**COMMENTS AND REPLIES**

**Online: *GSA Today*, Comments and Replies**
**Published Online: July 2009**

# Reply

## Lithostratigraphy for Quaternary glacial deposits: "If it ain't broke, don't fix it!"

***M.E. Räsänen,*** *Dept. of Geology, University of Turku, 20014 Turku, Finland, matti.rasanen@utu.fi;* ***J.M. Auri,*** *Geological Survey of Finland, Vaasantie 6, 67100 Kokkola, Finland;* ***J.V. Huitti, A.K. Klap,*** *Dept. of Geology, University of Turku, 20014 Turku, Finland; and* ***J.J. Virtasalo,*** *Dept. of Marine Geology, Leibniz Institute for Baltic Sea Research, Warnemünde, Seestrasse 15, D-18119 Rostock, Germany*

We thank Johnson et al. for their comments, which can be condensed into two central themes: (1) the level of lithological homogeneity of a lithostratigraphic formation, and (2) the difficulty of separating regional unconformities from local unconformities in Quaternary glacial strata.

These are not totally new arguments. In 1984, Eyles et al. discussed the lithological homogeneity of North American till beds and stressed the importance of lithofacies analyses for studying facies associations in order to reconstruct glacial depositional systems, instead of doing lithostratigraphy. Schultz (1982) and Gutteridge (2008) provided examples of how high lithological heterogeneity becomes a problem when lithostratigraphy is used and why unconformity-bounded units could be used instead. Murphy commented (1988) and Salvador replied (1988) on the general identification and nature of unconformities after the publication of a note on unconformity-bounded units by the International Stratigraphical Commission.

Although we are partly repeating these earlier discussions, we feel it necessary. While Eyles et al. (1984) pointed out the importance of depositional systems, we go one step further and propose that the combined use of allostratigraphy and lithostratigraphy (CUAL) would, in practice, be one possible formal stratigraphic method with descriptive terminology by which depositional systems could be outlined as allostratigraphic units.

Johnson et al. state that we display a commonly held misunderstanding about the use of lithostratigraphy and that nowhere in the North American Code of Stratigraphic Nomenclature (NACSN) is there a requirement for lithological homogeneity. We think, however, that the spirit and intentions of the International Stratigraphic Guide and the NACSN are similar and that some sort of identifiable homogeneity or unity in a lithostratigraphic formation is necessary to make lithocorrelation possible.

The International Stratigraphical Guide (Salvador, 1994, p. 32) states, "The critical requirement of the unit is the substantial degree of lithologic homogeneity (diversity in detail may in itself constitute a form of overall lithologic unity)." Likewise, the NACSN [2005, article 24, remark (a)] states, "The limits of a formation normally are those surfaces of lithic change that give it the greatest practicable unity of constitution," and [article 24, remark (b)], "A formation should possess some degree of internal lithic homogeneity or distinctive lithic features. It may contain between its upper and lower limits (i) rock of one lithic type, (ii) repetitions of two or more lithic types, or (iii) extreme lithic heterogeneity that itself may constitute a form of unity when compared to the adjacent rock units."

It is true that the Midwest is an ideal region for lithostratigraphy. But even there the stratigraphic record is, as characterized by Ager (1973), "more gap than record." So why not use all the available empirical data to build up a stratigraphic classification and framework? The characteristics of unconformities would then be taken into account to give a hierarchy for the units in the framework. These characteristics, with their related soil horizons and other features, are *implicitly* taken into account when lithostratigraphic units are defined. Yet, this is not *explicitly* shown in lithostratigraphic frameworks (e.g., the Minnesota state Geological Survey [MGS], British Geological Survey [BGS], and Deltares frameworks). Giving regional and local unconformities the importance they have in the stratigraphic packages would result in a more informative framework. Even Midwest stratigraphy would benefit from this approach.

Johnson et al. take issue with our characterization of the MGS approach as a loose use of lithostratigraphy. We do this because, along with the initial MGS principles, its additional requirement 2 that "most non-diamicton units will be included within the same formation as the diamicton to which it is compositionally and stratigraphically related" further increases the lithologic heterogeneity of their formations (Johnson et al. 2005). In the CUAL scheme, the unconformity-bounded diamictons and non-diamicton units would be part of an alloformation (Figs. 1 and 4–6 in Räsänen et al. [2009]). So, in practice, the MGS and CUAL approaches make the same deductive interpretation on the basis of general glacial sequence stratigraphic thinking in order to lump the deposits together in a reasonable manner.

Johnson et al. note that it would be difficult to decide in the field which unconformities are significant enough to define alloformations. We agree that glacial stratigraphy is complicated, but at the same time we point out that decisions on how to classify strata are not made in the field but rather after acquisition of a considerable body of regional stratigraphic data. Regional unconformities have a higher probability of having developed within certain facies associations and more

often include such features as paleosols, cryoturbation, and ichnofacies than do the local unconformities formed by, for instance, pure glacial dynamics. Regional unconformities differ from local unconformities in the same manner as regressive surfaces of erosion in coastal deposits differ from transgressive wave and tidal ravinement surfaces. In addition, the occasional use of correlative lithology to follow up the unconformities does not turn the CUAL approach into pure lithostratigraphy (cf. Murphy, 1988; Salvador, 1988).

Johnson et al. also state that we imply that geologists should select a certain classification approach. We review the different approaches because they have stratigraphic connotations and it is important to show how much they overlap. If we do stratigraphy, we should attempt to develop a common language; that is why guides and codes are written. It is important to realize that the unnecessary segregation (even isolation) of the European research community in particular into schools of geologists, Quaternary geologists, and physical geographers is the source of much of this multiple stratigraphic terminology and methodology.

## REFERENCES CITED


Ager, D.V. 1973, The nature of stratigraphic record: New York, John Wiley, 114 p.

Eyles, N., Miall, A.D., and Eyles, C.H., 1984, Lithofacies types and vertical profile models; an alternative approach to the description and environmental interpretation of glacial diamict and diamictite sequences, Reply: Sedimentology, v. 31, p. 883–898.

Gutteridge, P., 2008, Who needs lithostratigraphy?: Geoscientist: v. 18, no. 3, http://www.geolsoc.org.uk/page3249_en.html.

Johnson, M.D., Harris, K. L., Hobbs, H.C., Jennings, C.E., Knaeble, A.R., Lusardi, B.A., and Meyer, G.N., 2005, Formal Quaternary lithostratigraphy of Minnesota; a progress report [abs]: Geological Society of America Abstracts with Programs, v. 37, no. 5, p. 91.

Murphy, M.A. 1988, Unconformity-bounded stratigraphical units: Discussion: Geological Society of America Bulletin, v. 100, p. 155.

North American Commission for Stratigraphic Nomenclature, 2005, North American Stratigraphic Code: AAPG Bulletin, v. 89, p. 1547–1591.

Räsänen, M-E., Auri, J.M., Huitti, J.V., Klap, A.K., and Virtasalo, J.J., 2009, A shift from lithostratigraphic to allostratigraphic classification of Quaternary glacial deposits: GSA Today, v. 19, no. 2, p. 4–11, doi: 10.1130/GSATG20A.1.

Salvador, A., 1988, Reply: Unconformity-bounded stratigraphical units: Discussion: Geological Society of America Bulletin, v. 100, p. 156.

Salvador, A., editor, 1994, International Stratigraphic Guide: The International Union of Geological Sciences and the Geological Society of America, 214 p.

Schultz, E.H., 1982, The chronosome and supersome: Terms proposed for low-rank chronostratigraphic units: Canadian Petroleum Geology, v. 30, p. 29–33.