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Notes

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INTRODUCTION

During the last four years, a period when working meetings of the International Union of Geological Sciences (IUGS) Subcommission on the Systematics of Igneous Rocks were dealing with pyroclastic deposits, six questionnaires on the descriptive nomenclature and classification of pyroclastic rocks were circulated to more than 150 geologists throughout the world. One of the questionnaires accompanied an issue of the *Bulletin Volcanologique*. The answers were carefully analyzed to obtain representative opinions, upon which the recommendations in this paper are based. The recommendations were ratified by the Subcommission at its Paris meeting in July 1980.

From the beginning, the Subcommission aimed at a descriptive, rather than a genetic, classification suited for field use, including a minimum number of terms and based mainly on the granulometric properties of pyroclastic deposits. The Subcommission also intended to compile a separate glossary of common volcaniclastic rock terms, but this is still incomplete.

COMMENTS ON RECOMMENDED DEFINITIONS AND CLASSIFICATION

The following paragraphs outline the reasons for our final choice of nomenclature and classification summarized in the next section.

Term "Pyroclast"

Answers on the questionnaires revealed a major difference among active workers on pyroclastic rocks on the question of how broadly the terms "pyroclast" and "pyroclastic deposits" should be defined. One group, represented by geologists whose chief concern is pyroclastic rocks, prefers to restrict "pyroclastic deposits" to subaerial fall, flow, and surge deposits and to use the median grain diameter (of the nonballistic components) as a base of the granulometric classification. Another group, which is composed mainly of paleovolcanologists and geologists dealing only temporarily with pyroclastic rocks, prefers to include within the term "pyroclastic deposits" also lahars, subsurface and vent deposits (hyaloclastites, intrusion and extrusion breccias, tuff dikes, diatremes, and so forth). Because experienced volcanologists frequently cannot clearly recognize the specific genetic origin of a volcaniclastic rock in the field (for example, to distinguish hyaloclastites from other types of pyroclastic rocks), the Subcommission recommends that "pyroclastic deposit" be used in a broad sense. It defines "pyroclast" as "generated by disruption as a direct[1] result of volcanic action" instead of "generated by disruption during volcanic eruptions," pyroclastic deposits being "assemblages . . . of pyroclasts." Moreover, it allows "pyroclastic deposits" to contain as much as 25% by volume of epiclastic, organic, chemical sedimentary, and diagenetic admixtures. The extended meaning of "pyroclast" does not contradict the linguistic content of this term, "pyr" denoting fire and "clast" indicating breakage.

Terms "Agglomerate" and "Pyroclastic Breccia"

Following the preference of many volcanologists, "agglomerate" is applied to coherent as well as to incoherent materials, whereas "pyroclastic breccia" refers to mainly consolidated materials because the term "breccia" is traditionally used for coherent materials.

Term "Tuff"

How broadly should the term "tuff" be defined? The answers on this question ranged from "consolidated ash" to "all consolidated pyroclastic deposits." Two advantages would result if "tuff" were defined in the broad sense: (1) "Tuff could be used as a complementary term to "tephra." (2) Coming generations of earth scientists would be free to replace "pyroclastic breccia" and "agglomerate" by the terms "block tuff" and "bomb tuff," thus reducing the number of basic descriptive pyroclastic rock terms and using for polymodal or poorly sorted pyroclastics self-explanatory composite terms such as "ash-block tuff" or "bomb-lapilli tuff." The Subcommission decided to take only one step in this direction by using "tuff" not only for ash-size materials but also, as "lapilli tuff," for coarser pyroclastics. If the term "tuff" is used alone it should comprise, however, ash-size materials only.

[1]The adjective "direct" excludes autobrecciation of lava flows, because the lava flow itself is the direct result of volcanic action, not its brecciation.

Granulometric Classification

In their definitions, the *pyroclasts* are characterized by, in addition to other properties, their size, using as a quantifier the "mean diameter." In very coarse and in consolidated pyroclastic deposits the "mean diameter" is usually estimated by eye, whereas in incoherent materials it can be determined by sieving. Because there does not exist a standard procedure that could be prescribed for measuring the mean diameter in all cases in the same way, the Subcommission declines to define this term.

