CONFERENCE REPORT

A Symposium in Honour of Gerard V. Middleton: GeoConvention, Calgary, June 21, 2022

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Gerard Middleton, Emeritus Professor at McMaster University, passed away on 2nd November 2021 at the age of 90. Gerry, as he was happy to be called, was one of the first geologists in Canada to "self-identify" as a sedimentologist, although he started his career as a paleontologist working on Devonian carbonate sediments. He arrived at McMaster University in 1955, and soon switched to sedimentary geochemistry, and then to the study of clastic sedimentary processes, a field that, at that time, could be said to have not even reached the stage of infancy. In the 1960s and 1970s Gerry made fundamental advances in our understanding of sediment transport and the identification, classification and interpretation of hydrodynamic sedimentary structures and sediment gravity flows (a term Gerry coined). Gerry retired in 1996, and a special issue of this journal (v. 24, #1, 1997), under the editorship of then editor Roger Macqueen, was dedicated to his lifetime contributions as researcher, author and editor. Gerard's career and his substantial contributions to the progress of the geosciences in Canada are also expertly summarized in the obituary Bob Dalrymple and Janok Bhattacharya (2021) published in Geoscience Canada.

We now have a certain perspective with which to look back on Gerry's contributions to the science of sedimentology and assess their significance, and it is fair to say that he was at the centre of several of the most fundamental breakthroughs in our understanding of clastic sedimentary processes. The GeoConvention 2022 symposium was designed to focus on these developments, and the advances that have been made, based on his research, by his former students and associates, and by others who have benefited intellectually from his long-lasting influence. His many other contributions to the life and work of Canadian geoscience are ably summarized by Dalrymple and Bhattacharya (2021).

John Southard, of MIT, was invited to present some opening remarks to the symposium from his office, via Zoom. His personal reminiscences of working with Gerry, and the research they initiated in the field of sediment hydraulics helped to put the history and development of the field into perspective, and we enjoyed some of the personal stories of two productive researchers working together to essentially create an entire new field of sedimentology.

A truly successful research professor is one who can inspire students, and several of the speakers at this symposium (Dalrymple, Bhattacharya, Plint, Leckie and Arnott) were privileged to have been part of the large body of students who passed through the McMaster "school" of sedimentology in the 1970s, led by Gerry and his colleague, Roger Walker. Dalrymple was supervised by Gerry; Bhattacharya and Leckie by Walker; Plint was a post-doctoral fellow working with Roger Walker, and Arnott an undergraduate. For at least two decades, the 1970s and 1980s, the Middleton-Walker school was arguably one of the top two truly "world class" (a much overused term) places to do sedimentary geology; its only real rival, Oxford University, was led by Harold Reading. Readers of this journal will not need to be reminded of the amazing success of the famous "Facies Models" volume produced as a result of the collaborative work of Middleton and Walker. Gerry used to like to remind audiences that although Walker was the founder and editor of the "Facies Models" project, it was he, Gerry, who wrote the first ever textbook summary of facies models that appeared in the first edition of the Blatt, Middleton and Murray textbook, published in 1972.

It is not necessary to be a formal member of a research group to benefit from its influence. In my case, I became aware of the importance of McMaster University from the distance of Calgary, as a research scientist with the Geological Survey of Canada and made my first visit there as a seminar speaker in 1975. Later, I worked as Program Chair for the Sedimentology Congress that Gerry organized and chaired at McMaster University in 1982 on behalf of the International Association of Sedimentologists. I served as graduate advisor or examiner on several of the McMaster doctoral committees through this period, and always valued my involvement with the team.

