Isotope Revolution:
Using Normalized Isotope Ratios to Date Rock Samples

Teacher Instructions:

When you graph 3 or more points on a graph you may get a random pattern. But if you make a ratio of these points to a constant, the new ratios will graph as a straight line. This process is called normalizing.

If you compare a parent-daughter pair of three different samples through a series of half – lives you will not be able to tell the age of the sample without normalizing the ratios. You do this by comparing the parent and daughter to a stable isotope of the daughter element that is found in the mineral. The ratio of the two isotopes of the same element will be the same at T_0 since the element does not distinguish between isotopes. The different minerals in the rock will have different amounts of parent and daughter atoms but the ratio of the isotopes of any one element will be a constant.

The example we will use is the parent-daughter pair Samarium-147 and Neodymium-143. They will be normalized against Neodymium-144. Samarium-147 will go through alpha decay to form Neodymium-143. The half-life for this decay is 1.06×10^{11} a (yr).

We have made up two sets of bags "A" and "B".
Both sets will contain red beads which represent ^{147}Sm, blue beads which represent ^{144}Nd (stable) and white beads which represent ^{143}Nd. Set "A" will be the younger samples. We have made up the 3 bags of set "A" with the chart below showing the number of each color bead in each bag.

Rock @ T_0

Element/Isotope	Color of Bead	Mineral "P"	Mineral "Q"	Mineral "R"
Neodymium-143	White	18	6	24
Neodymium-144	Blue	9	3	12
Samarium-147	Red	20	40	60

The bags of set "B" will have the number of beads as shown in the following table.

Rock @ $T_{1/2}$

Element/Isotope	Color of Bead	Mineral "P"	Mineral "Q"	Mineral "R"
Neodymium-143	White	28	26	54
Neodymium-144	Blue	9	3	12
Samarium-147	Red	10	20	30

The numbers of beads of each color can vary, but in set "A" the ratio of white to red beads must remain constant.

When making up sets of bags there are some things of which to make students aware.

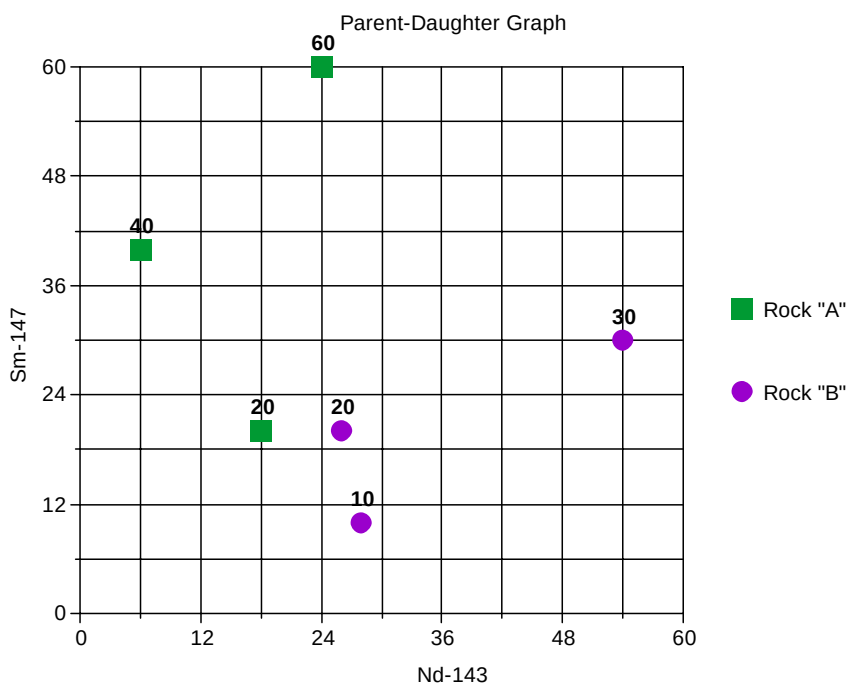
1. The different bags in a set represent different minerals.

2. All of the bags (minerals) from one set i.e. “A” are from the same rock and were formed at the same time.

3. The ratio of an element’s isotopes in a mineral will be the same at $T_{0.}$

Students will graph the number of Parent (Samarium-147) atoms against the number of daughter (Neodymium-143) atoms in each bag. They will plot the points from the “A” set of bags in one color and the points from the “B” set of bags in another color. The daughter atom should be plotted on the vertical axis and the parent atom on the horizontal axis.

This graph does not give us information that will allow the student to determine the age of the samples.



