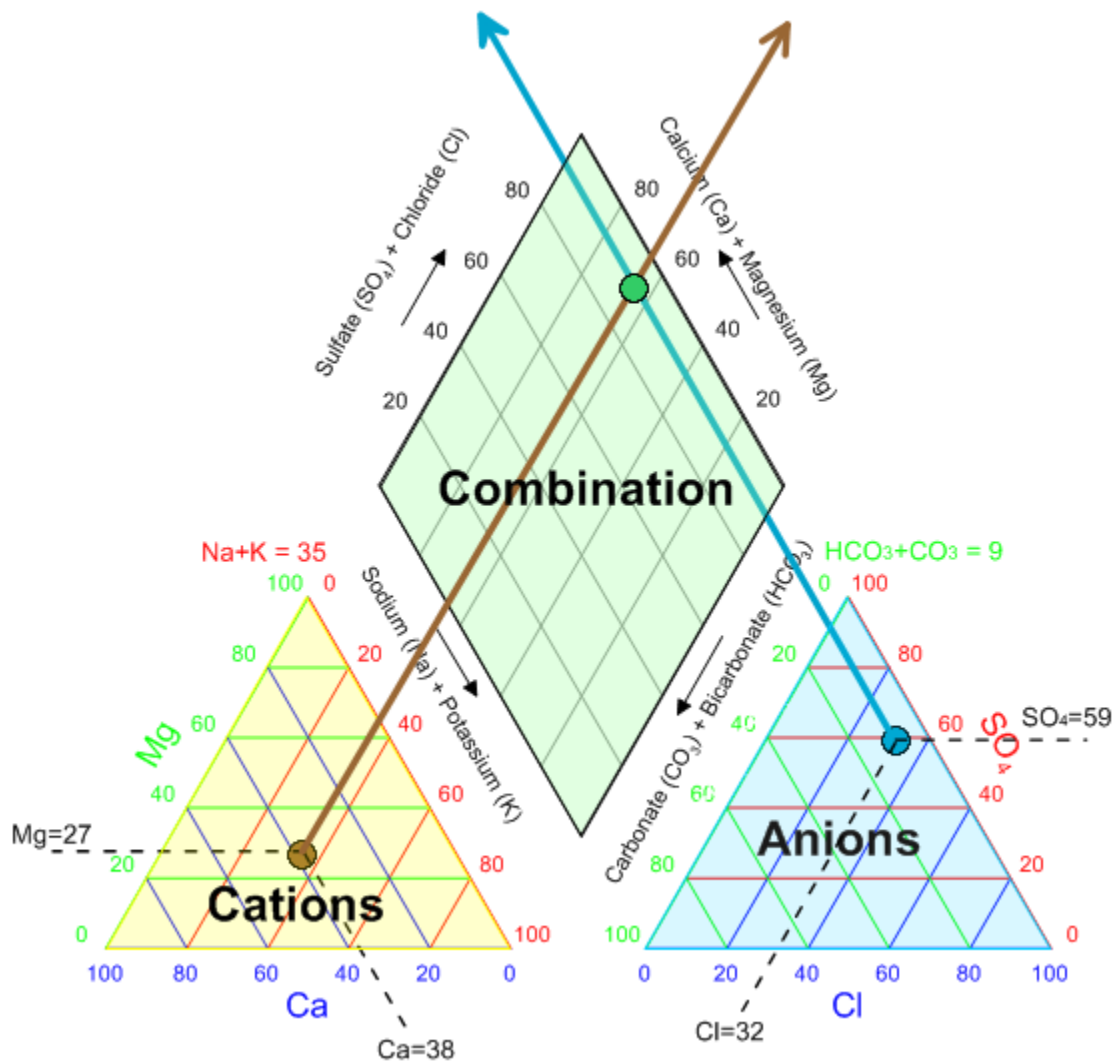


What is a piper plot?

A piper plot is a way of visualizing the chemistry of a rock, soil, or water sample. It's comprised of three pieces: a ternary diagram in the lower left representing the cations, a ternary diagram in the lower right representing the anions, and a diamond plot in the middle representing a combination of the two. To plot, take the normalized concentrations of each of your three cations for a sample and plot them on the lower left ternary diagram, using the colored axes as guides. Repeat for your anions on the lower right ternary diagram. Now, following a line parallel to the outer axis of each ternary diagram, project each point in the ternary diagrams upward until they intersect with one another in the diamond plot. This is where you draw the third point. These three points represent one sample. Repeat for your other samples.



The diamond diagram tells you different things depending on what you're plotting. For groundwater, for example, the top quadrant is calcium sulfate waters (gypsum ground water and mine drainage), the left

quadrant is calcium bicarbonate waters (shallow fresh ground water), the right quadrant is sodium chloride waters (marine and deep ancient ground water), and the bottom quadrant is sodium bicarbonate waters (deep ground water influenced by ion exchange).

How do I get the piper plot template files?

Although Grapher doesn't explicitly have a piper plot – plot type, there is a GRF file and a data file available online that you can use together as a template to create your own piper plot.

