EDITORIAL

The Allure of Vanished Worlds

Andrew Kerr

Department of Earth Sciences
Memorial University
St. John's, Newfoundland and Labrador, A1B 3X5, Canada
E-mail: akerr@mun.ca

Over the years, it has become a tradition that the first issue of *Geoscience Canada* contains some sort of editorial piece. When the deadline looms in March, I regret that this precedent was ever established. What can I possibly write that has relevance and interest to readers? We are still here, obviously, and we plan to continue as best we can and serve our Geoscience Community in Canada. Surviving as a small scientific journal in a large pond has more than its fair share of challenges, but our long-term goal is to grow and prosper, not just to persist. Our ongoing efforts would not be possible without the support of volunteers and GAC members, and of course the invaluable work of managing editor Cindy Murphy. So let my first statement this year be one of sincere thanks to Cindy and to all who assist us every year in smaller ways to produce the journal.

In previous editorials, I have outlined some of the challenges that we face, and especially the need for the submission of good papers on diverse topics. This is the only viable route towards raising our profile and impact in a world dominated by corporate publishing. I have discussed the open-access concept, and its possible benefits to journals like us, even with the additional fiscal challenges that it implies. In 2020, I even ventured into the impact of the Covid-19 pandemic on the lives and work of Earth Scientists, mostly in an effort to find silver linings in a large bank of clouds. I doubt that many readers really want to hear more on that subject after two more years, as it is all too familiar. All of these topics are important to *Geoscience Canada*, and some are clearly vital, and many will come back in future years. Hopefully, Covid will not be in that latter group. So, the search for topics suited to a 2022 editorial seemed fruitless for quite some time. In the end, I decided to avoid all the obvious but well-worn subjects and will spend a few pages to instead contemplate the past. Not the recent past, or even some historical past, but the distant and mysterious geological past that lies at the very heart of our chosen calling. Those who read to the end of this might well feel that this is no more than an escapist flight into imagination, and perhaps just a diversion from the many serious issues confronting our world in the spring of 2022. There may be indeed some truth in this perspective.

The two technical papers featured in this first issue for 2022 have much in common, although this is certainly not by our design. Both articles focus on the use of detrital zircon U–Pb geochronology to solve geological problems, but they also share a deeper theme. Superficially, they include statistics, probability density charts and tables of data, but they are in the end delving into something more fundamental. Both papers seek to recreate *vanished worlds* - places that existed tens to hundreds of millions of years ago on an Earth that was simultaneously familiar and alien. Earth Scientists are uniquely privileged to be aware of a multitude of vanished worlds, to the extent that we may take them for granted. It is just part of geoscience thinking in the broad sense, and we do not often pause to contemplate the enormity of such concepts. But I believe it serves us well to indulge our fascination for this far greater picture. Like many of us, I started out intending to study something else in my teens, but then ended up in some first-year geology classes. I was lucky enough to encounter young and passionate instructors, and the heady combination of the *new global tectonics* and visions of long-vanished worlds that they gave me led to a different academic path. It was like being exposed to the speculative breadth of science fiction buried within the scope of a vast historical adventure, and fifty years later, I still feel exactly that way. Earth Science truly gives us multiple worlds to explore, although at times we wish for even more.

The paper by James Sears and Luke Beranek is built from measurements on thousands of nearly invisible zircon grains, but it transports us well beyond such details. It returns us to a pre-glacial North America that had a very different geography and climate, and a great river that rivalled our modern Amazon. Robert Bell of the Geological Survey of Canada speculated in 1895 that most of North America once drained into Arctic waters, before huge ice sheets remodelled our geography. The story of the "Bell River", as it later came to be called, is now stored in the sands and silts of a vast delta beneath the frigid Labrador Sea, and by scattered residual outcrops on the Great Plains. This concept is astonishing enough, but it seems that this vanished northern Amazon once had headwaters in the desert southwest of our continent, although it was likely not arid in those times. James and Luke suggest that the development of the Colorado Plateau, including the early Grand Canyon, might be part of the Bell River's long story. After 50 years, I still marvel at how Earth processes link such distant

