A PROPOSED CLASSIFICATION SCHEME FOR PYROCLASTIC ROCKS

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INTRODUCTION

The geologist who works in the vast volcanic fields of southwestern New Mexico and southeastern Arizona soon becomes aware of the large volume of volcanic rock that can be described generally as "pyroclastic". Each geologist will, in his mind's eye, have a slightly different picture of the processes involved in the formation of such rocks, and of the point where the rock ceases to be pyroclastic and instead can be regarded as a flow. Most geologists will agree, however, that a pyroclastic rock (1), is produced by volcanic action or processes directly related to volcanism, (2) composed largely of broken rock, crystalline and/or glassy material, often cemented by a finer-grained matrix and, (3) more or less indurated and compacted so that it forms a bedded unit. In the case of (3), some rocks otherwise regarded as pyroclastic may be very soft and friable, and perhaps would be better regarded as a "pile" of broken rock, rather than a bed.

Another point soon realized in the study of such rocks is that a compositional name is often difficult to apply, especially if the fragments and matrix contain very little in the way of visible minerals. Even thin sections are apt to be misleading because of sampling problems and because the mineralogy of the aphanitic portions of the rock may be difficult to resolve. In many instances chemical analyses or studies of the refractive index of the fused rock are necessary in order to decide whether a given rock is, for example, a rhyolite or a latite.

In the following discussion of the classification of pyroclastic rocks, the problem of composition determination will not be considered, although the classification proposed is constructed so that compositional terms can readily be added to the rock name.

The literature contains numerous references to classifications of volcanic and pyroclastic rocks. Perhaps one of the best known papers is by Wentworth and Williams (1932), in which the authors undertake to define and classify all varieties of pyroclastic rocks. Comments on the problem of classification and definition of pyroclastic rocks have been made by Anderson (1933), Norton (1917) and Fisher (1958), among others. It is not the purpose of this paper to enter into a discussion of the literature on the subject of pyroclastic rock classification, nevertheless, one or two items deserve further comment.

The terminology of some of the formerly proposed classifications can become rather involved, thus, terms like "breccia", "agglomerate", "tuff", "lapilli", "volcanic conglomerate" and others hold for each geologist a slightly different concept, depending on his background and inclinations toward the subject. Further confusion may arise because the terms "tuff" and "breccia" are used both as rock names and size of particle names. In the event that "tuff" and "breccia" are used as rock names, there is little agreement as to what percentage of broken rock fragments of what size should be used as a distinguishing characteristic of each rock type.

It is hoped that the classification scheme for pyroclastic rocks proposed below will resolve some of these problems, without creating too many new ones.

PROPOSED CLASSIFICATION SCHEME FOR PYROCLASTIC ROCKS

A classification scheme for pyroclastic rocks should be compact enough to be used in the field and inclusive enough to cover most of the types of pyroclastic rocks encountered. The classification proposed here uses terms generally accepted and attempts to define these terms in a reasonable manner.

The three variables most readily recognized in pyroclastic rocks are: (1) the amount of glassy ("vitric") constituents present, especially as shards and blebs or as mixtures of glassy and aphanitic material; (2) the amount of crystalline ("crystal") mega-phenocrysts or crystal fragments; and, (3) the amount of "lithic" (rock) fragments, either of the same composition as the matrix, or of different composition. A convenient way of representing these three variables is by the use of a triangular diagram, as illustrated in Figure 1. This diagram is here referred to as a crystal-lithic-vitric (CLV) plot. In the preparation of "fields" within such diagrams, there is much room for ingenuity of design, and the design in Figure 1 represents one possible type of classification. The letters in the diagram refer to the field name, thus designating the crystal-lithic field, the vitric-lithic field and so on. The diagram is used by determining the percentage of crystal, lithic, and vitric constitutuents in a pyroclastic rock, where C+L+V must equal 100%, then plotting the point on the triangle which defines these percentages. This plot provides a descriptive prefix for the rock name.

Only three rock names are used in this classification. These names are "tuff", "breccia", and "tuff-breccia". A tuff is defined as an indurated pyroclastic rock, 90% of whose volume is made up of crystal, lithic, and/or vitric fragments which are less than 4 mm. in diameter. A tuff is analogous, by this definition, to a fine-grained, equigranular rock. A breccia is defined as an indurated pyroclastic rock, 90% of whose volume is made up of crystal, lithic and/ or vitric fragments which are greater than 4 mm. in diameter. The broken fragments are commonly angular. A breccia, by this definition, is analogous to a coarse grained rock. The term "breccia" is, of course, used in another sense in the fields of tectonics and sedimentation. A tuff-breccia is a pyroclastic rock whose lithic, vitric and/or crystal constituents have a great range in size, and which is analogous to an inequigranular rock with a prophyritic or seriate texture (See Figures 2, 3, and 4).

