range("j51") = "0"
 Range("j51").Select
 ActiveSheet.Range("j52") = "45"
 Range("j52").Select
 ActiveSheet.Range("j53") = "0"
 Range("j53").Select
 ActiveSheet.Range("j54") = "45"
 Range("j54").Select
 ActiveSheet.Range("j55") = "0"
 Range("j55").Select
 ActiveSheet.Range("j56") = "45"
 Range("j56").Select
 ActiveSheet.Range("d51") = "run"
 Range("d51").Select
 ActiveSheet.Range("d52") = "#"
 Range("d52").Select
 ActiveSheet.Range("g51") = "valid"
 Range("d51").Select
 ActiveSheet.Range("g52") = "values"
 Range("d52").Select
 'a50
ActiveSheet.Range("a50") = "Standard Results"
Range("a50").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
With Selection
    .HorizontalAlignment = xlLeft
End With
 ActiveSheet.Range("b50") = "(Neptune results, corrected for Rb, Kr, and mass bias)"
 Range("b50").Select
Range("a52:h52").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
Range("a76:c76").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
Range("d51:g51").Select
With Selection.Font
    .FontStyle = "Bold"
    .Size = 11
End With
Range("c76").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
Range("b50").Select
With Selection
    .HorizontalAlignment = xlLeft
End With
Range("e53:e74").Select
Selection.NumberFormat = "0.000000"
Range("f53:f74").Select
Selection.NumberFormat = "0.0E+00"
```

```
    Range("h53:h74").Select
    Selection.NumberFormat = "0.0"
    Range("a77").Select
    Selection.NumberFormat = "0.000000"
    Range("b77").Select
    Selection.NumberFormat = "0.0E+00"
    Range("c77").Select
    Selection.NumberFormat = "0.00E+00"
    'a79
    ActiveSheet.Range("a79") = "88Sr background over entire analytical run"
    Range("a79").Select
    With Selection.Font
       .FontStyle = "Bold"
       .Size = 11
    End With
    With Selection
       .HorizontalAlignment = xlLeft
    End With
     'a23
    ActiveSheet.Range("a23") = "Corrected for mass fractionation, Rb, and Kr interference"
    Range("a23").Select
    With Selection
       .HorizontalAlignment = xlLeft
    End With
    'b6 number format
    Range("b6").Select
    Selection.NumberFormat = "000."
'
'
'
'
'
Call Chart8786
Call ChartSr88V
Call ChartRb85V
Call ChartKr86V
Call ChartBckgrnd
ActiveSheet.PageSetup.PrintArea = "$A$1:$i$93"
Range("A1").Select
'rename

ActiveSheet.Name = Range("f4").Value & " " & Range("b6").Value


'add new worksheet and loop to top
       Set wsDest = ActiveWorkbook.Worksheets.Add
       DestNoRows = DestNoRows + 1

    End If


     Next i

End Sub
```

```
Sub removeEmpty()

Dim ws As Worksheet
For Each ws In Worksheets
    If ws.Range("A1").Value = "" Then
       Application.DisplayAlerts = False
       ws.Delete
       Application.DisplayAlerts = True
    End If
Next ws

End Sub
```

```
Sub SortSheets()
Dim lCount As Long, lCounted As Long
Dim lShtLast As Long
Dim lReply As Long

lShtLast = Sheets.Count

      For lCount = 1 To lShtLast
         For lCount2 = lCount To lShtLast
            If UCase(Sheets(lCount2).Range("B5")) < UCase(Sheets(lCount).Range("B5")) Then
               Sheets(lCount2).Move Before:=Sheets(lCount)
            End If

         Next lCount2
      Next lCount
'select 3rd worksheet as active
   Sheets(3).Select
   Range("A1").Select
End Sub
```

```
Sub activateSheets()
'
'Activate Sheets
Dim i As Long
ActiveSheet.Select
For i = 2 To ThisWorkbook.Sheets.Count
   If Sheets(i).Name <> "Combine Sheet" And Sheets(i).Name <> "Standards" And Sheets(i).Name <> "Samples" Then Sheets(i).Select
Replace:=False
Next i

End Sub
```

```
Sub Chart8786()
   Dim oChtObj As ChartObject
   Set oChtObj = ActiveSheet.ChartObjects.Add(Left:=0, Width:=465, Top:=355, Height:=105)