Geoscience Canada, v. 49, https://doi.org/10.12789/geocanj.2022.49.182 pages 1–6

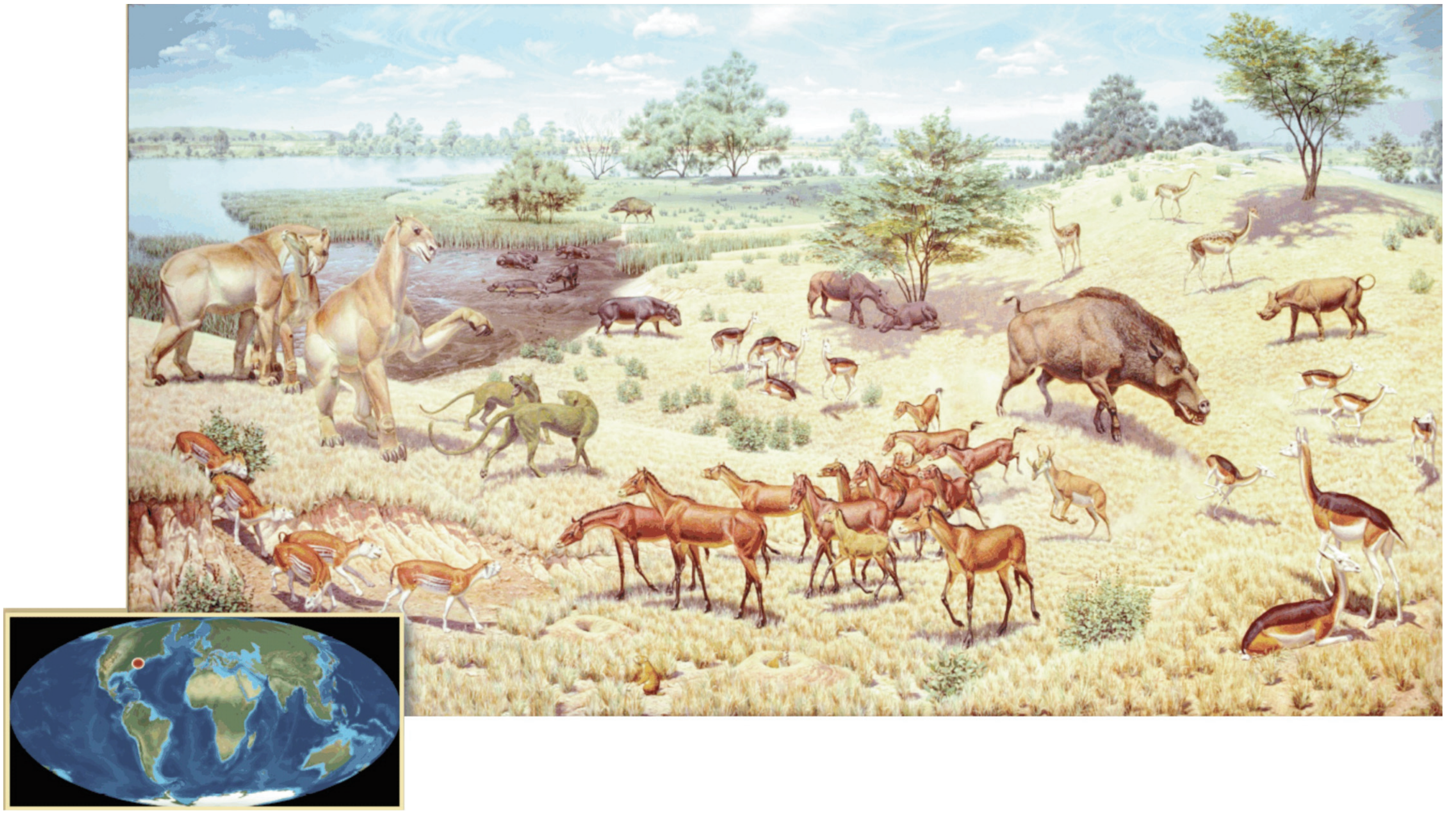

Figure 1. Artist's depiction of a Miocene landscape and fauna in North America, from the United States Geological Survey "Trail of Time" website (www.usgs.gov/youth-and-education-in-science). The painting depicts a wide waterway in the background, which can perhaps be thought of as the Bell River although (strictly speaking) this scene is intended to represent Virginia. The inset shows a global plate reconstruction for the Miocene Epoch, which broadly resembles the world map of today. Is this what the landscapes around the pre-glacial Bell River would have looked like?

and different places, even though it really should not surprise me. But when I read their paper as an editor, I wanted also to step beyond long-distance zircon transport and try to visualize this vanished world. This colossal drainage basin was initiated during one of the warmest climates in the geological record, so coal swamps existed in its delta, and as far north as present-day Ellesmere and Axel Heiberg islands. Forests flourished in landscapes we see today as ice-carved tundra. What other landscapes and environments existed across the land we now call Nunavut? During these warmer times, much of Ellesmere Island was probably covered by vegetation similar to modern Boreal forests, and pollens from vines and other semi-tropical plants are reported from other high-Arctic locations. What would it have been like to stand on a summit in the ancestral Torngat Mountains, and gaze across distant flatlands within a vast rift valley that would one day become an ice-choked sea? If only we could travel there, we could drift downstream with the waters of the Bell and see the remarkable mammals of the Paleogene and Neogene along its banks. We will never know all the details, but surely such a mighty river would be a vibrant ribbon of life, just like those of today. Artists have recreated many of the North American mammals of these times (see Figure 1; courtesy of the United States Geological Survey), and the image for the Miocene clearly includes a large waterway.

The paper by Dawn Kellett and Alex Zagorevski of the Geological Survey of Canada similarly uses geochronological and isotopic techniques to understand an ancient sedimentary basin now preserved within the mountains of present-day British Columbia and Yukon. But beyond its technical terms and data tables, it is an excursion to another vanished world - perhaps the real version of *Jurassic Park*. Visualizing this is a much greater