1. Navigate to the Grapher knowledge base article "[Can Grapher create a Piper plot? If so, how?](#)" and download the Piper.zip file.
2. Unzip the file to extract the GRF grapher file and the XLSX data file. The data file displays ID, cations, anions, and two combined columns. The cations and anions should all be normalized to add up to 100%.

How can I update the plot with my own data?

1. Use **File | Open** to open your XLSX file.
2. Replace data in Cols B-G with your own data. The units of your data doesn't matter, but your data does need to be normalized such that the sum of each of the cations is 100 (i.e. $B2+C2+D2=100$, $B3+C3+D3=100$, etc.) and the sum of each of the anions is 100 (i.e. $E2+F2+G2=100$, $E3+F3+G3=100$, etc.) . To do so, divide the concentration of one of your three cations [Na+K] by the sum of your cations [Na+K+Ca+Mg], then repeat for your other cations and do the same thing for your anions.
3. Go to **Cells | Data | Transform**. Change First row to 2 and then type *Transform equation: I=G+F*. Click *OK*.
4. Go to **Cells | Data | Transform**. Change First row to 2 and then type *Transform equation: J=B-sin(D2R(30))*I*. Click *OK*.

Note: The D2R part is really important here since it converts 30 degrees to radians, which is necessary before you can calculate the sine. If you're modifying this file in Excel, the equation will update as soon as you input your own data, but for your own information the equivalent command to $\sin(D2R(30))$ is $\text{SIN}(30\text{PI}()/180)$ or $\text{SIN}(\text{RADIANS}(30))$.

5. Use **File | Save** to save the data file to the same name, or **File | Save As** to save to your own name.
6. Use **File | Open** to open the GRF file that came in the ZIP file you downloaded.
7. If you saved your data to a new name, click on *Piper Points | Curve 1* in the **Object Manager**.
8. In the **Plot** tab of the **Property Manager**, change the *Worksheet* to your new data file.
9. Repeat for *Right Ternary* and *Left Ternary | Ternary Plot 1*.

Notice that there are numbers and letters displaying in the diamond plot rather than symbols. This is because these are labels displaying from the first column of the data file (the symbols have been turned off). To plot the symbols click on *Curve 1* in the **Piper Points** graph. In the **Symbol** tab of the **Property**

Manager increase the *Symbol frequency* to 1. Now go to the **Labels** tab and uncheck the *Display labels* box to turn off the labels.

How can I reverse the axes?

To reverse an axis on one of the plots:

1. Add a 'Data' column to your data file containing 0-100 **ascending** in increments of 20. This column has already been added to the XLSX file as Column L: Left Ternary Axis Locations.
2. Add a 'Labels' column to your data file containing 100-0 **descending** in increments of 20. This column has already been added to the XLSX file as Column M: Left Ternary Axis Labels.
3. Select the plot you want to reverse the axis for in the **Object Manager**.
4. In the **Tick Labels** tab of the **Property Manager** expand *Major label text* and:
 - a. Change *Label source* to *From worksheet*.
 - b. Select your worksheet from the cell next to *Worksheet*.
 - c. Change *Data column* to your 'Data' column.
 - d. Change *Label column* to your 'Label' column.


To reverse the direction of all axes on one of the ternary diagrams:


1. Follow the instructions above to reverse the direction of the *Ternary X Axis*, *Ternary Y Axis*, and *Ternary Z Axis* for the desired graph (*Right Ternary* or *Left Ternary*).
2. Click on the *Ternary Plot 1* in the **Object Manager** for the desired.
3. In the Plot tab of the Property Manager, verify that the X Column, Y Column, and Z Column are mapped properly for your newly-reversed axes.
 - a. For Left Ternary with axes ascending in the clockwise direction (correct), X=B, Y=D, and Z=C.
 - b. For Left Ternary with axes ascending in the counter-clockwise direction (incorrect), X=C, Y=B, and Z=D.
 - c. For Right Ternary with axes ascending in the counter-clockwise direction (correct), X=F, Y=G, and Z=E.
 - d. For Right Ternary with axes ascending in the clockwise direction (incorrect), X=E, Y=F, and Z=G.



How can I customize my symbols?

You can customize your piper plot by changing the symbols. This would be useful if you were plotting the results for multiple samples in a single piper plot. To create something akin to a 'classed ternary diagram', which doesn't currently exist in Grapher, you will need to add a symbol column to your data file. To do so:





1. In the Search bar of your Start menu type 'charmap' and hit Enter to open your computer's character map. This tells you what symbols in each font are mapped to what keyboard character.

2. Choose your font from the dropdown at the top (for example: GSI Default Symbols).
3. Double click your desired symbol (for example: ) and then hit the *Copy* button. In your worksheet, hit Ctrl+V to paste into the desired row of the Symbol column.

*Note: Certain characters may mean something special in Grapher, so they may be changed. For example,  in the GSI Default Symbols font pastes into the worksheet as a %, which changes to a numeric 0 as soon as you leave the cell because % is a numeric formatting option in Grapher. To fix this, you will need to designate this cell as text. You can do this by either adding a ' before the % or by typing in your symbol color before the symbol. For more on that, see step 7.