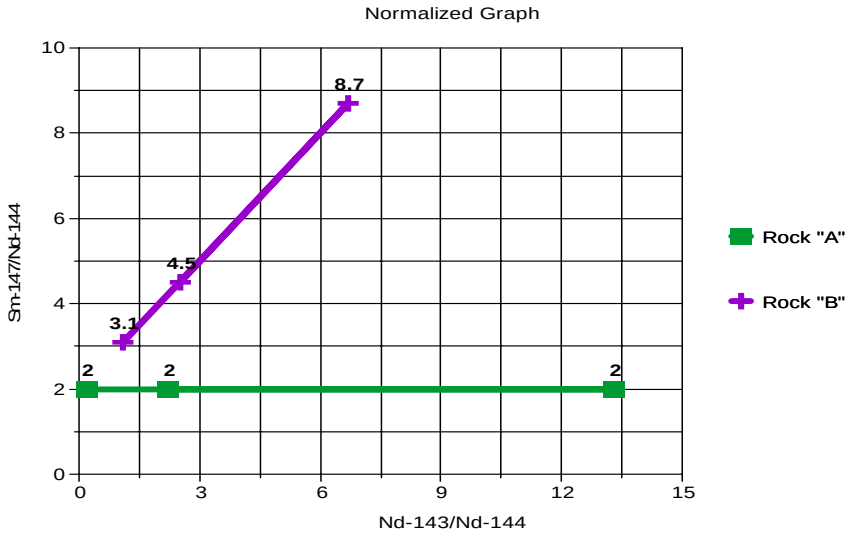
The following table can be drawn by the students to record the bead data from their bag.

Element/Isotope	Color of Bead	Mineral “P”	Mineral “Q”	Mineral “R”
Neodymium-143	White			
Neodymium-144	Blue			
Samarium-147	Red			

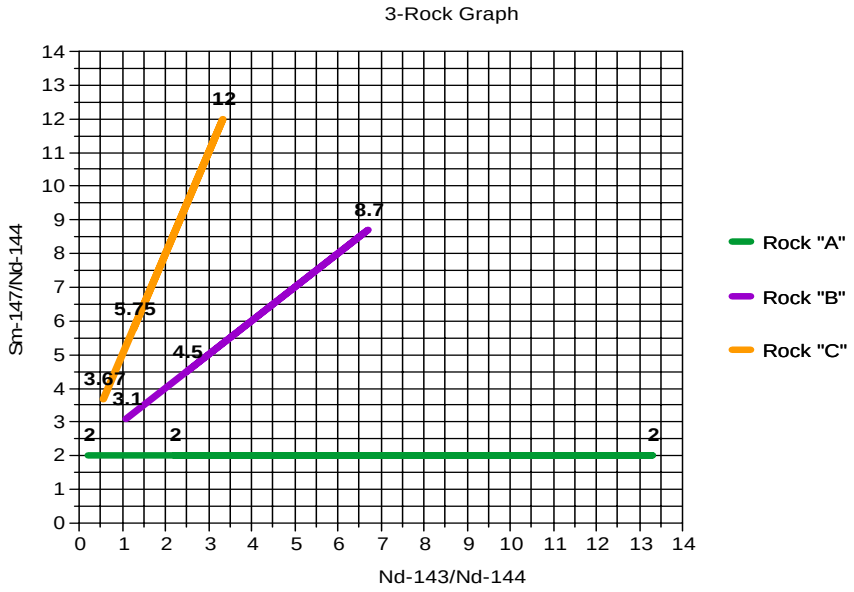
The student will then graph the normalized ratios of both sets of data and the student will see that the data from each set will form a straight line and that the slope of this line will indicate the age of the sample. The steeper the slope is, the older the rock.

To normalize the data make ratios of the parent atom to the stable isotope and, of the daughter isotope to the stable isotope. Then plot the parent/stable isotope ratio value against the daughter/stable isotope ratio. (Both ratios should be in decimal form.)

The graphs should look like the following.



The next graph is of 3 sets of data coming from 3 different rocks.



Isotope Revolution:
Using Normalized Isotope Ratios to Date Rock Samples

Student instructions:

You have two large bags labeled "A" and "B" with 3 smaller bags in it. The large bags represent rocks that have 3 different minerals in them. The 3 smaller bags represent the minerals in the rock. The beads in the bags represent different atoms or isotopes of the same atom. The following chart identifies the atoms/isotopes.

Atom / Isotope	Bead Color
Neodymium-143	White
Neonymium-144	Blue
Samarium-147	Red

1. Open large bag "A" and count the different colored beads in each of the smaller bags. Make a table to record your numbers. The 1st two columns of your table should be the same as the table drawn above.
2. Graph the number of ^{143}Nd atoms vs. ^{147}Sm atoms from this rock.
3. Open large bag "B" and count the different colored beads in each of the small bags. Make another table to record your results.
4. Graph the number of ^{143}Nd atoms vs. ^{147}Sm atoms from this rock in another color on the same axis that you used for the 1st rock.

Can you tell the age of the rock from this data?

5. Calculate the ratio of ^{143}Nd to ^{144}Nd and the ratio of ^{147}Sm to ^{144}Nd for each rock. Write these values as a decimal.
6. Put these values on a data table and graph them on a single axis. Graph the values for rock "A" and for rock "B" in Different colors.

Determine how you can tell the age of the rock from this graph.

The bags of set “A” have the following number of beads.

Rock “A”- T_0

Element/Isotope	Color of Bead	Mineral “P”	Mineral “Q”	Mineral “R”
Neodymium-143	White			
Neodymium-144	Blue			
Samarium-147	Red			

The bags of set “B” have the following number of beads.

Rock B - $T_{1/2}$

Element/Isotope	Color of Bead	Mineral “P”	Mineral “Q”	Mineral “R”
Neodymium-143	White			
Neodymium-144	Blue			
Samarium-147	Red			