Clays and Clay Minerals, Vol. 44, No. 5, 713–715, 1996.

REPLY

REPLY TO THE COMMENT BY D. M. MOORE ON "DEFINITION OF CLAY AND CLAY MINERAL: JOINT REPORT OF THE AIPEA NOMENCLATURE AND CMS NOMENCLATURE COMMITTEES"

Moore (1996) comments on the definition of "clay" and "clay mineral". Some of the proposed revisions in Moore (1996) are counter to currently accepted definitions, for example, "mineral", some involve the inconsistent use of terms, for example, "clay" vs. "clay mineral", and some involve radical changes in use for which there is little justification, for example, removing the characteristic of plasticity from the definition of "clay". In all cases, the proposed revisions are unacceptable.

Minerals and the Issue of Grain Size or Surface Area Requirements

With regard to the issue of minerals and grain size, Moore (1996) may be interpreted in 2 ways: 1) the definition of "mineral" should include a particle size requirement; and/or 2) clay minerals, as a subset of minerals, should be defined further to include a particle size requirement and by inference, surface area effects. With regard to item 1), the definition of a mineral may be found in all introductory mineralogy texts, such as Berry and Mason (1959) or Klein and Hurlbut (1993). It is beyond the scope of this Committee to redefine "mineral", nor is this warranted.

Before commenting on item 2), it is noteworthy that Moore (1996) refers to the importance of research in nanometer-size compounds and heterogeneous catalysts, but these research areas are not dealing with mineral definitions and are inappropriate analogies. Clearly, grain-size and surface effects are greatly important in clay mineral studies. However, the relevant issue is not the importance of the grain size or mineral surface in research, but whether these characteristics should be used as criteria in defining a clay mineral. For many reasons, surface area, grain size, or surface activity have no place in defining a clay mineral.

SURFACE EFFECTS. Surfaces are very heterogeneous and are difficult to characterize. Surfaces are easily poisoned by small amounts of impurities and may change rapidly when exposed to H_2O, air or other environments. Different surface structures exist for different orientations of the bulk. Thus, multiple surfaces exist for a bulk material and surfaces are too sensitive to environmental conditions; they cannot be used conveniently in a mineral classification scheme.

If instead of defining the surface, researchers merely define a characteristic believed to represent a surface, for example, how the material responds to adsorption of a particular cation, no certainty can be given that the measured property is related only to the surface in question. For example, the average response of 2 or more different surfaces may appear to satisfy the characteristics of a single surface, or a surface affected by environmental conditions, such as impurities, may appear to satisfy the characteristics of the surface in question.

GRAIN-SIZE EFFECTS. The particle size of clay minerals is the consequence of not only chemistry and atomic structure, but also the environment of growth. Fundamental intensive parameters such as temperature and pressure strongly influence crystal growth. Crystal-growth kinetics may be influenced greatly by the presence or absence of a vapor phase, which involves the activity of H_2O. Small changes in these parameters may have significant effects on the grain size of the product phases. Thus, grain size is a parameter that may measure a small effect in the formation of the material, and it is not a fundamental characteristic suitable for a classification scheme. Again, the argument is the appropriateness of using grain size in a classification scheme, and not the importance of grain size in properties of materials.

PRACTICAL CONSIDERATIONS. Grain-size requirements and, for analogous reasons, surface effects, for defining a mineral are impractical. First, the definition of the appropriate size fraction would be completely arbitrary. It could be argued that there should be a size fraction for "clays", another for "quasi-clays" and another for "non-clays". Second, do we assign a different mineral name to a different size fraction of a clay mineral? The number of new mineral names

Copyright © 1996, The Clay Minerals Society

https://doi.org/10.1346/CCMN.1996.0440516 Published online by Cambridge University Press

would be enormous. The point here is not that particle-size and surface effects are unimportant. However, surface effects and how they may relate to particle size and composition cannot readily be quantified. Also, it is noteworthy that the importance of the fine-grained aspects of clay minerals is reflected in the definition of clay.

