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REPORT

# DEFINITION OF CLAY AND CLAY MINERAL: JOINT REPORT OF THE AIPEA NOMENCLATURE AND CMS NOMENCLATURE COMMITTEES

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## INTRODUCTION

The definition of "clay" was first formalized in 1546 by Agricola. It has been revised many times since, although the fundamentals involving plasticity, particle size, and hardening on firing were retained by most. For an exhaustive account of the history of the definition to 1963, the reader is referred to Mackenzie (1963). More recent developments may be found in Weaver (1989).

The definition of clay raises the important issue of clay constituents and, implicitly, the definition of "clay mineral." Mackenzie (1963, p. 15) noted the inappropriateness of defining clay mineral as "any mineral which occurs in clay" since, among several reasons, it would include many accessory minerals that are not characteristic of clay. Previous definitions of "clay mineral" (e.g., Bailey 1980) simply equated clay minerals to phyllosilicates, thus endorsing the use of a term without apparent justification. The term "clay mineral," however, is useful when applied in context to clay constituents. The approach of equating "clay mineral" to phyllosilicate fails to consider the relationship of the properties of the bulk clay with the properties of the constituents of clay. This inconsistency is addressed here in part, without making major changes to current usage.

Weaver (1989, p. 5) noted an additional complication: the conceptual problem of combining particle size requirements of clay constituents with mineralogy. Because the term "mineral" has a precise definition that does not include particle size, it follows that the definition of a mineral group cannot be based on particle size.

Both the nomenclature committees of AIPEA and CMS started work on the definitions of clay at the same time, and it became clear that a more acceptable result would be obtained if the two committees joined efforts. This report represents the recommendations of both committees.

## CLAY

### *Definition*

The term "clay" refers to a naturally occurring material composed primarily of fine-grained minerals, which is generally plastic at appropriate water contents and will harden with dried or fired. Although clay usually contains phyllosilicates, it may contain other materials that impart plasticity and harden when dried or fired. Associated phases in clay may include materials that do not impart plasticity and organic matter.

### *Discussion*

The "naturally occurring" requirement of clay excludes synthetics. Based on the standard definition of mineral, clays are primarily inorganic materials excluding peat, muck, some soils, etc. that contain large quantities of organic materials. Associated phases, such as organic phases, may be present (see below for further discussion relating to associated phases). "Plasticity" refers to the ability of the material to be molded to any shape. The plastic properties do not require quantification to apply the term "clay" to a material. The "fine-grained" aspect cannot be quantified, because a specific particle size is not a property that is universally accepted by all disciplines. For example, most geologists and soil scientists use particle size less than 2 $\mu$m,

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sedimentologists use 4 μm, and colloid chemists use 1 μm for clay-particle size. Sedimentologists may use the term "clay" also to denote grain size only. It is more precise, however, to give the actual dimensions of the particles, e.g., particles less than 4 μm.

Plasticity is a property that is greatly affected by the chemical composition of the material. For example, some species of chlorite and mica can remain non-plastic upon grinding macroscopic flakes even where more than 70% of the material is less than 2 μm esd (equivalent spherical diameter). In contrast, other chlorites and micas become plastic upon grinding macroscopic flakes where 3% of the material is less than 2 μm esd.

Plasticity may be affected also by the aggregate nature of the particles in the material. For example, many "glauconite sands" are composed of ("sand size") grains of aggregates of fine-grained glauconite crystallites. Although the material may be plastic, they apparently contain no fines based on a standard grain size analysis. Clearly, such glauconite sands are composed of aggregates of clay. In contrast, many "flint clays" are greater than 95% kaolinite, yet they are nonplastic in their natural state and contain aggregate particles only greater than about 75 μm in size. Although the aggregates are composed of fine-grained kaolinite, plasticity is minimized because of the aggregate nature of the kaolinite crystallites. Thus, "flint clays" are an apparent exception to the plasticity attribute of the definition. The term "fine-grained" in the above definition refers to crystallite size and not to aggregate size.

Although the primary minerals composing clays are phyllosilicates, other materials that impart plasticity and harden upon drying or firing may comprise clays (see definition for "clay mineral" below). Associated phases in clays (*not* to be referred to as "associated clay phases," but as "associated phases in clay") may be minerals such as quartz, calcite, dolomite, feldspars, oxides, hydroxides, organic phases, etc. or noncrystalline phases, such as colloidal silica, iron hydroxide gels, organic gels, etc.

## CLAY MINERAL

### *Definition*

The term "clay mineral" refers to phyllosilicate minerals and to minerals which impart plasticity to clay and which harden upon drying or firing.

### *Discussion*

Currently, minerals known to produce the property of plasticity are phyllosilicates. Because minerals are not defined based on their crystallite size, appropriate phyllosilicates of any grain size may be considered "clay minerals." Likewise, clay minerals are not restricted, by definition, to phyllosilicates. If research reveals that a non-phyllosilicate mineral imparts plasticity to a clay and hardens upon drying or firing, this mineral is a "clay mineral." For example, if an oxy-hydroxide mineral in a clay shows plasticity and hardens upon drying or firing, it may be properly referred to as a "clay mineral." Thus, a clay is not required to be predominantly composed of phyllosilicates. Minerals that do not impart plasticity to clay and non-crystalline phases (regardless if they impart plasticity or not) are either "associated minerals" or "associated phases," respectively.

This definition departs from previous definitions (e.g., Bailey 1980) of clay minerals, where clay minerals were equated to phyllosilicates. The current definition broadens the scope of possible minerals defined as clay minerals. In addition, it specifically relates the property of plasticity and hardening upon drying or firing, which is basic to the definition of clay, to the definition of clay mineral. The definition of "clay mineral" includes all phyllosilicate minerals previously regarded as clay minerals and possible new clay minerals as discussed above.

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