KIRK BRYAN AWARD

Presented to John C. Ridge

with John C. Ridge, Greg Balco, Robert L. Bayless, Catherine C. Beck, Laura B. Carter, Jody L. Dean, Emily B. Voytek, Jeremy H. Wei

For
"**The new North American varve chronology: a precise record of southeastern Laurentide Ice Sheet deglaciation and climate, 18.2–12.5 kyr BP, and correlations with Greenland ice core records**" 2012, American Journal of Science 312: 685-722.

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Citation by Gail M. Ashley

This is a truly an outstanding paper that represents major advancements in the fields of both Quaternary geology and geomorphology (the corner stones of the Division).

The paper is concise, well written and the concepts and results summarized clearly. It represents over two decades of meticulous field and laboratory work and yet the data are synthesized and presented in just a few diagrams. The paper summarizes nearly 6000 years represented by the North American Varve Chronology (NAVC). I highlight below what I think are the 6 major contributions of this landmark publication:

(1) *An interdisciplinary approach to collection and integration of data.* The paper was based on the knowledge of local and regional field relations of glacial deposits in a vast area from southern Connecticut to Quebec. It required the integration of geomorphology, sedimentology, stratigraphy and glacial geology on a range of temporal and spatial scales.

(2) *Best practices in sedimentology.* The basis of the chronology is ultimately the varved sediments, annual deposits accumulated in lakes from glacial meltwater. The paper presents beautiful, high-resolution photos of the sediments. The close-ups of the laminae show the inter-annular variability at different locations. No two varves are alike, but the rhythmic beat of the annual cycle is clearly depicted and reflects the sedimentation processes that formed them. The detailed logs of the varves are the paper's key data source.

(3) *Best practices in stratigraphy.* The varves in New England were recorded and compiled by Ernst Antevs (1922). But, his record was "floating" and there were gaps, some minor errors, and there was a general lack of confidence in his findings because of the paucity of independent dating. Ridge and co-authors revised the NAVC, established a credible record by using cores combined with outcrop data and radiocarbon dates. They corrected the errors in Antev's record, closed a major gap and extended the record by ~1000 years. Using detailed logs of varves and basic principles of stratigraphy, the record now reaches 5,659 continuous years spanning most of the last deglaciation.

(4) *Interpretation of Laurentide Ice Sheet dynamics.* The precise chronology (within ~ a decade) represented by the NAVC has opened doors to interpreting both the environment in which the varves formed (dynamics of the northeastern portion of Laurentide Ice Sheet), as well as other records associated with deglaciation, such as local climate changes, sea level rise, moraine belts, re-vegetation of the landscape, migration of animals, and arrival of humans.

(5) *Potential for determining the response of Northern Hemisphere ice sheets to climate change.* One of the extraordinary outcomes of the American Journal of Science paper is the potential for correlation of the NAVC to the Greenland Ice Core record. Comparison of varve thickness records with Greenland ice-core climate records show that after 15,000 yr BP, climate changes of sub-century and longer scales recorded in both records appear identical and synchronous indicating there was a link between North Atlantic climate and marginal processes of the southeastern sector of the Laurentide Ice Sheet. Prior to 15,000 yr BP the correlation is not as strong suggesting dominance by local factors.

(6) *The varve record is a yard stick against which future climate change can be compared.* With the planet warming, modern ice sheets will likely contribute to eustatic sea level rise, but how much and at what rate is debated. The NAVC record and its tight correlation to the Greenland Ice Core record makes it a valuable tool to guide predictions of future sea level rise.

In summary, the Ridge et al. 2012 publication in AJS is a paper of great distinction advancing the sciences of geomorphology and Quaternary geology. Built on over 2 decades of research and presented in a clear readable document, this publication will have impact on our science for years to come. It is most deserving of the QG&G Kirk Bryan Award.

Response by John C. Ridge

Thank you, Gail for your very kind words. It is both a great honor and a humbling experience to receive the Kirk Bryan Award and we thank the Quaternary Geology and Geomorphology Division for making this award possible. Our gratitude goes to the people and organizations that made our work possible. We would like to thank the National Science Foundation and the drillers of the U.S. Geological Survey, especially Glen Berwick, Eugene Cobbs, and Jeff Grey. Also, Carl Koteff of the USGS and former New Hampshire State Geologist Gene Boudette both supported field mapping in southwestern New Hampshire that would prove to be invaluable in finding critical drilling sites. Our paper was the culmination many smaller studies over the last 25 years, mostly by undergraduate students at Tufts. They put the pieces in place that would be critical to turning the original New England Varve Chronology into a continuous, calibrated sequence.

