Logging volcanic sequences: representing measured sections as graphic logs.

The principles are the same as for measuring and drawing sedimentary logs. Vertical sections through volcanic sequences (e.g. stream sections, cliff sections, foreshore exposures, borehole logs) may be represented by graphic logs, drawn to scale, using patterns and symbols to denote lithology, structures etc. This document is based on an original by Paul Guion, edited by Roger Suthren.

Procedure in the field

The best procedure in the field is to record all your observations systematically in your notebook. This will be drawn on a graphic log later (there are a number of problems associated with drawing a graphic log directly in the field). The recommended procedure is:

1. ***Plan your work.*** How much section is there to measure, and how much time have you got? This will determine the scale at which you log. If you have 500m of section to log in a day, don't start off by measuring each 2cm bed, otherwise you'll never get to the top! Reconnoitre the section before starting to log, and make preliminary decisions about how to divide it up. Always start logging at the base of the sequence.

2. Decide where the ***base and top*** of the unit are. Depending on the objectives and scale of logging, a unit may be a single bed of one rock type; several beds of the same lithology or facies; or a group of interbeds of two or more different lithologies or facies. Where several beds are included in one unit, you should make notes on bed thickness, and how it changes up the unit. Give each unit a letter or number for reference.

3. Measure the ***thickness*** of the unit and record its ***geometry*** (e.g. does it show lateral thickness changes? is it parallel-sided or lenticular? does it die out laterally?). Sketch the geometry. Ensure that you are measuring the true thickness of the bed, by measuring perpendicular to the dip. Also record the thickness of any gaps in the section.

4. Record the nature of the ***basal contact*** of the bed. Is it sharp or gradational? Is it planar, erosive, or deformed? If erosive, what are the depth and steepness of the erosion surface? Is the base faulted? or unseen? If it is a channel or other non-planar surface, show its actual shape on the log. If the top shows evidence of oxidation or weathering, show that on your log.

5. Give a detailed description of the ***lithology*** and ***texture***, using a standard hand specimen description scheme. Record composition, grain size and other aspects of texture carefully. Name the lithology. Does the lithology change up the unit, or laterally? If several lithologies occur within the unit, describe each in detail. If the same lithology is repeated through the sequence, it need only be described in detail the first time it is encountered.

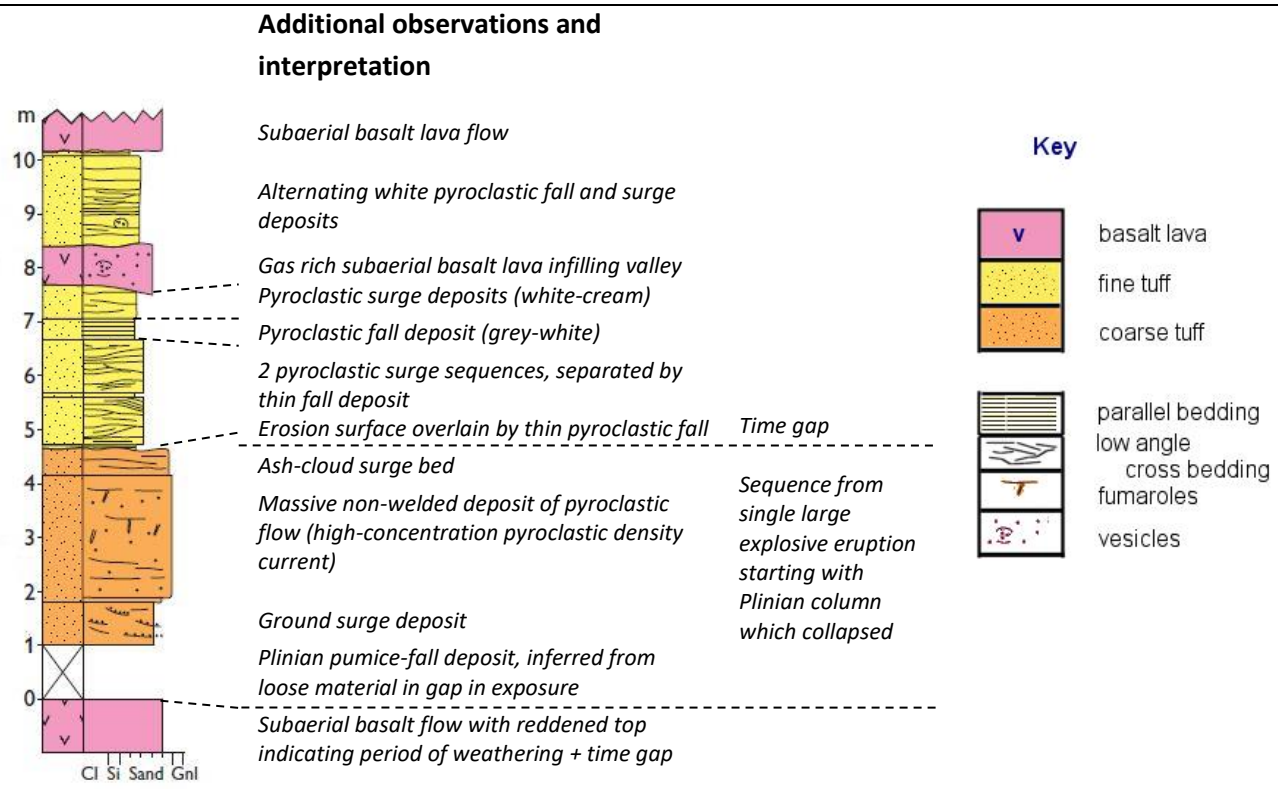
6. Record any ***sedimentary or volcanic structures*** present, describing them in as much detail as possible, with the aid of diagrams. For example, it is not sufficient to record just that cross bedding is present. You must record the type (planar tabular, trough etc.), the height of the sets, the angle of the foresets, any grain-size changes within the foresets, etc. Record depositional and erosional structures, flow structures (e.g. flow banding, pillows), and structures produced by alteration.