leap than my imaginary voyage down the Bell River because there are only tenuous connections to our modern geography or topography. This long-vanished world was changed and moved by the power of tectonic orogeny, not just by the slow shift of global climates. As the Earth recovered from its catastrophic mass extinction at the end of the Permian, numerous Mesozoic island chains littered the ocean offshore from a stable continental shelf where the Rocky Mountains would eventually tower (Figure 2). We can only speculate about their sizes, shapes and geometries, and they bear only collective names today as "terranes" within the Cordilleran Orogenic Belt. We suspect that one of them, now called Yukon-Tanana, might have been larger, as it had a longer history, and was rifted away from North America in some earlier event. For the most part, these island networks of the Triassic and Jurassic *literally* vanished, as their volcanic peaks were eroded and dissected even as they erupted. The remains of a vanished archipelago remain in the folded and faulted sandstones

Figure 2. Reconstruction of North American paleogeography for the early Cretaceous period. The maze of islands located north and west of present-day British Columbia represents the area where the sedimentary rocks of the Laberge Group were deposited in an active tectonic environment during the Jurassic. The Rocky Mountains, which dominate the Canadian Cordillera, are just beginning to develop; over time their growth will rearrange continental drainage, to create the Paleogene and Neogene Bell River basin, which connected parts of the Cordillera to the Labrador Sea. The Labrador Sea is just beginning to develop on the opposite side of North America at this time. Original diagram by Ron Blakey, from the book *Four Billion Years and Counting*, published by the Canadian Federation of Earth Sciences.

and conglomerates of the Jurassic Laberge Group, which also preserves information on how this sedimentary basin was locally deformed and uplifted, even as other parts of it were still accumulating. Painting a picture of this vanished world reveals a much stranger place, but it does contain some characters familiar to most children, even if they do not have geologists in their families. This was another hothouse world, with no signs of polar ice, and inconspicuous mammals, which are generally portrayed as nervous oppressed victims of marauding dinosaurs. By our standards, it was a tropical environment, but likely very different from what we see today, particularly in terms of vegetation. Lush island slopes would have been dom-