The two additional speakers, Bell and Englert, represent that huge body of researchers whose science ultimately stemmed from the advances initiated by Gerry, through the body of work carried out by his successors and colleagues world-wide. The study of sediment gravity flows and submarine fans, and turbidites systems in general, exploded in the 1980s, largely as a result of the widespread use of submarine sonar methods and advanced seafloor coring, and the growing importance of deep-water sediments as petroleum reservoirs. But Middleton's major contributions, in particular his original

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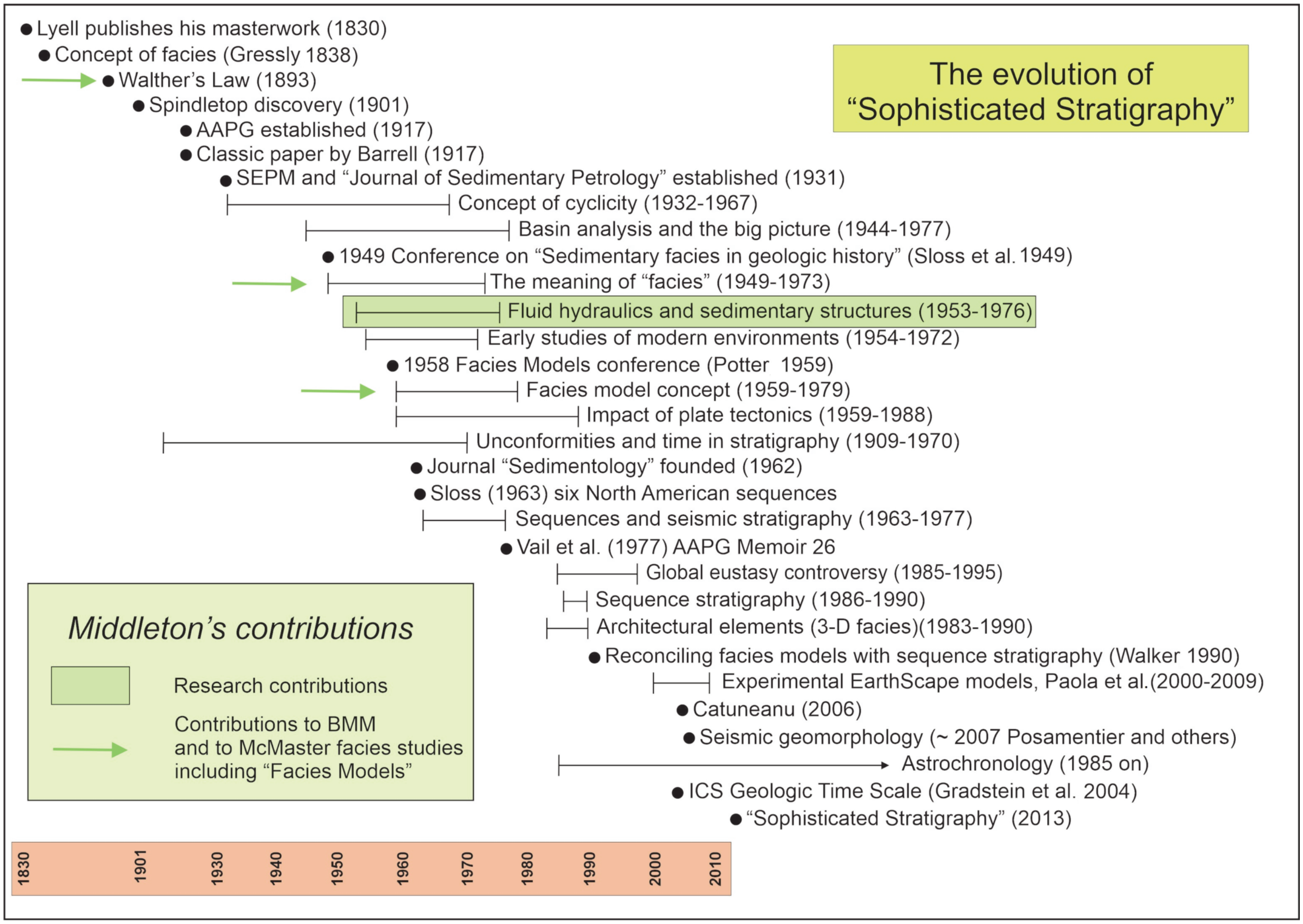

Figure 1. The development of the major components of modern stratigraphy, with Gerard Middleton's major contributions shown in green. BMM = the textbook authored by Blatt, Middleton and Murray; AAPG = American Association of Petroleum Geologists; SEPM = Society for Sedimentary Geology. Diagram adapted from Miall (2022).

classification of sediment gravity flows, which is now almost 50 years old, remained central to this work. These two speakers, a post-doctoral fellow and doctoral student, respectively, studying with Steve Hubbert at the University of Calgary, provided two good examples of how our depth of knowledge of a specialized field can be successfully expanded and made more complete by the healthy growth of intellectual scholarship.