4. Copy and paste this row into any other rows where you wish to use this column.
5. In the character map, delete the symbol in the box and the bottom and choose your next symbol.
6. Repeat steps 3-5 until you've chosen a symbol for each row in your worksheet.
7. To customize the colors for each of our custom symbols, we will add math text instructions to each cell in the Symbol column designating the color. There are certain colors that can be designated by name, such as red, blue, and black. For a full list, search for Math Text Instructions in the Help. Using these types of colors, we can set our 's to all be red with this in each cell: `\red >`. For any other color, you will need to designate the RGB values of the color. To determine the RGB color, click on one of the ternary plots and then go to the **Line** tab in the **Property Manager**. Choose your color from the dropdown list. Expand the dropdown again and click the *Custom* button at the bottom. In the **Custom** tab it will display the RGB values of the selected color. To set these 's to Light Orange instead, we will use `\rgbr255 \rgbg153 \rgbb51 >`. Here `\rgbr` designates the R value, `\rgbg` designates the G value, and `\rgbb` designates the B value.
8. In the Plot tab, select *Curve 1* in the **Object Manager**.
9. In the **Symbol** tab of the **Property Manager** make sure the symbol *Frequency* is 0.
10. In the **Labels** tab check the box to *Display labels*.
 - a. Set the *Horizontal alignment* and the *Vertical alignment* both to *Center* and verify that the *X offset* and *Y offset* are both 0, so the label appears exactly where the symbol would have.
 - b. Change the *Column* to your symbol column.
 - c. Change your *Face* in the *Font* section to GSI Default Symbols (or whatever font you chose symbols from) to display the symbol you chose from the character map rather than the character it's mapped to.
11. Select *Right Ternary | Ternary Plot 1* in the **Object Manager**.
12. In the **Symbol** tab of the **Property Manager** set *Size* to 0
13. In the **Labels** tab check the box to *Display labels*.
 - a. Set the *Horizontal alignment* and the *Vertical alignment* both to *Center* and verify that the *X offset* and *Y offset* are both 0, so the label appears exactly where the symbol would have.
 - b. Uncheck *Include X value*, *Include Y value*, and *Include Z value*.
 - c. Check the box to *Use worksheet labels* and set the *Column* to your symbol column.
 - d. Change your *Face* in the *Font* section to GSI Default Symbols (or whatever font you chose your symbols from) to display the symbol you chose from the character map rather than the character it's mapped to.
14. Repeat steps 8-10 for *Left Ternary | Ternary Plot 1*.

How can I create a legend showing each different symbol?

Let's say I use the GSI Default Symbols characters , , , and  in my plot [represented in the Arial font by >,), %, and “]

1. Go to **Draw | Text**.
2. Click on the page where you want your legend.
3. Set size to 12 points. Type the following with spaces in between each row:
> – Sample 1
) – Sample 2
% – Sample 3
“ – Sample 4
3. Highlight each empty space between lines and make the size 6.
4. Highlight >. Change the font to GSI Default Symbols and the color to red.
5. Repeat step 4 for the other symbols, choosing the appropriate color for that symbol.
6. If you want you can draw a rounded rectangle (**Draw | Rounded Rectangle**) and then go to **Arrange | Group | Group** to group the rectangle and the text into a single object (this will keep the pieces together if you move or resize the legend).

How can I turn on grid lines for each of the plots?

1. Select *Ternary Z Axis* under the *Right Ternary* graph in the **Object Manager**.
2. In the **Grid Lines** tab of the **Property Manager** check the box next to *At major ticks*.
3. If you wish to turn off the tick marks, in the **Tick Marks** tab of the **Property Manager** make sure both *Show ticks on top* and *Show ticks on bottom* are unchecked.
4. Repeat steps 1-3 for *Ternary Y Axis* and *Ternary X Axis*.
5. Repeat steps 1-4 for the *Left Ternary* graph.
6. Select *Ternary Z Axis* under *Upper right side up* in the **Object Manager**.
7. In the **Grid Lines** tab of the **Property Manager** check the box next to *At major ticks*.
8. If you wish to turn off the tick marks, in the **Tick Marks** tab of the **Property Manager** make sure both *Show ticks on top* and *Show ticks on bottom* are unchecked.
9. Turn on *Ternary X Axis* under *Upper right side up* by checking the box next to it in the **Object Manager**.
10. Select *Ternary X Axis*.
11. In the **Grid Lines** tab of the **Property Manager** check the box next to *At major ticks*.
12. If you wish to turn off the tick marks, in the **Tick Marks** tab of the **Property Manager** make sure both *Show ticks on top* and *Show ticks on bottom* are unchecked.
13. In the **Axis** tab click the *Editor* button under *Axis title*. Delete the text in the box and click *OK*.
14. Repeat steps 6-13 for *Upside down*.
15. In the **Line** tab set the *Style* to *Invisible*.