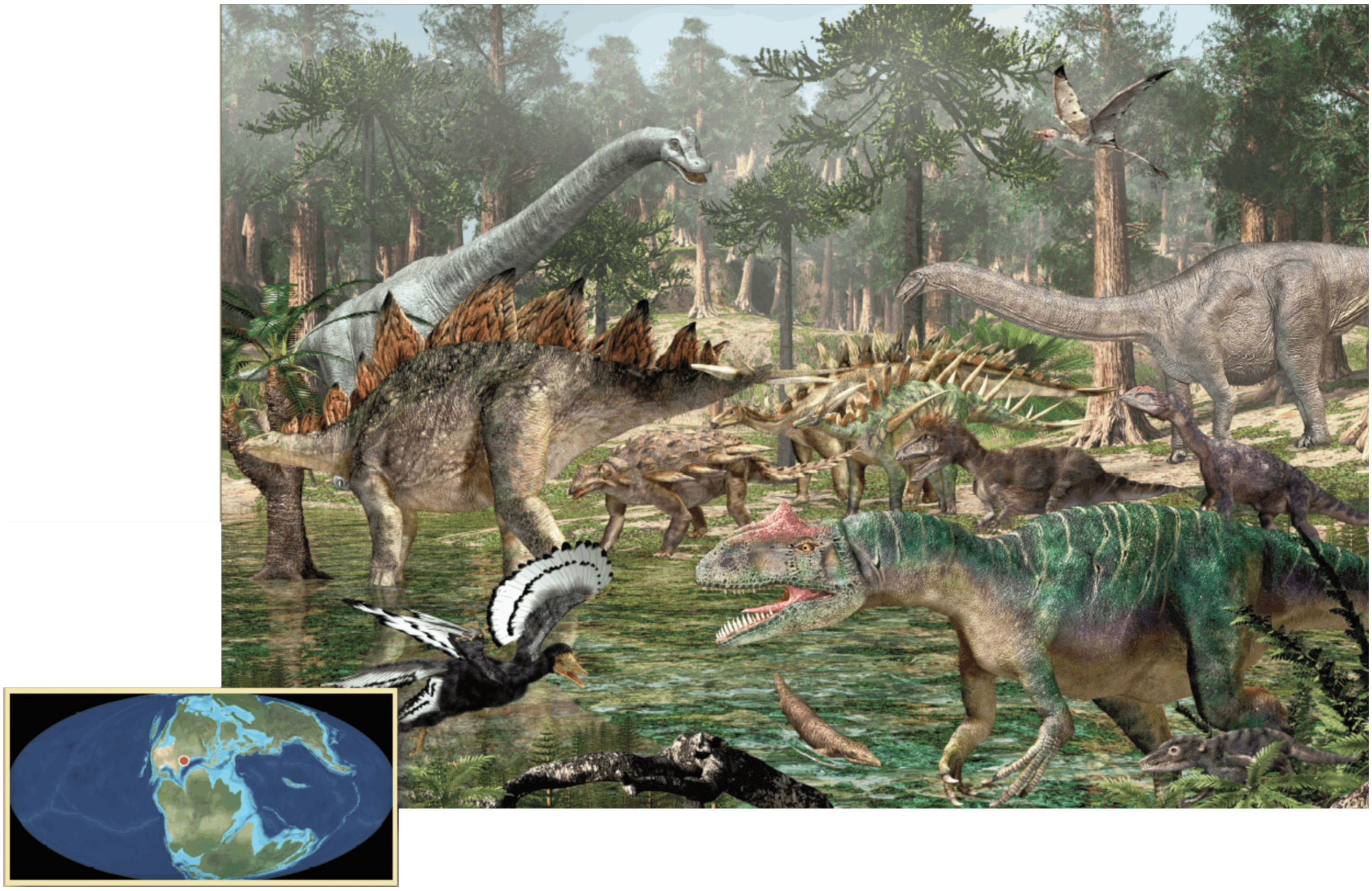

Figure 3. Artist's depiction of a Jurassic landscape and fauna in North America, from the United States Geological Survey "Trail of Time" website (www.usgs.gov/youth-and-education-in-science). The painting naturally depicts a wide variety of dinosaurs, some of which will be familiar. Although species might have differed in detail, some are probably representative of predators that lurked on the scattered islands of Jurassic British Columbia. Note that the vegetation is dominated by conifers and cycads, rather than the flowering trees of today's tropical regions. Inset shows Jurassic paleogeography, which is quite different from what we see on the world map of today.

inated by massive conifers and cycads - evergreen plants that resemble modern palms - and flowers (as we know them) had yet to evolve. What would it be like to go back in time and sail ancient turquoise seas in this Jurassic Eden, or to walk on its beaches of (presumably) black sand? We are told that the laws of physics will always forbid such excursions, but I feel sure that most geologists would jump at the chance if offered to them, even with the ever-present risk of being eaten by some sort of *Saurus*. Although the dinosaurian villains that populate the Hollywood version did not actually evolve until the Cretaceous, the reconstruction of Jurassic fauna provided by artists of the United States Geological Survey (Figure 3) implies that a variety of dangerous predators awaits any careless time-traveller.

Despite their contrasts, there is a thread of connection between the vanished worlds of Jurassic British Columbia and the Paleogene to Neogene Bell River. It was the development of the modern Cordilleran Orogenic Belt in late Mesozoic times that remodelled the drainage systems of North America and forced its inland sea to retreat through the corridor that would become the trunk route of the Bell River. Much later, geographic changes caused by tectonics in ancestral Central and South America may have set the stage for a transition to an icehouse climate and the great Pleistocene glaciations that would divert the Bell's course. These vanished worlds that we like to construct do not exist in isolation but are part of a continuum. Each is influenced by its ancestors and influences its descendants, just like the characters in a vast novel. A saga that Earth Scientists are uniquely privileged to understand and interpret.

