

NOMENCLATURE FOR STACKING IN PHYLLOSILICATES: REPORT OF THE ASSOCIATION INTERNATIONALE POUR L'ETUDE DES ARGILES (AIPEA) NOMENCLATURE COMMITTEE FOR 2008

STEPHEN GUGGENHEIM^{1,*}, JOHN M. ADAMS², FAÏZA BERGAYA³, MARIA F. BRIGATTI⁴, VICTOR A. DRITS⁵,
MILTON L. L. FORMOSO⁶, EMILIO GALÁN⁷, TOSHIHIRO KOGURE⁸, HELGE STANJEK⁹, AND JOSEPH W. STUCKI¹⁰

¹ Chairman, AIPEA Nomenclature Committee, Department of Earth and Environmental Sciences, University of Illinois at Chicago, 845 W. Taylor St., Chicago, Illinois 60607, USA

² (*ex officio*, Principal Editor, *Clay Minerals*), Department of Engineering, School of Engineering and Computer Science, University of Exeter, Harrison Building, North Park Road, Exeter EX4 4QF, United Kingdom

³ Centre de Recherche de la Matière Divisée, CNRS (National Center of Scientific Research)-University of Orléans, 1b Rue de la Férollerie, 45 071 Orléans Cedex 2, France

⁴ Department of Earth Sciences, University of Modena, Largo S. Eufemia 19, I-41100, Modena, Italy

⁵ Geological Institute of the Russian Academy of Science, 7 Pyzerskii Per, Moscow J-17 Russia

⁶ 9500, Ave Bento Gonçalves, Campus do Vale, Instit. of Geosciences, University Federal do Rio Grande do Sul, Porto Alegre - RS - Brazil, CEP-91540-000

⁷ Departamento de Cristalografía y Mineralogía, Facultad de Química, Universidad de Sevilla, 41071 Sevilla, Spain

⁸ Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan

⁹ Clay and Interface Mineralogy, RWTH Aachen University, Wuellnerstr. 2, D52056 Aachen, Germany

¹⁰ (*ex officio*, Editor-in-Chief, *Clays and Clay Minerals*), Department of Natural Resources and Environmental Sciences, 1102 S. Goodwin Ave., University of Illinois, Urbana, Illinois, 61801, USA

Kogure and co-workers have published several papers reporting the stacking structures of various 2:1 layer phyllosilicates (*e.g.* aspidolite, Kogure *et al.* (2004); wonesite, Kogure *et al.* (2005); pyrophyllite, Kogure *et al.* (2006)), mainly by using high-resolution transmission electron microscopy (HR-TEM). However, there is ambiguity in wording that refers to the lateral displacement between two tetrahedral sheets across the interlayer regions. Zvyagin *et al.* (1969) used the symbol “ τ ” for this displacement, which describes the structures of pyrophyllite and talc, but no universally accepted wording was used for other 2:1 phyllosilicates or 1:1 phyllosilicates. Bailey (1984, p. 32) referred to the “layer offset” for this displacement in mica, but the original meaning of ‘layer offset’ can be taken as the ‘displacement’ to offset the *intralayer* shift of the 2:1 layer. A more precise meaning of these terms is needed that can be applied to not only the micas, but to other 2:1 layer phyllosilicates also. Recommendations are also included for 1:1 layers.

2:1 LAYERS

Discussion

The adjective ‘interlayer’ is ambiguous. Interlayer implies ‘the region between the two adjacent layers’ or ‘the relation between the two adjacent layers.’ Hence,

this adjective can be used for both the displacement at the interlayer region and relative displacement between the adjacent layers themselves.

An alternative is to use ‘interlayer displacement’ or ‘interlayer shift’ for the displacement only (Figure 1) between the two tetrahedral sheets across the interlayer region, as the counterpart of the intralayer displacement or intralayer shift in the 2:1 layer. In this case, the terms ‘layer displacement’ or ‘adjacent layer displacement’ (and not just ‘interlayer’) must be used to refer to the relative displacement between the adjacent layers, *i.e.* $-c(\cos\beta)/a$ for the *1M* polytype. In other words:

Layer displacement =

Intralayer displacement + Interlayer displacement.

Recommendation

The layer displacement for 2:1 layers is defined as the sum of the intralayer displacement and the interlayer displacement. The intralayer displacement refers to the intralayer shift of Bailey (1984, p. 32) of the upper tetrahedral sheet relative to the lower tetrahedral sheet of a 2:1 layer (as measured from the geometric centers of the ditrigonal rings and is ideally $a/3$). The interlayer displacement refers to the lateral displacement between the two tetrahedral sheets of adjacent 2:1 layers across the interlayer space. This displacement is measured either from the geometric centers of the ditrigonal rings or from the tetrahedral cations in adjacent layers, and is typically 0.02 Å in muscovite and 0.23 Å in paragonite (Bailey, 1984). Similarly, the interlayer distance (commonly based on the average *z* coordinate of the basal oxygen atoms) refers to the spacing between the two