For students of the methods of science, then, this symposium could provide an excellent example of a path diagram or Venn Diagram, summarizing how science advances and scholarship succeeds by the sharing and building of accomplishments on the successes of others. Abstracts of all the papers presented are available at the GeoConvention website, www.geoconvention.com.

To turn to the specifics, I kicked off the morning session with a presentation that, first, summarized Gerry's major intellectual contributions, and then turned to a particular specialized interest of his. I showed these two diagrams (Figures 1 and 2), designed to put his contributions in perspective relative to the broader developments in sedimentology and related fields that have led to the modern science of what I like to call "sophisticated stratigraphy." Gerry's fascination with "processes" was particularly important in establishing the methods of facies analysis, in part by his translation from the German and promotion of what became one of the founding principles of facies methods — Walther's law. This is the principle that "*Environments found side-by-side in nature are represented in the same order in vertical profile.*" In terms of his own research, his experimental work with turbidity currents and his introduction of flow-regime concepts to sedimentary geology were fundamental to the methods and principles of facies analysis.

Gerry believed in the value and importance of quantitative methods, and he wrote and lectured extensively on the topic of sediment mechanics. In the 1990s he became intrigued by the emerging field of fractals. The fractal model is characterized by the self-similarity of objects and processes operating over a wide range of physical scales and time scales. A good example of a fractal distribution in sedimentary geology is that demonstrated by the body of data assembled and illustrated graphically by Pete Sadler in 1981 revealing the relationship between the elapsed time represented by the deposition of a strati-