7. Measure and record ***palaeocurrent directions***. Ensure that you note the type of structure you are measuring (e.g. trough cross-bedding azimuth; flute direction; wave ripple crest trend). Where dip is >20 degrees, you will also need to record the dip and strike of the bed, and the plunge of fold hinges, in order to perform stereographic re-orientation.

8. Before you move onto the next unit, attempt a brief ***interpretation*** of the ***processes and conditions*** involved. Don't be afraid of recording the obvious. Think about, for example, energy levels, mode of transport and deposition (bedload traction, settling from suspension etc.). You should be thinking how to interpret the units whilst you are logging, and are still able to test your hypothesis.

9. Only ***after*** thinking about processes and conditions should you attempt a brief ***environmental interpretation***. State the ***evidence*** for each of your conclusions. Do not try to interpret the ***overall*** environment until you have logged the whole section, or at least several units.

Drawing the graphic log



Example of a simple graphic log through a volcanic sequence

Modified from Vosgerau et al. (2010). (Interpretations added for illustrative purposes; they may not correspond to those in the article)

The following attributes of sedimentary and volcanic rocks can be represented diagrammatically on a graphic log: lithology, grain size, structures, fossils, palaeocurrents. Additional observations and interpretations are added as notes opposite the appropriate unit.

First, accurately complete the details at the top of the logging form.

Decide on an appropriate scale (this will depend on the length of the section, and the degree of detail you wish to show). In the left-hand columns of the log, show a regularly spaced scale, in metres, and record stratigraphical names and ages.

Now record the following information for each unit:

- Lithology is represented as patterns in a column on the left, and grain-size is represented on the right as a profile of varying width (wide for coarse, narrow for fine). If a unit contains more than one lithology, the column may be divided horizontally or vertically to include two or more patterns.
- Right-hand profile shows grain size of fragmental deposits. Arbitrary width should be used for non-fragmental material such as lava.
- Structures are shown as symbols within the right-hand profile. Fossils, trace fossils and palaeocurrents (correctly orientated line or arrow) are usually shown to the right of this. An example of a graphic log is shown below.
- For common lithologies, structures and fossils, standard patterns and symbols may be used, as shown in the example. It is impossible to design a scheme which will represent all the variations in volcanic rocks. Thus, for more unusual features, you may invent your own patterns and symbols. The most useful are those which bear a resemblance to the item being depicted, so that they convey an immediate visual impression to the observer. Individual geologists have different styles of drawing logs, but the best advice is to make your logs look as much like the actual sequence as possible. ***Whichever symbols and patterns are used, they must all be shown in a <u>KEY</u> accompanying the log.***

As you draw your log, you should write an interpretation of the processes, conditions and local environments for each unit in the right-hand column of the log. You may also use this column to record additional descriptive information which is sufficiently important to show on the log. Do not use this column to repeat in words information which is already shown as symbols on the log.

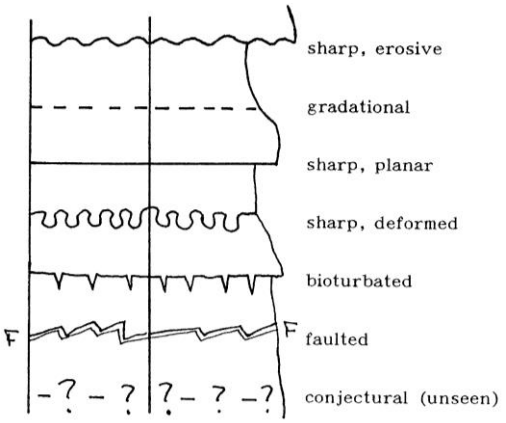
Finally, once your log has been completed, you should attempt a brief interpretation of the overall environment(s), and of any changes in process, conditions and environment through the sequence. This can be written on the back of the log sheet.

