DEBATE ABOUT IMPACTITE NOMENCLATURE – RECENT PROBLEMS. W. U. Reimold[1], J. W. Horton Jr.[2], and R.T. Schmitt[1], [1]Museum for Natural History (Mineralogy), Humboldt-University in Berlin, Invalidenstrasse 43, 10115 Berlin, Germany (e-mail uwe.reimold@museum.hu-berlin.de); [2]U.S. Geological Survey, 926A National Center, Reston, VA 20192, USA.

Introduction: Following several years of discussion of an informally proposed impactite nomenclature [1], Stöffler and Grieve (2007) [2] published the long awaited and immediately widely recognized proposal on impactite nomenclature on behalf of the IUGS Subcommission on the Systematics of Metamorphic Rocks. In the authors' own words, this proposed nomenclature represents "provisional results" of the subcommission's work. The classification comprises systematics of lithologic types generated in *single* as well as *multiple impacts*, with a particular subdivision for *proximal* and *distal impactites*. Already, the proposed terminology is being widely applied within the impact-cratering community, although with varied degrees of rigidity/flexibility. However, recent studies bring up specific problems that suggest that parts of the classification need revisiting.

Suevites: Significant debate has ensued as a consequence of two publications [3,4] promoting the idea that suevite from the Ries crater, for 50 years considered a melt-fragment-bearing impactite with an essentially clastic matrix ("particulate matrix" according to [2]), should rather be considered impact melt rock with a melt groundmass. This idea questions the validity of the term "suevite" (and by implication) the entire polymict-impact-breccia nomenclature of the IUGS subcommission.

Further suevite issues have arisen from the detailed studies of cores from two ICDP drilling projects in impact structures. First, drill cores LB-07A and LB–8A from the interior of the Bosumwti impact structure in Ghana [5,6] brought a series of impactites to the fore that seemingly comprises both suevite (with melt fragments) and lithic impact breccia (devoid of melt fragments). Melt-bearing and melt-free breccias were classified from thin section studies that imply that these two breccia types occur intimately intercalated – or that sampling for thin section production sometimes intersected a few small melt particles, sometimes not. This raises the question whether there should be a set minimum limit of melt abundance, such as 1 vol%, in order to distinguish bona fide suevite from polymict lithic impact breccias that do not have a melt fragment component at all.

Scale of classification: A related issue is how the nomenclature applies at scales larger than a meter for units on geologic maps, columns, and cross sections. This question arose from current efforts to prepare a geologic column for impactites drilled by ICDP/USGS in the moat of the Chesapeake Bay impact structure [7]. The general lithostratigraphic classification of units (>1 m) in parts of a ca. 154 m interval of impactites [8], based on macroscopic core examination and petrographic data from dozens of thin sections, locally differs from the classification of selected specific samples within these units based on detailed petrographic analysis. An issue was whether entire units in the lower part of this impactite interval (between 1,551 and 1,474 m depth) should be called "melt-poor suevite" where macroscopic melt particles are either absent or unconfirmed and only a small fraction of many samples studied in thin section contain rare microscopic melt particles and, thus, are suevite. The general term "polymict impact breccia" is being used for these geologic units [8], while individual samples are more specifically classified as lithic impact breccia or suevite, depending on the presence or absence of melt particles. "Polymict impact breccia" in Stöffler and Grieve's (2007) glossary and "polymict breccia" in their Table 2 are interchangeable variations of the same term, which their Table 2 shows to be a general category that encompasses both suevite (with cogenetic melt particles) and lithic impact breccia (without melt particles). Thus, if part of a large polymict impact breccia unit is suevite, this does not require all of it to be suevite.

Marine impactites: The Chesapeake Bay drill core also contains a thick sequence described as "sediment-clast breccia and sediment megablocks" [7], including the informally named Exmore beds or Exmore breccia [9, 10]. This sequence is interpreted to be related to avalanching and ocean resurge processes in the immediate period following the deposition of coherent impactite [10]. However, parts of this sequence contain shocked mineral grains, impact metamorphosed lithic clasts, and rare impact melt clasts; the latter could locally preclude the term "sediment-clast breccia" for melt-bearing zones and favor calling them "suevite." This entire sequence could well be considered a form of "impactite" [10], and parts are essentially a mixture of reworked shock-affected and impact-melted particles derived from within the transient impact crater with much larger volumes of unshocked resurge sediment from a wider region. This form of "secondary impactite" (formation or modification of impact breccias by or as an immediate consequence of marine impact, in general) is not considered by the proposed IUGS nomenclature of impactites.