Instead of "median diameter,"[2] the more generalized term "average diameter" has been used in the granulometric classification of *pyroclastic deposits*, taking into account that granulometric analyses will rarely be carried out and that generally the grain size will be estimated by eye.

The Subcommission, in deciding on appropriate granulometric size limits, would have preferred to divide the granulometric scale at 50, 2, and 0.05 or 0.1 mm. Because these numbers are not even numbers on the ϕ scale widely used by sedimentologists, the 64, 2, and 1/16 mm limits were choosen. These numbers, however, have to be regarded as provisional as long as international agreement on granulometric divisions of sedimentary rocks is lacking. When in future such an agreement is achieved, it may be necessary to modify the divisions so that they will fit appropriate sedimentary size limits. Sedimentologists are invited to reinforce their efforts to establish a unified granulometric classification of sediments.

[2]The median diameter of the grain population of a rock is the diameter by which the area below a weight-percentage frequency distribution curve is divided into two equal parts.

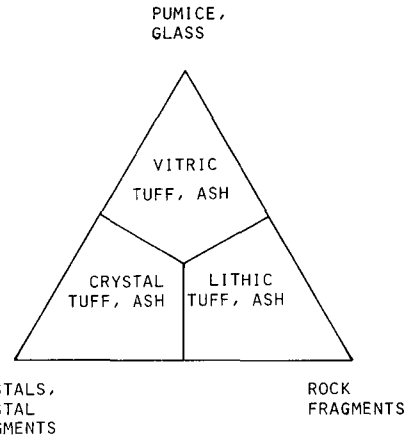

Figure 1. Subdivision of tuffs and ashes according to their fragmental composition.

Genetic Prefixes

The terms for pyroclastic deposits cited below may be prefixed by terms denoting the specific genetic origin of the deposit or the chemical composition of the parent magma—for example, "air-fall tuff," "lacustrine tuff," "laharic ash-lapilli tuff," "rhyolitic crystal tuff," "vent agglomerate." The terms may also be replaced by purely genetic terms, such as "hyaloclastite" and "base-surge deposits," whenever it seems appropriate to do so.

Term "Epiclast"

The definitions of "epiclast," "epiclastic deposit," and "epiclastic rock" must be regarded as provisional because they fall outside the purview of the Subcommission. They had to be given to clearly delineate pyroclasts and pyroclastic deposits from epiclasts and epiclastic deposits.

RECOMMENDED DEFINITIONS AND CLASSIFICATION

Pyroclasts

Pyroclasts are the individual crystals, crystal fragments, glass fragments, and rock fragments generated by disruption as a direct result of volcanic action. The shapes they assumed during disruption or during subsequent transport to the primary deposit must not have been altered by later redeposition processes. If they were altered, the crystals or fragments would be called "reworked pyroclasts" or "epiclasts" (if their pyroclastic origin is uncertain).

A *bomb* is a pyroclast with a mean diameter commonly exceeding 64 mm. Its shape (ellipsoidal, discoidal, or irregular) or its surface (for example, "bread-crust" surface) indicates that during its formation and subsequent transport it was in a wholly or partly molten condition.

A *block* is a pyroclast with a mean diameter exceeding 64 mm, whose commonly angular to subangular shape indicates that during its formation it was in a solid state.

Lapilli are pyroclasts of any shape, with mean diameters of 2 to 64 mm.

Ash grains are pyroclasts with mean diameters smaller than 2 mm.

Dust grains (or *fine ash grains*) are pyroclasts with mean diameters smaller than 1/16 mm.

Pyroclastic Deposits: General Terms

Pyroclastic deposits (= "*pyroclastics*") include both consolidated[3] and unconsolidated assemblages of pyroclasts. They must contain more than 75% pyroclasts by volume.