FURTHER COMMENT. Although the Joint Committee rejects the idea of using particle size as a requirement for clay mineral, the Joint Committee certainly recognizes the importance of surface area effects in clay minerals. A "clay mineral" must impart plasticity to a clay or harden when dried or fired whereas an "associated mineral" does not have this property. These types of phases are separated by category because clays have specific properties and because clay minerals have these properties. Particle size may play a role here. Phyllosilicates, even those that do not impart plasticity to clay, are still referred to as "clay minerals" only because of past usage.

The Use of Plasticity and Hardening Upon Firing as Criteria to Define "Clay"

Clay is a naturally occurring material with certain properties, even if the detailed mineralogy of the sample is unknown. Historically, the properties used to define "clay" have been plasticity and hardening when dried or fired. These properties to describe "clay" have been a critical feature in the definition for hundreds of years, and the Joint Committee did not feel that it should change the definition needlessly.

Moore (1996) noted that fine-grained fly ash is plastic and implied that, under the definition provided in Guggenheim and Martin (1995), this material should be considered a clay. We disagree in that fly ash is man-made; therefore, it is not a clay even if plastic. However, if fly ash were naturally occurring and were composed of minerals, it would be considered a "clay". Fly ash does meet the plasticity requirement. The Joint Committee is aware that the definition of "clay" as given by Guggenheim and Martin (1995) may lead to new materials that could meet the definition of clay.

Nomenclature and its Relationship to Associated Disciplines

Moore (1996) presents a discourse on the philosophical and practical importance of nomenclature. In addition, Moore (1996) specifies a third "criticism" as follows: The present definition "has put unnecessary distance between our discipline and neighboring disciplines that can potentially damage our ability to communicate with them". The response to both aspects is given below.

The third criticism is an opinion that we do not share, but we cannot presently assess the future impact of the definitions as presented in Guggenheim and Martin (1995). Rarely however, do definitions remain static for all time and, as we acquire new data, we expect that these definitions will evolve. The fact that nomenclature committees exist at all suggests that these definitions will be reassessed. Wherever possible, the goal of a nomenclature committee is to develop nomenclature that follows current usage, that is self-consistent, that is useful to the researcher and that is compatible for all disciplines. These points are compatible with both Moore (1996) and Guggenheim and Martin (1995), although how they are achieved apparently is the point of contention here, and not the philosophical underpinnings.

Developing a Universally Acceptable Definition for Clay-Related Terms

Moore (1996) makes the following suggestion: "Clearly state as a committee that you are aware that clay is used three different ways in our discipline: as a size term, as a rock term, and as a mineral term".

Guggenheim and Martin (1995) clearly discussed (first paragraph, Discussion Section) the difficulties in defining "fine-grained" as it relates to clay. They noted that "most geologists and soil scientists use particle size <2 μm, 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, for example, particles <4 μm". This is a precise statement regarding size terminology.

A precise statement regarding clay as a rock term is more difficult. The Joint Committee found that the definition of "rock" was controversial. For example, there was an apparent split among European vs. North American members about whether rocks must be lithified. This illustrates the need to consider how common terms are defined and understood by an international community. The final document avoids the issue of rock specifically, although the use of "associated phases" is borrowed from rock classification schemes.

Clay should never be used as a "mineral term", contrary to the statement by Moore (1996). The Joint Committee makes a clear distinction between "clay" and "clay mineral", because the 2 terms are not synonymous. Rocks generally contain more than 1 mineral, and thus there is an inconsistency to use the term "clay" both as a mineral term and a rock term, as suggested by Moore (1996). When talking with researchers from allied disciplines it is important to clarify the language. However, Moore (1996) apparently argues that all definitions of clay should be given. Such an approach further clouds the issue since there can be **no** consensus if all definitions are to be accepted. Because the Clay Minerals Society and AIPEA involve researchers from many disciplines, each work-

https://doi.org/10.1346/CCMN.1996.0440516 Published online by Cambridge University Press

ing on clay materials, these are the organizations that must lead in developing a universally acceptable definition for clay-related terms.