* E-mail address of corresponding author:

xtal@uic.edu

DOI: 10.1346/CCMN.2009.0570112

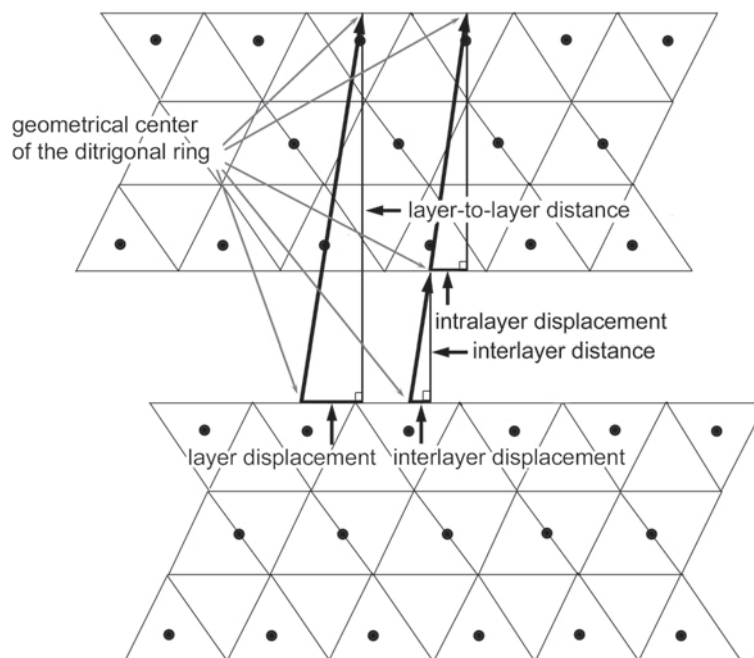


Figure 1. Illustration of the terms used in this report for 2:1 phyllosilicates. The view is down the [010] direction and no interlayer cation is shown for simplicity.

basal oxygen planes across the interlayer region. The “structure unit” is defined by Bailey (1980) as the total assemblage of the layer plus the interlayer. The layer-to-layer distance for a one-layer structure (Figure 1) is the distance consistent with the structure-unit definition. A two-layer structure would have twice the basal spacing compared to a one-layer (e.g. for mica-2M, basal spacing approximately equal to 20 Å, but a layer-to-layer distance consistent with the structure unit of ~10 Å). Finally, interlayer material refers to any substance between two basal oxygen planes across the interlayer region; see Guggenheim *et al.* (2006).

1:1 LAYERS

Discussion

For 1:1 layers, the layer displacement can also be defined as the relative lateral displacement between adjacent layers. However, Bailey (1988) termed this displacement “interlayer shift.” The definitions of an intralayer displacement and interlayer displacement in 1:1 layers, similar to those in 2:1 layers, are problematic, especially for trioctahedral cases, but in part also because there is no upper (tetrahedral) sheet to consider.

Recommendation

To avoid confusion and to maintain parallelism with 2:1 layers, the term ‘layer displacement’ should be used instead of ‘interlayer shift.’ The terms ‘adjacent layer displacement’ and ‘layer shift’ are equivalent to ‘layer displacement.’

REFERENCES

- Bailey, S.W. (1980) Structures of layer silicates. Pp. 1–124 in: *Crystal Structures of Clay Minerals and their X-ray Identification* (G.W. Brindley and G. Brown, editors). Monograph 5, Mineralogical Society, London.
- Bailey, S.W. (1984) Crystal chemistry of the true micas. Pp. 13–60 in: *Micas* (S.W. Bailey, editor). Reviews in Mineralogy, 13, Mineralogical Society of America, Washington, D.C.
- Bailey, S.W. (1988) Polytypism of 1:1 layer silicates. Pp. 13–60 in: *Hydrous Phyllosilicates (Exclusive of Micas)* (S.W. Bailey, editor). Reviews in Mineralogy, 19, Mineralogical Society of America, Washington, D.C.
- Guggenheim, S., Adams, J.M., Bain, D.C., Bergaya, F., Brigatti, M.F., Drits, V.A., Formoso, M.L.L., Galán, E., Kogure, T., and Stanjek, H. (2006) Summary of recommendations of nomenclature committees relevant to clay mineralogy: Report of the Association Internationale pour l’Etude des Argiles (AIPEA) Nomenclature Committee for 2006. *Clays and Clay Minerals*, 54, 761–772.
- Kogure, T., Banno, Y., and Miyawaki, R. (2004) Interlayer structure in aspidolite, the Na analogue of phlogopite. *European Journal of Mineralogy*, 16, 891–897.
- Kogure, T., Miyawaki, R., and Banno, Y. (2005) True structure of wonesite, an interlayer-deficient trioctahedral sodium mica. *American Mineralogist*, 90, 725–731.
- Kogure, T., Jige, M., Kameda, J., Yamagishi, A., and Kitagawa, R. (2006) Stacking structures in pyrophyllite revealed by high-resolution transmission electron microscopy (HRTEM). *American Mineralogist*, 91, 1293–1299.
- Zvyagin, B.B., Mishchenko, K.S., and Soboleva, S.V. (1969) Structure of pyrophyllite and talc in relation to the polytypes of mica-type minerals. *Soviet Physics-Crystallography*, 13, 511–515.

(Received 14 October 2008; Ms. 209)