Clays and Clay Minerals, Vol. 44, No. 5, 710–712, 1996.

COMMENT

COMMENT ON: DEFINITION OF CLAY AND CLAY MINERAL: JOINT REPORT OF THE AIPEA NOMENCLATURE AND CMS NOMENCLATURE COMMITTEES†

Key Words—Clay, Definition, Plasticity, Mineral, Size

"Words are the instruments of thought; they form the channel along which the thought flows; they are the moulds in which thought is shaped. If we wish to think correctly it is essential that we use the correct word."

Aldous Huxley (1936)

In spite of the otherwise quite appropriate words from Mr. Huxley, all disciplines, and society in general, have trouble maintaining the bounds of their languages. Languages evolve and mutate as certainly as the ticking away of the unstable isotopes we use for dating. Turn to the front of any large dictionary where a brief history of language is given, or to a text on historical linguistics, and you will find a statement that says, one way or another, that two important and pervasive qualities characterize not only English, but all living languages: change and variability. That such changes are expected and take place are phenomena studied by linguists, for example, Hock (1991). There is variability of meaning with context and change with time. Because of context, we certainly do not confuse an ear of grain with the ear as an appendage of the head. Variability also arises because words are used differently in different situations by people with different purposes and outlooks. Changes in meaning with time result from different or increased understanding of a process, or a new and different application of an older process or article. Metaphorical and analogical uses also introduce changes. For example, who thought of butterflies and bees in terms of boxing before Muhammad Ali?

Bowen (1928, p 321–322) stated that a classification scheme will be of use and will endure to the extent that it coincides with real qualities of the nature of the things being classified. The same can be said for nomenclature, terms will be of use and will endure to the extent that they coincide with real qualities. And, as with all types of classification and nomenclature, boundaries blur in proportion to the detail in which they are studied. The limitations of our understanding become apparent as we try to pin down definitions of, in this case, clay and clay mineral. Real qualities, I suspect we will all agree, keep receding before us as we learn more about the materials and processes of our discipline. This in no way dismisses the responsibility we have for trying to maintain agreement on the meanings of the words we use. To the contrary, realization of the slippery nature of meanings requires additional responsibilities. In addition, we need to recognize the needs of the disciplines that border ours. If we allow our terminology to become too restricted, too esoteric, the neighboring disciplines will have more difficulty communicating with us than they do now. I am sure there is no disagreement that care and nurturing of our system of nomenclature is a primary concern of everyone associated with the study of clay-sized minerals. We owe a great deal to the present and past nomenclature committees for their efforts to constrain and focus the meanings of the words we use, and to try to balance all of the competing and cooperating interests.

That said, let me turn to a suggestion and three specific criticisms of Guggenheim and Martin (1995). My suggestion first, 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. Users who do not clearly separate these meanings provide one of our most consistent sources of confusion. Each of these uses has utility or each would not have survived. The nomenclature committee could clearly separate them, and do it in a way that sedimentologists as well as engineers and soil scientists could continue to communicate with us. When clay is used as a size term, it is usually quite clear from context, but we need to urge users to be explicit. The other two uses are more confusing. When refer-

† In reference to Clays Clay Miner 43:255–256. Guggenheim and Martin. 1995.

https://doi.org/10.1346/CCMN.1996.0440515 Published online by Cambridge University Press

ring to material from an outcrop, a core or other mass quantity, clay should always be a rock term. There are several valid definitions. Folk's (1974) definition is certainly adequate: for rocks with >67% clay-sized minerals, if it is unindurated it is clay, if it is indurated, it is claystone, if indurated and laminated, it is shale, recognizing of course, that troublesome intermediates will be a problem whatever classification scheme we choose. That leaves the question of what to do with clay-sized minerals. Before I offer my views on that, I need to take up the question of size, and hence my first criticism of the nomenclature committee.

In spite of the *non sequitur* attributed to Weaver (Guggenheim and Martin 1995), size certainly is used as a definitive criterion in our attempts to erect classification schemes that reflect what we see in nature (Bowen 1928). The use of Weaver's logic ignores the peculiar characteristics of very small particles. When you examine the particle size distribution curves for quartz or feldspar from sediments, the abundance begins to drop off sharply at about 20 μm, and becomes very low at approximately 4 μm. This is because the physical processes that grind or chip quartz and feldspar in turbulent waters become ineffective at very small grain sizes where the inertia of the grains is small compared to the viscous forces in the water. You will recall that the fall of particles larger than about 20 μm through a non-turbulent, isothermal fluid is described by the Impact Law in which velocity is proportional to the square root of the diameter of the particle. Conversely for particles <20 μm, Stokes's Law applies. These numbers are for spherical particles. However, most clay-sized mineral particles are tablet or flake shaped and therefore settle only about half as fast as spheres. In addition, there are no non-turbulent streams, lakes or oceans so that settling velocities would be slower yet for the smallest particles, the larger ones least affected.