I first learned about some of these vanished worlds in introductory geology courses, and they were an important influence on my decision to follow a career in Earth Sciences. I was even lucky enough to once teach a course on the topic, back in the days of blackboards and overhead projectors. I think that many readers had parallel experiences with learning historical geology as an integrated topic, but this is not necessarily the case for many Earth Science students in the 21st century. At Memorial University, there is no longer an introductory course devoted to Earth History, although it is still listed as "inactive" in formal documents. It has been that way for many years. There is, however, an excellent course entitled *Earth's Story*, but this is designed as an elective, without science prerequisites, placing some limits on its content and scope.

Although this course does not count as a credit towards an Earth Science degree, many students do complete it, and my colleague Sharon Deemer tells me that they find that it has much value in connecting diverse topics discussed in more specialized offerings. Given the immensity and breadth of the topic, and our modern view of the Earth as an "evolving planetary system", I find the absence of a dedicated core Earth History course more and more puzzling. To me, it provides a natural narrative to connect what we now know about the dynamic Earth and initially explore the many things that we still do not understand about it. Supercontinent cycles and the great mysteries of mass extinctions are just two of the most obvious examples, but Earth History also provides much insight into the controls of climates, atmospheric evolution and the profound influence of the biosphere on almost all aspects of planetary development. Vanished worlds also have relevance to our familiar world, and to less familiar worlds that our descendants may contend with. For example, the Paleocene–Eocene Thermal Maximum (PETM), which corresponds to the early times of the Bell River, provides a possible past analogue for today's rapid anthropogenic climate warming, although the rates of change then were orders of magnitude less than we are experiencing today.