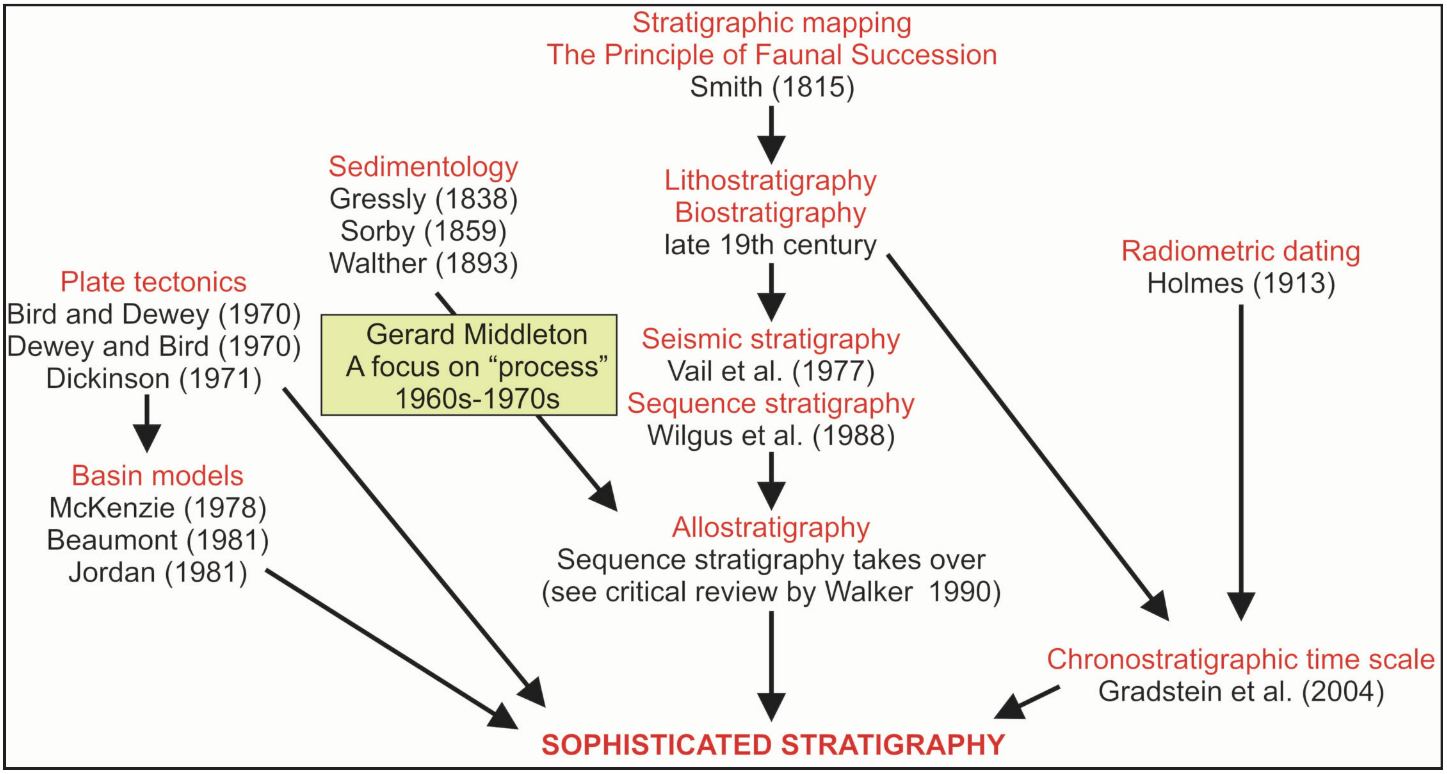

Figure 2. The major components of modern "Sophisticated Stratigraphy", and their integration into our modern science. Middleton's major contributions lay in his interests in sedimentological process studies. Diagram adapted from Miall (2022).

graphic succession and the sedimentation rate that can be calculated from that section. The relationship between the two parameters is linear on a log-log scale; what is called a "power law" relationship. Although published as long ago as 1981, this relationship has never been properly explained in proper Middletonian terms, that is to say, by an explanation in terms of sedimentary processes. Some of my recent work has been to assemble the data documenting how sedimentary processes operating over some fifteen orders of magnitude of time scale would readily explain Sadler's data, and this, in turn, led, in a paper jointly written with Janok Bhattacharya and John Holbrook, to the presentation and description of a simple graphical device designed to explain the "Stratigraphy Machine" that makes sedimentary successions in nature.

One of the outcomes of this work to explore what has become called the "Sadler effect" has been an increased interest in the significance of sedimentary breaks in the stratigraphic record. Breaks on all scales, representing anywhere from seconds in time to hundreds of millions of years, are ubiquitous in the record, but have not been accorded the importance necessary to appreciate their significance. The second paper in the symposium, that by Guy Plint, helped to rectify that. His lengthy career of data collection in the Alberta Basin, amplified by that of his many graduate students, has generated some remarkable patterns, including the demonstration of a mid-Cretaceous Milankovitch-scale (the time band 10^4–10^5 years) control on changes in sedimentary accommodation that can be correlated intercontinentally, between Alberta and Bohemia. With Guy's immense data bank of sedimentary detail documenting these correlations, he was able to pinpoint an erosional hiatus representing a million years of missing time in a monotonous succession of shales in a canyon in the Alberta foothills, revealed only by an apparently insignificant little lens of chert pebbles. Amongst the other fascinating outcomes of very detailed correlation was the revelation that at times the subsidence history of the Alberta Basin could be likened to what happens when people jump around on a trampoline — short lived, local, thickening caused by the shifting locus of thrust subsidence. Although this is difficult to demonstrate with words alone, the illustrations provided by Guy made this analogy very clear.