With oChtObj.Chart
   .ChartType = xlXYScatter
   .SetSourceData Source:=ActiveSheet.Range("j6:k56")
   .SeriesCollection(1).XValues = Range("j6:j50")
   .SeriesCollection(1).Values = Range("k6:k50")
   .SeriesCollection(1).Name = "ratio"
      'format
      '.SeriesCollection(1).Border.ColorIndex = 1
      '.SeriesCollection(1).Border.Weight = xlThin
      '.SeriesCollection(1).Border.LineStyle = xlNone
      '.SeriesCollection(1).MarkerBackgroundColorIndex = 5
      .SeriesCollection(1).MarkerForegroundColorIndex = 1
      .SeriesCollection(1).MarkerStyle = xlCircle
      .SeriesCollection(1).MarkerSize = 6
   'newseries
   .SeriesCollection.NewSeries
   .SeriesCollection(2).XValues = Range("j51:j52")
   .SeriesCollection(2).Values = Range("k51:k52")
   .SeriesCollection(2).Name = "mean"
      'format
      .SeriesCollection(2).Border.ColorIndex = 1
      .SeriesCollection(2).Border.Weight = xlMedium
      .SeriesCollection(2).Border.LineStyle = xlDash
      '.SeriesCollection(2).MarkerBackgroundColorIndex = 5
      '.SeriesCollection(2).MarkerForegroundColorIndex = 1
      .SeriesCollection(2).MarkerStyle = xlNone
      '.SeriesCollection(2).MarkerSize = 6
   'newseries
   .SeriesCollection.NewSeries
   .SeriesCollection(3).XValues = Range("j53:j54")
```

```
    .SeriesCollection(3).Values = Range("k53:k54")
    .SeriesCollection(3).Name = "+ 2 sigma"
       'format
       .SeriesCollection(3).Border.ColorIndex = 1
       .SeriesCollection(3).Border.Weight = xlThin
       .SeriesCollection(3).Border.LineStyle = xlDot
       '.SeriesCollection(3).MarkerBackgroundColorIndex = 5
       '.SeriesCollection(3).MarkerForegroundColorIndex = 1
       .SeriesCollection(3).MarkerStyle = xlNone
       '.SeriesCollection(3).MarkerSize = 6
    'newseries
    .SeriesCollection.NewSeries
    .SeriesCollection(4).XValues = Range("j55:j56")
    .SeriesCollection(4).Values = Range("k55:k56")
    .SeriesCollection(4).Name = "- 2 sigma"
       'format
       .SeriesCollection(4).Border.ColorIndex = 1
       .SeriesCollection(4).Border.Weight = xlThin
       .SeriesCollection(4).Border.LineStyle = xlDot
       '.SeriesCollection(4).MarkerBackgroundColorIndex = 5
       '.SeriesCollection(4).MarkerForegroundColorIndex = 1
       .SeriesCollection(4).MarkerStyle = xlNone
       '.SeriesCollection(4).MarkerSize = 6


    .HasLegend = True
    .HasTitle = False
    .Axes(xlValue).TickLabels.NumberFormat = "0.00000"
    .Axes(xlValue).HasMajorGridlines = False
    .Axes(xlCategory).MinimumScale = 0
    .Axes(xlCategory).MaximumScale = 45

End With

Set oRange = Nothing
Set oChtObj = Nothing

End Sub
```

```
Sub ChartSr88V()
    Dim oChtObj As ChartObject
    Set oChtObj = ActiveSheet.ChartObjects.Add(Left:=0, Width:=465, Top:=461, Height:=105)

With oChtObj.Chart
    .ChartType = xlXYScatter
    .SetSourceData Source:=ActiveSheet.Range("j6:j50, l6:l50")
    .SeriesCollection(1).XValues = Range("j6:j50")
    .SeriesCollection(1).Values = Range("l6:l50")
    .SeriesCollection(1).Name = "88Sr(V)"
       'format
       .SeriesCollection(1).Border.ColorIndex = 3
       .SeriesCollection(1).Border.Weight = xlThick
       .SeriesCollection(1).Border.LineStyle = xlSolid
       '.SeriesCollection(1).MarkerBackgroundColorIndex = 5
       '.SeriesCollection(1).MarkerForegroundColorIndex = 1
       .SeriesCollection(1).MarkerStyle = xlNone
       '.SeriesCollection(1).MarkerSize = 6


    .HasLegend = True
    .HasTitle = True
    .HasTitle = False
    .Axes(xlValue).TickLabels.NumberFormat = "0.0"
    .Axes(xlValue).HasMajorGridlines = False
    .Axes(xlCategory).MinimumScale = 0
    .Axes(xlCategory).MaximumScale = 45