But clay-sized minerals do not usually exist as small particles because they have been ground by natural processes. They are small because they have grown as crystals 'from the ground up,' so to speak. Their sizes are limited by the very slow kinetics that prevail in the low temperature environments in which they form, and by the high density of structural defects that would destabilize them as larger crystals. The particle size distribution curves for detrital minerals like quartz and the diagenetic clay minerals cross in the region of 2 to 4 μm. This leads to relatively pure concentrations of clay minerals in the clay-sized fraction, a quality clearly reflected in classification schemes. 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 techniques and gadgets. When we are just learning how to deal with these minerals as individuals, is this the time to de-emphasize the importance of their size?

So, why can not the definition of a mineral group be based upon particle size? If we link our definitions to important characteristics, why not ask which ones are most pertinent to our view of these materials today? Size as a defining characteristic is certainly apparent in neighboring disciplines. Activity of heterogeneous catalysts is a function of surface area or surface to volume ratio. Another indication that particle or crystallite size is increasingly recognized as a property that has direct influence on behavior can be seen in a recent special topic issue of *Science* that treated the burgeoning research into properties unique to nanometer-sized compounds (Service 1996). Are we ready to diminish the importance of size as others are increasing its importance?

If we accept the importance of size as a defining criterion, then perhaps our real problem is what to call minerals in the clay-size realm. We do need to have room for the hydrated oxides, zeolites and a few others. However, we need to keep firmly in mind that for the large majority of cases (Martin et al. 1991, opening sentence), the minerals we are dealing with are phyllosilicates. In addition, any accepted nomenclature must keep its connections with its immediate predecessors and with the usage in related disciplines. Therefore, a workable and satisfactory comfort level should be attainable using the term clay minerals to explicitly mean that the minerals so designated are mostly phyllosilicates with some exceptions, such as in some relatively uncommon soils.

To move on to my second criticism, I think, based on the material on plasticity and hardening on firing presented by Guggenheim and Martin (1995), that they have almost argued themselves out of using these as criteria for classifying a mineral as a clay mineral. There seem so many exceptions, so many materials that can have plasticity, for example, fine-grained fly ash, and so many that are truly clay-sized phyllosilicates that do not have plasticity, for example, flint clays and "some species of chlorite and mica" (Guggenheim and Martin 1995), that they seem thoroughly useless as criteria. And for "associated phases in clay," what of those that do not behave plastically or harden on firing, unless you include melting. These are good examples of terms that need to be replaced by terms more clearly reflecting our increasingly detailed insight into the characteristics of clay-sized minerals.

My third criticism is that by taking away the criterion of size and by re-emphasizing plasticity and hardening on firing, the committee has put unnecessary distance between our discipline and neighboring disciplines that can potentially damage our ability to communicate with them.

In summary, we need to recognize: 1) the inherent nature of meanings to change as our understanding changes, that change and variability are inevitable; 2) size is a primary characteristic, a characteristic that affects behaviors in a fundamental way; and 3) our responsibility to maintain "the channels along which the thought flows," not only for our own discipline but for neighboring disciplines.

ACKNOWLEDGMENTS

I gratefully acknowledge discussions and critical readings by G. Grathoff, R. Hughes and R. Reynolds.

Illinois State Geological Survey D. M. MOORE
615 E. Peabody Dr.
Champaign, IL 61820

REFERENCES

Bowen NL. 1928. The evolution of igneous rocks. Princeton, NJ: Princeton University Press. 334 p.

Folk RL. 1974. Petrology of sedimentary rocks. Austin, TX: Hemphill Publishing Co. 182 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.

Hock HH. 1991. Principles of historical linguistics, 2nd revised and updated edition. New York: Mouton de Gruyter. 744 p.

Martin RT, chair. 1991. Report of the Clay Minerals Society nomenclature committee. Revised classification of clay materials. Clays Clay Miner 39:333–335.

Service RF. 1996. Small clusters hit the big time. Science 271:920–922.

(Received 26 March 1996; accepted 3 May 1996; Ms. 2756)