The scale of things was very much a preoccupation of the next speaker, Janok Bhattacharya, who recalled for us the work he was employed to carry out in his pre-academic days to try to understand the distribution, orientation, scale and heterogeneity of sandstone and shale bodies in the Prudhoe Bay oil field, the largest conventional oil field in North America. The field was beginning to show signs of decline in the early 1990s, leading the operating companies to appeal to sedimentological expertise to try to increase productivity. The research inevitably led to the familiar conundrum of those trying to do sedimentology in the subsurface, the lack of data points, and the tendency to over-correlate everything, making the sand bodies look much broader than they usually are. To a considerable (but not total) extent, the advent of sequence stratigraphy, has helped to overcome this problem, but this does not

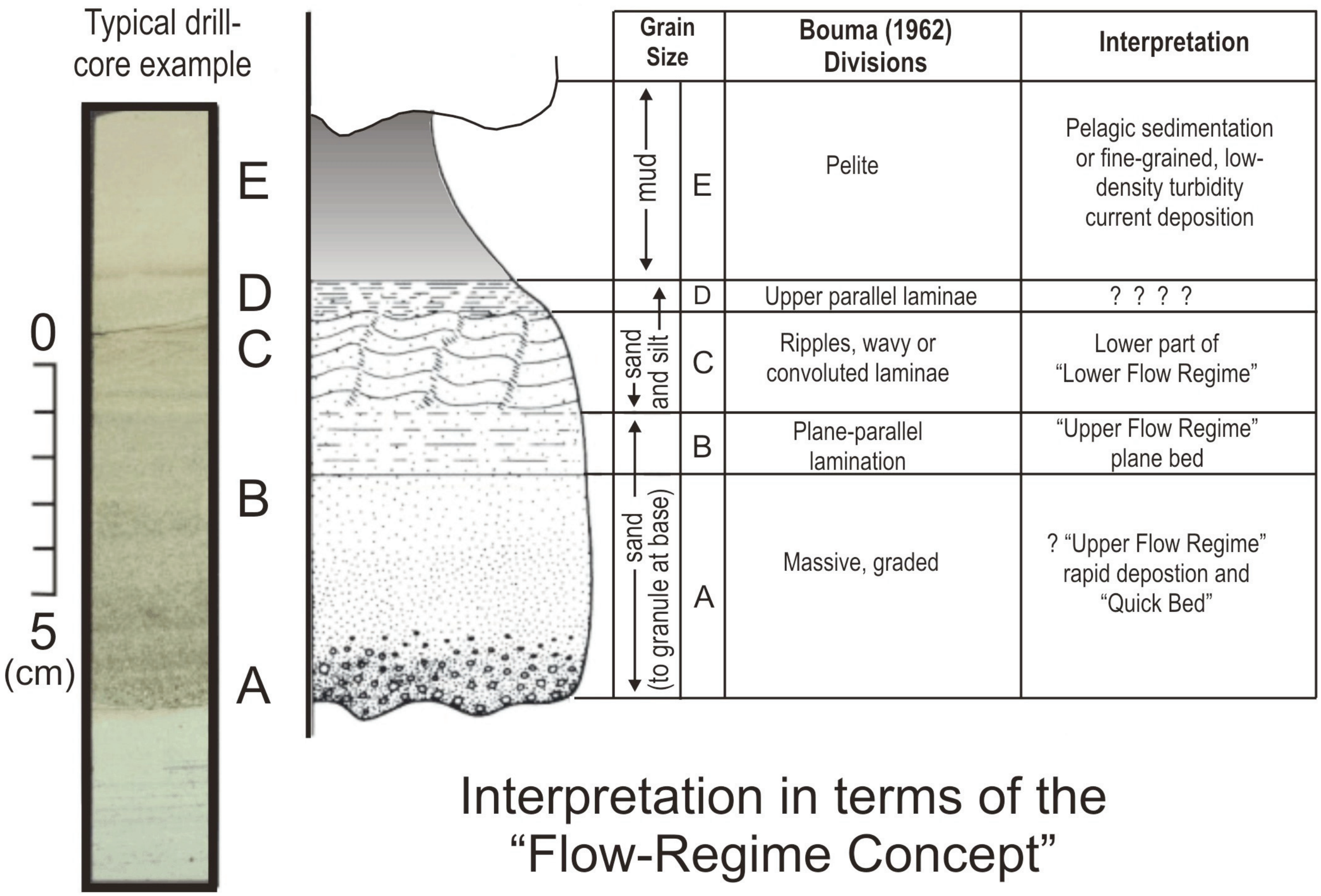

Figure 3. A Bouma sequence and its interpretation. Modified from Miall (2022).

necessarily work in any useful way in the nonmarine environment, unless there are broad allogenic controls at work to generate regional differences in facies and scale.