I am thankful for the recognition our paper has received, but not just for the scientific merit that it may have. The *American Journal of Science* and its editors allowed us to pursue other objectives as well. First, it is our hope that the paper will provoke interest in varve chronology in North America, which has been under-utilized for too long. There are many untapped reservoirs of varves that would lend themselves to glacial stratigraphy. Varves are more than just a time scale because they can dovetail with many other types of investigations, including: radiocarbon chronology, precise ages and rates of deglaciation, variations in weather and climate, correlation with ice core records, paleomagnetic stratigraphy, cosmogenic nuclide dating of deglaciation, and the chronology of trace and microfossils. We have only scratched the surface in these endeavors, even in New England where glacial lakes and long varve sequences are abundant and well studied.

Another objective was to write a paper that would be a widely-read educational publication. As much as possible, we hope the paper will inspire budding "varve-ologists" and inform the Quaternary community of the relevance of varve studies.

A final objective was to provide an historical perspective on glacial varve chronology in North America. After the formulation of the New England Varve Chronology in the 1920s by Ernst Antevs, and before the full value of the chronology could be appreciated, it was mostly rejected in the U.S. as an accurate time scale. In fact, mention and references to the New England Varve Chronology were not included in the later two editions of Richard Foster Flint's textbooks on glacial geology. It was a time when varve chronology seemed to be incompatible with the first radiocarbon ages from New England.

There were several scientists whose work advocated for acceptance of the varve chronology, but they were largely ignored by the Quaternary community. Beginning in 1938, geophysicists used the varve chronology to assemble paleomagnetic records. Most noteworthy is the work of Alvin McNish, Ellis Johnson, Oscar Torreson, and Thomas Murphy that was later refined by Ken Verosub. In the 1970s Gail Ashley also published what is still the definitive paper on the sedimentology of varves in the Connecticut Valley and at a time when skepticism regarding varves was high and there were few women in the field.

When I started my career at Tufts, although I had heard about the New England Varve Chronology and was intrigued by it, I didn't arrive with the idea of studying varve chronology. However, I had the good fortune of being a friend of Fred Larsen (now emeritus) at Norwich University in Vermont. Fred contacted me in 1988 saying, "Jack, I found the Rosetta Stone!" The Rosetta Stone turned out to be a 20-meter excavation for tennis court material in a clay pit with over 600 varves along Canoe Brook in Dummerston, Vermont. With Fred's encouragement we measured the section and matched it exactly to Ernst Antevs' chronology. We published the record along with the first radiocarbon ages from New England varves in the *GSA Bulletin*. Shortly afterward I received a letter from Dick Goldthwait, praising us for our work and also making it known that he had fond memories as a teenager of helping Ernst Antevs assemble his varve records in the attic of his parents' home in Hanover, New Hampshire.

I have also been lucky in another respect. I had colleagues in the Geology Department at Tufts, especially Charlie Stearns and Bert Reuss, who encouraged me to pursue varves as an avenue of research despite negative attitudes about varves in New England. The science seemed solid and as Charlie Stearns once told me: His PhD advisor at Harvard, Kirk Bryan, always thought varves were a great idea and that Antevs' varve chronology should not be dismissed.

We often admire some past geologist's work as being brilliant, but frequently qualify our accolades in light of past academic training and older technology. For me this person is Ernst Antevs, but I do not have to qualify my admiration. He arrived in America from Sweden in 1920 with his mentor Gerard De Geer. By 1922 Antevs published 90% of the New England Varve Chronology with field measurement of 101 varve sections in New England and New York. By 1931 he had formulated almost all the other glacial varve sequences that we have today across the United States and Canada. In his free time Antevs published a book on the alpine vegetation zones of the White Mountains in New Hampshire and wrote articles on the Pleistocene of the Great Basin, dendrochronology, and the pattern of glacial isostasy in New England. All of these investigations have been improved since Antevs' time but his work on varves still stands. In the 1930s Ernst Antevs moved to a ranch in Arizona where he and Kirk Bryan shared an interest in the climate change chronology of the Southwest as it related to postglacial archaeology. It seems fitting that Ernst Antevs receive recognition and our paper is dedicated to him and his work on varves.

Again, the Kirk Bryan Award is a tremendous honor and on behalf of my co-authors I thank all those who nominated our paper and the Quaternary Geology and Geomorphology Division for recognizing our work.