Transitional lithology: Studies of Chesapeake Bay impact breccias and also of impactites recently procured in the SUBO 18 Enkingen borehole in the southern Ries crater [11] have indicated another serious issue: Like the suevites and lithic impact breccias from Bosumtwi and the lower part of the Chesapeake Bay impactite sequence, which seemingly are intercalated with locally gradational boundaries, there are 75 m of *suevites and impact melt rocks* in the Enkingen borehole that show a complex gradation from massive melt-matrix-dominated breccia to particulate, typical suevite with individual and well separated melt fragments (at vastly different proportions (<20% to >65%). In addition, there occurs a series of transitional types of melt-rich breccia, including a prominent "ignimbrite-like" assemblage of macroscopically welded melt fragments that are separated only by millimeter-wide seams of "suevitic" particulate groundmass. This transitional lithology between impact melt rock and suevite is clearly not recognized by the IUGS proposal. This obviously leads to the question whether [3,4] may have studied such melt-dominated material forming a pod or lens within regular suevite with a lithic/mineral clast-dominated, although melt-fragment-bearing groundmass.

Pseudotachylitic breccias: Finally, the proposed IUGS nomenclature for *impactites* also contributes to the "pseudotachylite" issue [12,13]. It refers to (ibid) "Shock veins and vein networks (previously termed "pseudotachylites") are formed during the compression stage, since they often occur as clasts within later formed breccia dykes" [2]. In Table 2 of this classification, this group of rocks falls into the compartment "Dykes, veins and vein networks," – which in the text is further subdivided to include impact breccia and shock vein occurrences. The cited definition clearly does away with the "pseudotachylite controversy" by reducing this term to only one meaning: shock melt veins produced during shock compression. Unfortunately, the glossary term attached to the IUGS nomenclature "Impact pseudotachylite (*Pseudotachylite* produced by *impact metamorphism*, Dyke-like breccia formed from frictional melting in the basement of impact craters, resulting often in irregular vein-like networks. Typically, it contains unshocked and shocked mineral and lithic clasts in a fine-grained aphanitic matrix, see also *melt vein*)" reopens the controversy by adding frictional genesis to the earlier shock melting genesis. The term "melt vein" is said to be synonymous to "shock vein".

Checking the IUGS nomenclature of *fault rock* terms [14], one finds ("fig. 2.3.1.") that pseudotachylite is classified under "cohesive fault rock". The IUGS nomenclature for *contact metamorphic rocks* [15] defines pseudotachylite as produced by "*frictional heating in fault zones*" (p. 9). The now quite old pseudotachylite problem is alive and well (see also various abstracts to this conference). Vredefort pseudotachylitic breccias are debated to be the result of shock melting, friction melting, or decompression melting, or whether they could represent influx of impact melt rock from the level of the crater floor.

Conclusion: This review of selected problems is likely not an exhaustive account of impactite nomenclature issues. However, it may suffice to demonstrate the importance of this subject, and the confusion that in all likelihood affects every impact worker. It is proposed to use the Large Meteorite Impacts IV conference for detailed discussion of these problems, and to attempt to prepare recommendations for consideration upon revision and finalization of the IUGS nomenclature of impactites.

References: [1] Stöffler, D. & Grieve, R.A.F., 1994, LPS XXV, 1347-1348; [2] http://www.bgs.ac.uk/SCMR/docs/papers/paper_11.pdf & http://www.bgs.ac.uk/SCMR/glossary2.html; [3] Osinski, G.R., 2003, MAPS 38, 1641-1668; [4] Osinski, G.R., 2004, EPSL 226, 529-543; [5] Coney, L. et al., 2006, MAPS 42, 569-589; [6] Ferrière, L. et al., 2006, MAPS 42, 611-633; [7] Gohn, G. et al., 2006, EOS 87, No. 35, 29 August 2006, 3pp.; [8] Horton, J.W. Jr. et al., this volume; [9] Poag, W. et al., 2004, The Chesapeake Bay Crater, Springer, Berlin-Heidelberg, 522pp.; [10] Horton, J.W. Jr. et al., 2008, GSA SP 437; [11] Phl, J. et al., this volume; [12] Reimold, W.U. & Gibson, R.L., 2005, Impact Tectonics, Springer, Berlin-Heidelberg, pp. 1-53; [13] Reimold, W.U. & Gibson, R.L., Chemie der Erde 66, 1-35; [14] http://www.bgs.ac.uk/SCMR/docs/papers/paper_3.pdf;[15] http://www.bgs.ac.uk/SCMR/docs/papers/paper_10.pdf