After a coffee break we came back to hear Bill Arnott describe his fascination with the "D" division of the Bouma turbidite, and how it comes to be there. This is the enigmatic layer of plane-laminated fine sand and silt that comes in at the top of a Bouma-type turbidite (Fig. 3). To explain it required a truly Middletonian approach to the problem – physical experimentation. Elegant diagrams were used to show how these experiments revealed the combination of flow velocity and sediment concentration that generated the "D" beds, including the fine lamination. Clever experimentation and physical deduction revealed the lamination to be a product of the alternation between laminar and turbulent flow.

Bob Dalrymple was the only one of our eight speakers directly supervised by Gerry, and he spoke to us (with pictures) about wading about with Gerry in the mud of the Bay of Fundy trying to collect the right samples in the right places before the incoming tides overwhelmed them. Bob's thesis work had led to a much-cited model of estuarine sedimentation, but the topic of his talk on Tuesday was tidal bores, and once again, it was careful observation of the sediment record that both stimulated his interest in the topic and provided the basis of the interpretations. Looking at sediment peels from some old cores he noticed repeated examples of some unexpected structureless layers on scales of a few millimetres to centimetres, and once again, the tried and tested methods of interpretation based on direct observation, analogue comparison (with turbidity currents), and hydraulic calculation, provided the complete explanation of how tidal bores work and how they add to and modify the sediment record.

The next two papers were presented by students at the University of Calgary, where an impressive school of sedimentology has been built by Steven Hubbard. Amongst the many irons in Steve's fire is his long-term project to investigate the deep-water stratigraphic record preserved in the Andean basins of southern Chile and Argentina. Daniel Bell focused on some apparently anomalous stratigraphic patterns in one of the units there, the Tres Pasos Formation. The explanation that emerged from observation and interpretation was that migrating knickpoints in the feeder channels of turbidite systems were developing distinct patterns of scour and deposition. Analogue studies of a modern channel in Bute Inlet, British Columbia, provided the necessary real-time observations and measurements to amplify and confirm the interpretation.

Rebecca Englert traced the deposits of turbidity currents in another Chilean deposit that showed evidence of modification and diversion by basin-floor topographic barriers and active faults. She linked hydraulic interpretations and directional (paleocurrent) data to changes in thickness, geometry and facies of the final deposits. Like Daniel's studies, Rebecca's work provides key parameters of considerable interest when deposits of this type are being assessed for reservoir heterogeneities in present-day deep-water exploration projects.

There was one more paper in our symposium, which I will return to in a moment, but here I want to make some remarks about some common themes that emerged in all the seven papers summarized to this point. To do this, I want to go back to one of the really early (early 70s) significant observations that Roger Walker made soon after hummocky cross-stratification had been identified as a new type of sedimentary structure. He and his student, Tony Hamblin, had found it in an outcrop of the Jurassic–Cretaceous coal-bearing sedimentary rocks exposed along the TransCanada Highway just east of Banff. Careful observation indicated that the structure occurs in a continuous section sandwiched between turbidites below and coal-bearing deposits above, suggesting that the structure was developed through a regressive episode during which the basin floor evolved from deep to shallow marine and then to a coastal setting. This ultimately allowed the origin of the to-then unexplained structure to be interpreted as a product of shallow-shelf sedimentation, an interpretation contained in a famous SEPM short-course on hydraulic sedimentary structures in 1975 (Harms et al. 1975). My Point? Careful observation, and a growing ability to interpret these observations, was based on our increasing knowledge of sedimentary processes. Each one of the first seven papers in our symposium was characterized by careful, meticulous observation, commonly on a millimetre or centimetre scale, and in some cases situated within stratigraphic settings several kilometres to even thousands of kilometres in extent. This is not your grandfather's stratigraphy, of the type that, of necessity, dominated much of the work of the Geological Survey of Canada when I was there in the 1970s, helping to nail down the architecture of the vast sedimentary basins located in Western and Arctic Canada using basic lithostratigraphic methods. No longer. The sequence stratigraphy revolution has showed us that to solve stratigraphic and sedimentologic problems we often need to do everything, from the SEM study of thin sections to regional-scale sequence-stratigraphic correlation or deep crustal-reflection seismic work. This is the reality of "sophisticated stratigraphy".

