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Editorial

Preface: The Nickelsen–Groshong volume: Low-temperature deformation mechanisms and their interpretation

In 1994 the Structural Geology and Tectonics Division of the Geological Society of America honored Prof. Richard P. Nickelsen of Bucknell University with the Career Contribution Award. The fact that he is the only recipient to date from a predominantly undergraduate institution testifies to the magnitude of this accomplishment without the ancillary support of graduate student research around which most successful big-time research university careers are built. The success of Dick's career is, arguably, reflected in the undergraduates that he mentored over the years with Richard H. Groshong being one shining example. Shortly after Rick arrived at Bucknell in the fall of 1961, Dick introduced him to low-temperature deformation mechanisms in the Appalachian Mountains, a passion both carried through their careers. The structures that best symbolize the confluence of Dick's career with that of his student, Rick, are fourth order folds in limestone between shale beds from the Silurian Mifflintown Formation in the north flank to the White Deer Ridge Anticline (Fig. 2). Dick brought these folds to Rick's attention and they became the focus of Rick's Ph.D. thesis at Brown. With this volume we wish to honor the careers of both scholars with a series of papers concerning their favorite subject, low-temperature deformation in forelands of the world (Fig. 1). To this end we introduce this volume with a detailed review of both careers.

Richard P. Nickelsen

Dick Nickelsen came to geology at Dartmouth College and went on to hone his eye for detailed structural studies under the mentorship of Ernst Cloos at Johns Hopkins University. There he unraveled the structural and stratigraphic relationships of low-grade metasedimentary rocks in the Blue Ridge near Harpers Ferry WV and VA. During his faculty appointment at Penn State, Nickelsen began mapping fracture patterns over more than twenty quadrangles on the Appalachian Plateau. He found a remarkable difference between fracture patterns in coal and in other clastic rocks. This work showed the possibilities for a higher resolution in structural history of the Appalachian foreland basin and stimulated a groundswell of interest in the mechanical and tectonic information locked up in fracture arrays in mildly deformed sedimentary rocks.

Dick was at the forefront of the deformation mechanism revolution of the 1970s. He was one of the first scientists to characterize the microstructural evidence of pressure solution in sedimentary rocks, noting truncation relationships and concentrations of relatively insoluble residues in cleavage planes. He placed cleavage development in sedimentary rocks on the same continuum as slaty cleavage development, challenging the then favored hypothesis of soft sediment slaty cleavage development.

The Bear Valley strip mine in the Middle Anthracite Region provided a superb, three dimensional laboratory to test his early ideas about the sequence of formation of joints, rock cleavage, faults and folds that had arisen in his study of the mildly deformed rocks of the Appalachian Plateau. Over a seventeen-year period Nickelsen mapped all the exposed mesoscopic structures and carefully teased out a six-phase sequence of progressive deformation based on cross cutting relationships and orientation analyses. Part of what makes the Bear Valley study so special is that all of the observed structures formed during one orogeny and it is a wonderful case study of the myriad of structures that form before, during and after folding of strata.

Perhaps Nickelsen's happiest moments in the field were spent in central southern Norway, where he spent five field seasons mapping complex, and as it turns out thoroughly misunderstood, structural relationships in low-grade metasedimentary rocks. In classic Nickelsen style, his reexamination of the stratigraphic relationships while conducting structural mapping, led to a complete reevaluation of the structural and stratigraphic position of the Valdres Group sparagmites and major changes in the geologic map of Norway.

In recent years, Nickelsen's research has turned to mapping folded faults, primarily in the southern part of the Pennsylvania salient. As he mapped décollements in this system, he recognized a remarkable fault zone structure in the carbon rich shales of the Appalachian foreland basin. By comparing fault zone development at different localities and degrees of development, he was able to develop a theory for the development of cleavage duplexes that facilitate thrust sheet transport. During his campaign to better understand the fault structure of the Valley and Ridge, he has completely mapped numerous quadrangles, working out the kinematics of overprinting fault systems. Dick recognized that fault zones of different ages have distinctively different textural properties making them distinguishable in the field. The deceptively simple linear ridges of the Valley and Ridge are much more complicated than previously thought. Some of the ridges are held up by 100 m wide en echelon fault blocks, the product of non-coaxial folding of thrust duplexes. Other ridges appear to have undergone dramatic lateral extension by strike slip faulting. And as it turns out, the valleys are no less complex.