End With
```

```
Set oRange = Nothing
Set oChtObj = Nothing

End Sub
```

```
Sub ChartRb85V()
   Dim oChtObj As ChartObject
   Set oChtObj = ActiveSheet.ChartObjects.Add(Left:=0, Width:=465, Top:=568, Height:=80)

With oChtObj.Chart
   .ChartType = xlXYScatter
   .SetSourceData Source:=ActiveSheet.Range("j6:j50, o6:o50")
   .SeriesCollection(1).XValues = Range("j6:j50")
   .SeriesCollection(1).Values = Range("o6:o50")
   .SeriesCollection(1).Name = "85Rb(V)"
      'format
      .SeriesCollection(1).Border.ColorIndex = 4
      .SeriesCollection(1).Border.Weight = xlThick
      .SeriesCollection(1).Border.LineStyle = xlSolid
      '.SeriesCollection(1).MarkerBackgroundColorIndex = 5
      '.SeriesCollection(1).MarkerForegroundColorIndex = 1
      .SeriesCollection(1).MarkerStyle = xlNone
      '.SeriesCollection(1).MarkerSize = 6


   .HasLegend = True
   .HasTitle = True
   .HasTitle = False
   .Axes(xlValue).TickLabels.NumberFormat = "0.00000"
   .Axes(xlValue).HasMajorGridlines = False
   .Axes(xlCategory).MinimumScale = 0
   .Axes(xlCategory).MaximumScale = 45

End With

Set oRange = Nothing
Set oChtObj = Nothing


End Sub
```

```
Sub ChartKr86V()
   Dim oChtObj As ChartObject
   Set oChtObj = ActiveSheet.ChartObjects.Add(Left:=0, Width:=465, Top:=649, Height:=62)

With oChtObj.Chart
   .ChartType = xlXYScatter
   .SetSourceData Source:=ActiveSheet.Range("j6:j50, o6:o50")
   .SeriesCollection(1).XValues = Range("j6:j50")
   .SeriesCollection(1).Values = Range("o6:o50")
   .SeriesCollection(1).Name = "86 Kr(V)"
      'format
      .SeriesCollection(1).Border.ColorIndex = 44
      .SeriesCollection(1).Border.Weight = xlThick
      .SeriesCollection(1).Border.LineStyle = xlSolid
      '.SeriesCollection(1).MarkerBackgroundColorIndex = 5
      '.SeriesCollection(1).MarkerForegroundColorIndex = 1
      .SeriesCollection(1).MarkerStyle = xlNone
      '.SeriesCollection(1).MarkerSize = 6


   .HasLegend = True
   .HasTitle = True
   .HasTitle = False
   .Axes(xlValue).TickLabels.NumberFormat = "0.00000"
   .Axes(xlValue).HasMajorGridlines = False
   .Axes(xlCategory).MinimumScale = 0
```

```
    .Axes(xlCategory).MaximumScale = 45

End With

Set oRange = Nothing
Set oChtObj = Nothing

End Sub
```

```
Sub ChartBckgrnd()
    Dim oChtObj As ChartObject
    Set oChtObj = ActiveSheet.ChartObjects.Add(Left:=0, Width:=465, Top:=1200, Height:=105)

With oChtObj.Chart
    .ChartType = xlXYScatter
    .SetSourceData Source:=ActiveSheet.Range("q6:q90, r6:r90")
    .SeriesCollection(1).XValues = Range("q6:q90")
    .SeriesCollection(1).Values = Range("r6:r90")
    .SeriesCollection(1).Name = "88Sr(V)"
        'format
        .SeriesCollection(1).Border.ColorIndex = 29
        .SeriesCollection(1).Border.Weight = xlThick
        .SeriesCollection(1).Border.LineStyle = xlSolid
        '.SeriesCollection(1).MarkerBackgroundColorIndex = 5
        '.SeriesCollection(1).MarkerForegroundColorIndex = 1
        .SeriesCollection(1).MarkerStyle = xlNone
        '.SeriesCollection(1).MarkerSize = 6


    .HasLegend = True
    .HasTitle = True
    .HasTitle = False
    .Axes(xlValue).TickLabels.NumberFormat = "0.000"
    .Axes(xlValue).HasMajorGridlines = False
    .Axes(xlCategory).MinimumScale = 0


End With

Set oRange = Nothing
Set oChtObj = Nothing
End Sub
```

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