Using the three rock names and the descriptive information from the CLV plot, the rock description can be as detailed or as general as desired. At one extreme is the simple description of a pyroclastic rock as a tuff, breccia, or tuff-breccia, without regard to the type of constituents. At the other is the complete description as to the relative amount of lithic, crystal and vitric constituents, and the relative size and abundance of these constituents. Using the CLV plot and the three rock names, a total of 27 varieties of pyroclastic rock can be described, although some of these may be rare--for example a crystal breccia.

Three examples are figured to further develop the way in which the classification is used. Figures 2, 3, and 4 show a schematic representation of the rock as it would appear in the hand specimen or in a cut section. The CLV plot is shown beneath each rock, and the rock name is given. It should be pointed out, incidentally, that the CLV plots for the tuffs and tuff-breccias can often be made quite accurately by use of thin sections and the integrating stage. Representative thin sections of breccias are somewhat more difficult to make because of the larger size of the fragments. After some practice and comparison with published percentage-of-area diagrams, a reasonably good percentage estimate of the various kinds of fragments can be made by eye. Similarly, the position of a pyroclastic rock on the CLV plot can also be estimated with reasonable accuracy, enabling one to choose the correct field on the triangle.

Figures 2, 3, and 4 show, respectively, the rock texture and CLV plot for a lithic-crystal breccia, a vitric-crystal tuff and a lithic-vitric tuff-breccia. In each figure, the position of the point in the CLV triangle is estimated from the picture of the rock texture.

Additional descriptive terms can be prefixed. For example, should a chemical analysis or refractive index test show that the rock in Figure 3 is a rhyolite, the rock name would be "rhyolitic vitric-crystal tuff". Further, should the internal structures and textures in the rock shown in Figure 3 indicate that compaction and welding had taken place, then the rock name would be "welded rhyolitic vitric-crystal tuff". Such a name, while more cumbersome than the term "welded tuff", imparts additional descriptive information in a systematic manner. Appropriate abbreviations can, of course, be used for all rock names. Other examples of the use of this classification scheme have been presented by Wargo (1959).

A question may arise if the broken fragment of rock in a breccia consists dominantly of glass or contains numerous crystals. For the purposes of this classification, such broken fragments should be regarded as lithic constituents, regardless of their composition, reserving the terms "vitric" and "crystal" for glass shards and blebs and free crystal fragments, respectively. Where "fragments-within-fragments" are encountered, the larger broken piece should be used as a measure of the size of the lithic constituent. Another problem occurs in the case of devitrified glass. The question as to whether such material should be regarded as crystal or vitric depends largely on the degree of devitrification and on the inclination of the geologist. If the glass is only partially devitrified, and the resulting crystals are extremely small it is perhaps best to use the term "vitric" and qualify it with the prefix "devitrified".

Since nature makes the rocks and man the classifications, it is not unlikely that examples will be found which will fit poorly into the scheme proposed here. Also, it may be desirable to change the shapes and sizes of the fields in the CLV plot to better describe the rocks in a particular terrane.

SUMMARY

In summary, a scheme for the classification of pyroclastic rocks has been proposed, which considers the following elements: (1) amount of crysta, lithic and vitric constituents in the rock and, (2) size of the crystal, lithic and vitric constituents. These factors are used to construct a crystal-lithic-vitric plot and to determine which of three rock names is applicable. The CLV plot provides the descriptive prefix to the rock name. Other information on composition and special textural features can also be prefixed.

A pyroclastic rock is classified in the following manner:

1. Determine the relative percentages of the crystal, lithic and vitric constituents ($C + L + V - 100\%$)

2. Determine the correct field on the CLV triangle with the information from "1".

3. Estimate or measure the size of the particles. If 90% or more of the volume is made up of particles which are over 4mm. in diameter, the rock name is breccia. If 90% or more of the volume is made up of particles which are less than 4 mm. in diameter, the rock name is tuff. If the particles have a great range in size (eg. 40% over 4 mm., 60% under 4 mm.) the rock name is tuff-breccia.

4. Prefix the CLV field determined in "2" to the rock name in "3" for a complete descriptive term.

5. Prefix compositional and textural terms if desired.

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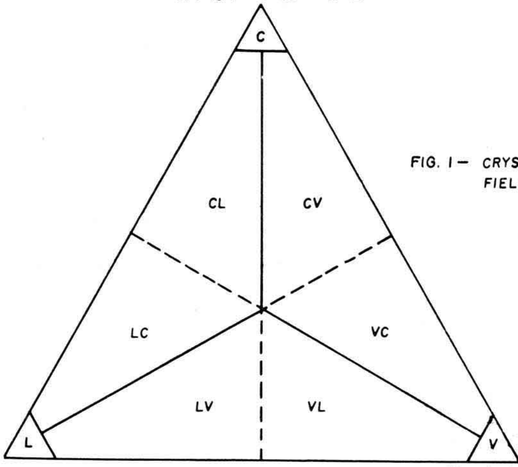

FIG. 1 — CRYSTAL-LITHIC-VITRIC FIELDS IN A C-L-V TRIANGLE

FIG. 2,3,4 — ROCK TEXTURES, C-L-V PLOTS AND ROCK NAMES

FIG. 2 FIG. 3 FIG. 4