So, finally to the last paper, which Dale Leckie waited patiently to present. After a lengthy career in the petroleum industry in Alberta, Dale turned to a retirement project to explain Alberta's spectacular scenery to the general (non-geological) public. Sedimentology, of the type we had been hearing about during the morning, and large-scale stratigraphy of the type Dale had been working on during his career with the Geological Survey of Canada, Nexen and elsewhere, all contain fascinating information for the public, if only someone could make the translation from the specialized to the non-technical. Dale uses art, such as beautiful landscape paintings of the Alberta scenery, to draw the public into his science stories, and he melds First Nations memories and artefacts, such as petroglyphs on sedimentary outcrops, with sedimentology and the natural environment, to present complete multi-faceted stories about this amazing province in books and lectures. I particularly liked the one about how east-verging thrust ramps provide perfect drivers for the updrafts utilized by migrating eagles. He says that people have a hard time believing that studies show as much as 20 kilometres of rock have already been removed from the Rockies by post-tectonic erosion. And that the 2013 flood that devastated Calgary and Canmore and High River, was "only" a 40-year event. As Dalrymple and Bhattacharya (2021) remarked about Gerry, "*he had a passion for synthesizing information and passing that knowledge on to others.*"

I have always maintained that the general public could understand and enjoy a great deal more than they generally get from standard media presentations of scientific studies. The types of report that commonly appear in the mainstream media or television specials, even those prepared by respected organizations like National Geographic, are often awful, in the sense that while the visuals may be spectacular, the science is commonly reduced to the trivial. The weekend before our symposium my wife and I had gone to Calgary's Spark Science Centre with our two Calgary grandchildren and their mother, and there we enjoyed a visually spectacular movie about volcanoes. But it was so frustrating to listen to the simplistic explanations about "exploding" volcanoes and the "quieter" ones on Hawaii, and not be fed any ideas at all about why they are so different. I thought about the volcano lectures I used to give to my first-year class, and the three PowerPoint slides that would have put it all in context – the plate-tectonic explanation of where volcanoes are located (mainly subduction and rift related) and how the differences in magma source explained by these two main locations helped, in turn to explain the degree of gaseous content, explosive character and viscosity of lavas. Trouble is, it would seem that most media specials are put together by arts types who may be exceptionally good at photography, but whose eyes glaze over when "science" rears its ugly head. So many moments to explain blindingly obvious geology to the uninitiated, missed. My thoughts about volcanoes were shared with Dale after his lecture, and he agreed with me that this was another example of the problem with effective science communication. His work in this field seems to hold the promise of being much more successful than many earlier attempts at using science to inform and educate the public.

Later in the afternoon Janok had arranged for a McMaster University alumni reception, which about twenty former students, and honourary members, like me, attended, for beer and reminiscence. We told our stories about Gerry and Roger in the field (Bob and Janok's obituary has some of this, and need not be repeated here), and in our own way we remembered

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those amazing evening seminars that they held for their students and any visitor brave enough to express their tentative opinions about sediments in this unstructured setting. Those were the days. Thank you, Gerry, for what you did for so many budding scientists, and for the reputation for geology that Canada gained internationally in that far-off time. You are remembered.

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