During his four decades of teaching at Bucknell University, Dick's gifted teaching enlightened generations of liberal arts and

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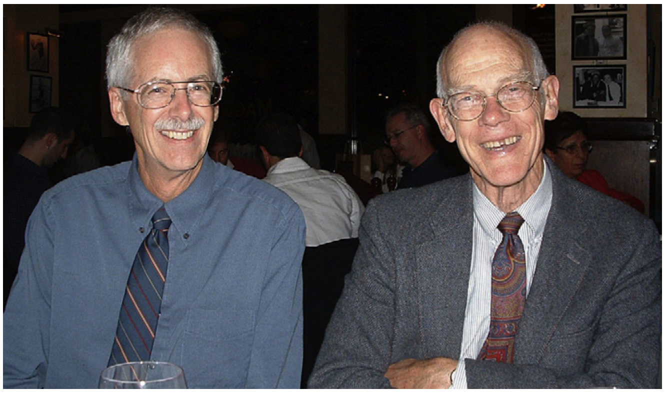

Fig. 1. Richard H Groshong and Richard P. Nickelsen at the 2006 GSA in Philadelphia.

engineering students, and of course inspired many undergraduate geology students (such as honoree Rick Groshong) who went on to rewarding careers as geoscientists. He has taught courses for major energy research groups, made regular presentations and field trips for the stone and aggregate industry, gave short courses for K-12 teachers, and led countless informal trips for visiting student research groups. He made a habit of sharing his structural studies with geoscientists of all stripes, leading numerous field conferences with rich guidebooks that serve as excellent resources for field geologists today. A dedicated environmentalist, he has consistently welcomed opportunities to alert others to the importance of geology in environmental issues.

Richard H. Groshong

Rick Groshong's formal training in geology started at Bucknell University (B.S. 1965), where he had the tremendous good fortune to be turned on to geology by Dick Nickelsen. Jack Allen taught Rick crystallography, which also turned out to be critical to Rick's dissertation research. This taught Rick that one never knows what skill will be crucial to future work. Rick went on to the University of Texas at Austin (M.A. 1967) where he mapped joints along the Llano uplift under the supervision of Robert E. Boyer. At Texas he realized that he needed to understand mechanics and headed to Brown University (Ph.D. 1971) to study with William Chapple, who was then working on the mechanics of buckle folding. Out of this research arose the twinned-calcite strain gauge technique and the realization that the grain–strain in the folds was far too small because much of the strain was by pressure solution. The strain gauge method grew from concepts in the unpublished dissertation of James Conel, known to Bill Chapple because they had been students together under Barkley Kamb at Caltech.

Fig. 2. Fold at White Deer.

Rick went on to become an Assistant Professor at Syracuse University for three years where as part of a survey of classical east-coast microstructure localities he discovered that the "soft-sediment" cleavage of the Martinsburg slate was instead the result of strain and pressure solution. He then moved to the oil industry where he worked in the Cities Service Oil Company research laboratory for a decade (1973–1983). Rick established a clay modeling laboratory, a technique he had learned as an undergraduate from Dick, who in turn had learned it from Ernst Cloos. The Cities lab had a first class group of structural geologists with strong backgrounds in mechanics. They recognized that to solve exploration and development problems, they needed a thorough knowledge of well-documented structural geometries and practical tools for the prediction and validation of structures. Rick's research moved toward structural styles and kinematic modeling.

The next 20 years of his career were spent at the University of Alabama where much of his research focused on the connection between meso- and micro-scale strain and map-scale structure as exemplified by the work of doctoral students Schuman Wu, David Ferrill, and Betsy Dransfield Torrez. Rick's personal deformation mechanism work culminated in a widely cited GSA Centennial review paper. He developed relationships between layer-parallel strain and fold-fault geometry in the oblique-simple shear kinematic model, and explored connections between layer-parallel strain, displaced area, and depth to detachment with postdoc Jean-Luc Epard. Another interest in salt piercement structures is reflected in the dissertations of Roger Brewer and Hongwei Yin. In the early 1990s he began a fruitful collaboration with Jack Pashin of the Geological Survey of Alabama to develop detailed 3D structural interpretations from well-log data in the mature hydrocarbon provinces of the northern Gulf of Mexico and the Black Warrior basin of the southern Appalachians. This work led to a best-paper award with postdoc Jaifu Qi, the dissertation of Guohai Jin, numerous MS theses, and Rick's textbook on 3D structural geology.

Rick was co-founder of the GSA Structure-Tectonics Division, serving as its first secretary-treasurer and later as chairman. He also co-founded the informal Appalachian Tectonic-Studies Group, which has an annual field trip to foster exchanges on Appalachian geology. Teaching structural geology has always been integral to Rick's research, summarizing the best of what is already known and identifying what remains to be done. His graduate seminars in comparative structural geology and mapping subsurface structures were popular with Alabama students and continue to be sought out by oil-industry employees.

In honor of his work and retirement in 2003 to become Professor Emeritus at the University of Alabama, a Special Session was organized for the 2006 Geological Society of America Meeting in Philadelphia titled "Deformation in Sedimentary Rocks – A Tribute to Richard H. Groshong, Jr." This Special Issue of the Journal of Structural Geology is an outgrowth of that Special Session and is dedicated to Richard H. Groshong, Jr. and his mentor at Bucknell, Richard P. Nickelsen, both of whom have had major positive influences on our understanding of low-temperature deformation mechanisms and their interpretation in the Appalachians and around the world (Figs. 1 and 2).

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