Pyroclastic rocks are predominantly consolidated pyroclastic deposits.

Tephra is a collective term for pyroclastic deposits that are predominantly unconsolidated.

[3]"Consolidated" as used in the following is thought to comprise adjectives such as "coherent," "cemented," and "indurated."

TABLE 1. GRANULOMETRIC CLASSIFICATION OF PYROCLASTS AND OF UNIMODAL, WELL-SORTED PYROCLASTIC DEPOSITS

Clast size (mm)	Pyroclast	Pyroclastic deposit	
		Mainly unconsolidated: tephra	Mainly consolidated: pyroclastic rock
	Bomb, block	Agglomerate, bed of blocks or bomb, block tephra	Agglomerate, pyroclastic breccia
64 mm			
	Lapillus	Layer, bed of lapilli or lapilli tephra	Lapilli tuff
2 mm			
	Coarse ash grain	Coarse ash	Coarse (ash) tuff
1/16 mm			
	Fine ash grain (dust grain)	Fine ash (dust)	Fine (ash) tuff (dust tuff)

TABLE 2. TERMS FOR MIXED PYROCLASTIC-EPICLASTIC ROCKS

Pyroclastic*		Tuffites (mixed pyroclastic-epiclastic)	Epiclastic (volcanic and/or nonvolcanic)	Avg clast size (mm)
Agglomerate, agglutinate pyroclastic breccia		Tuffaceous conglomerate, tuffaceous breccia	Conglomerate, breccia	64
Lapilli tuff				2
(Ash) tuff	coarse	Tuffaceous sandstone	Sandstone	1/16
	fine	Tuffaceous siltstone	Siltstone	
		Tuffaceous mudstone, shale	Mudstone, shale	1/256
100	75		25	0% by volume
← Pyroclasts				
→ Volcanic + nonvolcanic epiclasts (+ minor amounts of biogenic, chemical sedimentary and authigenic constituents)				

*Terms according to Table 1.

Pyroclastic Deposits: Terms for Unimodal and Well-Sorted Pyroclastic Deposits (Table 1, Figure 1)

A *pyroclastic breccia* is a pyroclastic rock whose average pyroclast size exceeds 64 mm and in which angular pyroclasts predominate.

An *agglomerate* is a pyroclastic rock or deposit whose average pyroclast size exceeds 64 mm and in which rounded pyroclasts predominate.

A *lapilli tuff* is a pyroclastic rock whose average pyroclast size is 2 to 64 mm.

A *tuff* (or *ash tuff*) is a pyroclastic rock whose average pyroclast size is less than 2 mm.

A *dust tuff* (or *fine ash tuff*) is a pyroclastic rock whose average pyroclast size is less than 1/16 mm.

Pyroclastic Deposits: Terms for Polymodal or Poorly Sorted Pyroclastic Rocks

Polymodal or poorly sorted pyroclastic rocks containing pyroclasts of more than one dominant size fraction should be named by using an appropriate combination of the terms cited in Table 1. Examples:

ash-lapilli tuff (lapilli > ash)
lapilli-ash tuff (ash > lapilli)
lapilli tuff–breccia/–agglomerate (lapilli ~ blocks/bombs)
(ash) tuff–breccia/–agglomerate (ash ~ blocks/bombs)
ash–lapilli tuff–breccia/–agglomerate (lapilli > ash ~ blocks/bombs).

Epiclasts and Epiclastic Deposits

Epiclasts are crystals, crystal fragments, glass fragments, and rock fragments that have been liberated from any type of preexisting rock (volcanic or nonvolcanic) by weathering or erosion and transported from their place of origin by gravity, air, water, or ice.

An *epiclastic deposit* is a consolidated or unconsolidated aggregate of epiclasts.

An *epiclastic rock* is a mainly consolidated epiclastic deposit.

Mixed Pyroclastic-Epiclastic Rocks (Table 2)

"Tuffites" are rocks consisting of mixtures of pyroclasts and epiclasts (<75% pyroclasts, >25% epiclasts by volume).

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