Symbols and patterns for volcanic sequences

The symbols and patterns below were devised mainly for using with sedimentary rocks. Devise new symbols for volcanic lithologies and features. Where possible, the symbol or pattern should resemble the feature or rock type you are trying to depict. Make sure you show all your symbols in a key.

Contact types

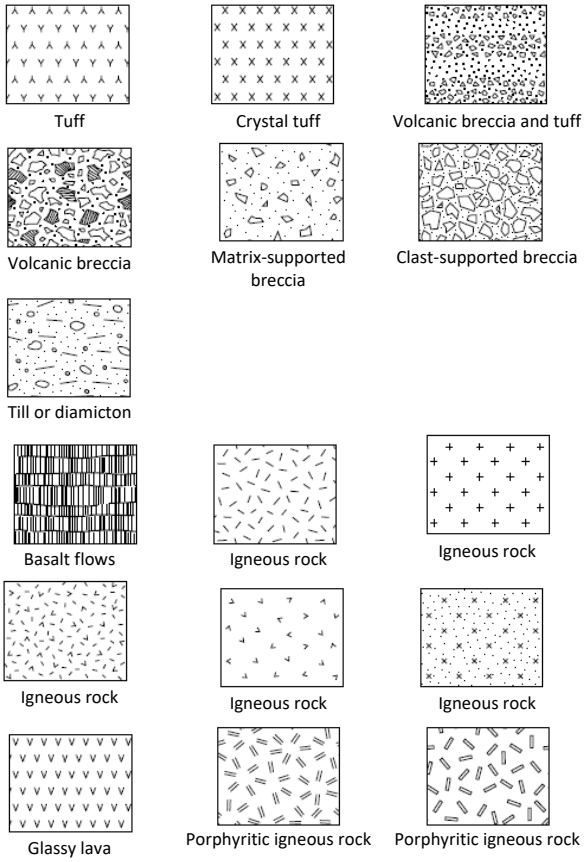
The type of contact at the base of each unit is often of great significance, and should always be recorded. The various line styles for the different types of contact are represented in both columns.



Lithologies

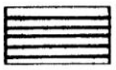
These are represented in the left-hand column only on your log. Use these symbols, or devise your own. Use mixed patterns for mixed lithologies.

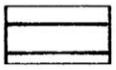
These symbols are from the USGS National Geologic Map Database.

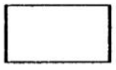


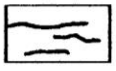
Structures and other features

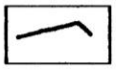
These are shown within the vertical profile log on the right.


parallel lamination

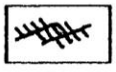

parallel bedding

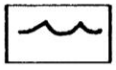

massive

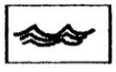

irregular stratification

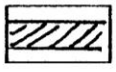

current ripples


current ripple cross-lamination

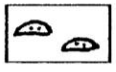

climbing ripple cross-lamination

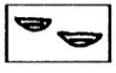

wave ripples

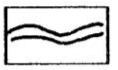

wave ripple cross-lamination

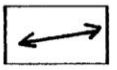

planar tabular cross-bedding


trough cross-bedding


lenticular bedding (sandstone lenses)

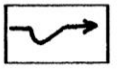

flaser bedding (mudstone lenses)

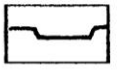

wavy bedding

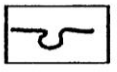

primary current lineation (parting lineation)

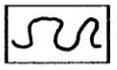

graded bedding

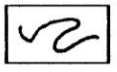

reverse graded bedding

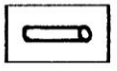

flutes

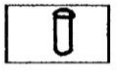

grooves


load structures

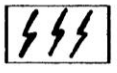

contorted or convolute bedding


slumping


horizontal burrows


vertical burrows


U-burrows


bioturbation (intense)

Devise other symbols as necessary.

References

Vosgerau, H, Guarnieri, P, Weibel, R, Larsen, M, Dennehy, C, Sørensen, E V and Knudsen, C (2010). *Study of a Palaeogene intrabasaltic sedimentary unit in southern East Greenland: from 3-D photogeology to micropetrography*. Geological Survey of Denmark and Greenland Bulletin **20**, 75–78. Open Access: www.geus.dk/publications/bull