Non-Nomenclature Issues

Moore (1996) uses terminology such as "our discipline" and "neighboring disciplines", and we do not understand what this means. Clearly, the science of clay mineralogy is actively pursued in many disciplines, including engineering, soil science, mineralogy, chemistry, material science and others. Moore (1996) acknowledges the diversity of the science. In fact, it is a major point, and yet the use of "our discipline" and "neighboring disciplines" conveys the message that there are clear separations. We believe that this usage is unfortunate.

Moore (1996) argues that essentially all clays form in low-temperature environments, thereby producing small particles due to "slow kinetics". Although diagenetic processes are commonly related to the formation of clay materials, many clays do form by mechanical weathering, in contrast to the comments of Moore (1996). Clays do exist in glacial tills and soils derived from glacial materials, and such deposits are common and widespread. Pedogenesis may impose modifications of these clay materials in soils, but the bulk of the clay fractions are inherited from finely divided silicates. Furthermore, Moore (1996) indicates that only "relatively pure concentrations of clay minerals in the clay-sized fraction" exist. Although this is true for many diagenetic clays, this is not a common feature of all clays.

Moore (1996) suggests that "our ability to deal with clay-sized minerals has only recently taken quantum steps ahead with the introduction of atomic force microscopes, X-ray adsorption spectroscopy, and related instruments and gadgets. When we are just learning how to deal with these minerals as individuals. . ." Although these instruments offer new and exciting avenues of research, the ability to study clay-sized minerals as individual particles is not new. Clay-sized materials have been studied effectively for many years, for example, consider the effect of the use of the transmission electron microscope in clay science since the early 1950s.

Erratum

We note that an error occurred in the printing of the definition of clay (Guggenheim and Martin 1995) in the version published in *Clays and Clay Minerals,* where the word "with" was printed instead of "when". The correct sentence should read "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 when dried or fired".

We re-iterate the main points of our response. The Joint Committee has defined "clay" and "clay mineral", and these terms are not interchangeable. The use of either grain size or surface area is not suitable for a mineral classification scheme.

[1]*Department of Geological Sciences* STEPHEN GUGGENHEIM†
University of Illinois at Chicago
845 W. Taylor St.
Chicago, Illinois 60607

[2]*Ardaman and Associates, Inc.* ROBERT T. MARTIN‡
8008 S. Orange Ave.
Orlando, Florida 32859

† Chairman of the AIPEA Nomenclature Committee: The other members are A. Alietti (Italy), V. A. Drits (Russia), M. L. L. Formoso (Brazil), E. Galán (Spain), H. M. Köster (Germany), H. Paquet (France), T. Watanabe (Japan), and *ex officio* members D. C. Bain (Editor, *Clay Minerals*) and W. H. Hudnall (Editor, *Clays and Clay Minerals*).

‡ Former Chairman of the CMS Nomenclature Committee: Other members are D. L. Bish (present Chairman), D. S. Fanning, S. Guggenheim, H. Kodama, and F. J. Wicks.

REFERENCES

Berry LG, Mason B. 1959. Mineralogy: Concepts, description, determinations. San Francisco, CA: W.H. Freeman and Company. 630 p.

Guggenheim S, Martin RT. 1995. Definition of clay and clay mineral: Joint Report of the AIPEA Nomenclature and CMS Nomenclature Committees. Clays Clay Miner 43: 255–256.

Klein C, Hurlbut CS, Jr. 1993. Manual of mineralogy, 21st edition. New York: John Wiley and Sons, Inc. 682 p.

Moore, DM. 1996. Comment on: definition of clay and clay mineral: Joint Report of the AIPEA Nomenclature and CMS Nomenclature Committees. Clays Clay Miner 44: 710–712.

(Received 10 June 1996; accepted 12 June 1996; Ms. 2763)

https://doi.org/10.1346/CCMN.1996.0440516 Published online by Cambridge University Press