It seems that Memorial University is not alone in devolving Earth History as a core component in its undergraduate program. An informal survey of other Earth Science departments across Canada suggests that many no longer offer such a course to students in their first or second years. Some do retain courses that include selected aspects of historical geology, but this is often associated closely with paleontology. There are of course many connections between these disciplines, and paleontology certainly defines many recent chapters in Earth's story, but I am sure that most paleontologists would agree that it is not the *only* story. Other departments follow Memorial's route in offering Earth History as a more generalized elective designed primarily for non-science majors or for related science majors. My survey was not detailed or comprehensive, and I did not get responses from all my queries, but it left me with a feeling that some of today's Earth Science students may be missing out on something fundamental and fascinating. I went on to look at available textbooks that explore this topic and I was surprised to find very few of recent vintage. The one I am most familiar with from my own use in teaching is *Earth System History*, by Steven Stanley and John Luczaj, last updated in 2015, which is a good combination of essential geoscience and a well-structured voyage through time. Beyond that there is not that much to choose from, although I was intrigued by Andrew Knoll's new book *A Brief History of Earth: Four Billion Years in Eight Chapters*, published just last summer. From its modest price, I think this must be a popular science book, and it is an obvious candidate for a review in some later issue this year. Robert M. Hazen's *The Story of Earth* (2012) is definitely in the popular science category, at half the price again, but still a very good read for non-geologists. I have always recommended it as supplementary reading to first-year classes, and hopefully some of them took that advice. Most other Earth History oriented texts seem to be second hand editions of older works – in sharp contrast to the general abundance and diversity of introductory Earth Science texts that emphasize physical geology. For readers in Canada, there is of course an excellent choice in *Four Billion Years and Counting*, published by the Canadian Federation of Earth Sciences, and this is almost a text in itself, but its historical focus is understandably very much on Canada.

I personally believe that this subject is one that all prospective Earth Scientists should encounter through an integrated treatment in the early stages of their program. For those who continue on to other aspects of Earth Science, it provides a framework to link and connect concepts and observations from other courses, including tectonics, paleontology, petrology, economic geology and even planetary science. For those who do not continue in mainstream Earth Science, but choose other paths, it provides an entirely new way of understanding the world that surrounds them, and the countless other worlds that preceded it. But most importantly, this remarkable 4.5 billion year saga surely has the narrative power to recruit those who may not yet realize that they are destined to become Earth Scientists. Those who simply cannot resist opportunities to explore vanished worlds and all their unanswered questions are surely needed as part of our profession's future.

In closing, I will of course suggest that *Geoscience Canada* could have some role to play in better understanding vanished worlds and bringing them to future generations. After all, no editor should ever pass up the opportunity to promote the preparation and submission of papers! The history of the Earth is not one smooth and continuous ride, but rather one of stops and starts, with times of rapid unidirectional change. I would not deny that some chapters are more interesting and controversial than others, but this view really depends on perspective. For example, the late Martin Brazier's famous characterization of the middle Proterozoic as *The Boring Billion* could never be endorsed by any economic geologist. Nevertheless, it is fair to say that some stretches of our long saga generate more debate than others, because the details, causes and effects of some fundamental changes in the Earth System remain obscure. The periodic mass extinctions of the Phanerozoic are perhaps the most obvious examples, but we can find many puzzles in the Precambrian depths. For example, what was the Hadean really like? Did it really live up to its name or, as some contend, was it actually as cold as Hell? Much still remains controversial in our understanding of the Great Oxidation Event(s) that define the earliest Proterozoic, leading to vast iron deposits that support our industrial civilization, and perhaps indirectly causing global glaciations. And what of the so-called *Canfield Oceans* that then persisted for nearly a billion years beyond those events, perhaps allowing the formation of other key metal resources that we now depend on? At the other end of the Proterozoic, the world-spanning glaciers returned again, but we are a long way from understanding the ultimate causes, or the links that might connect the *Snowball Earth* to suddenly increased atmospheric oxygenation and the first large multicellular organisms of the Ediacaran (Figure 4). What are the current views about the so-called *Cambrian Explosion* that later introduced familiar groups of organisms whose

https://doi.org/10.12789/geocanj.2022.49.182

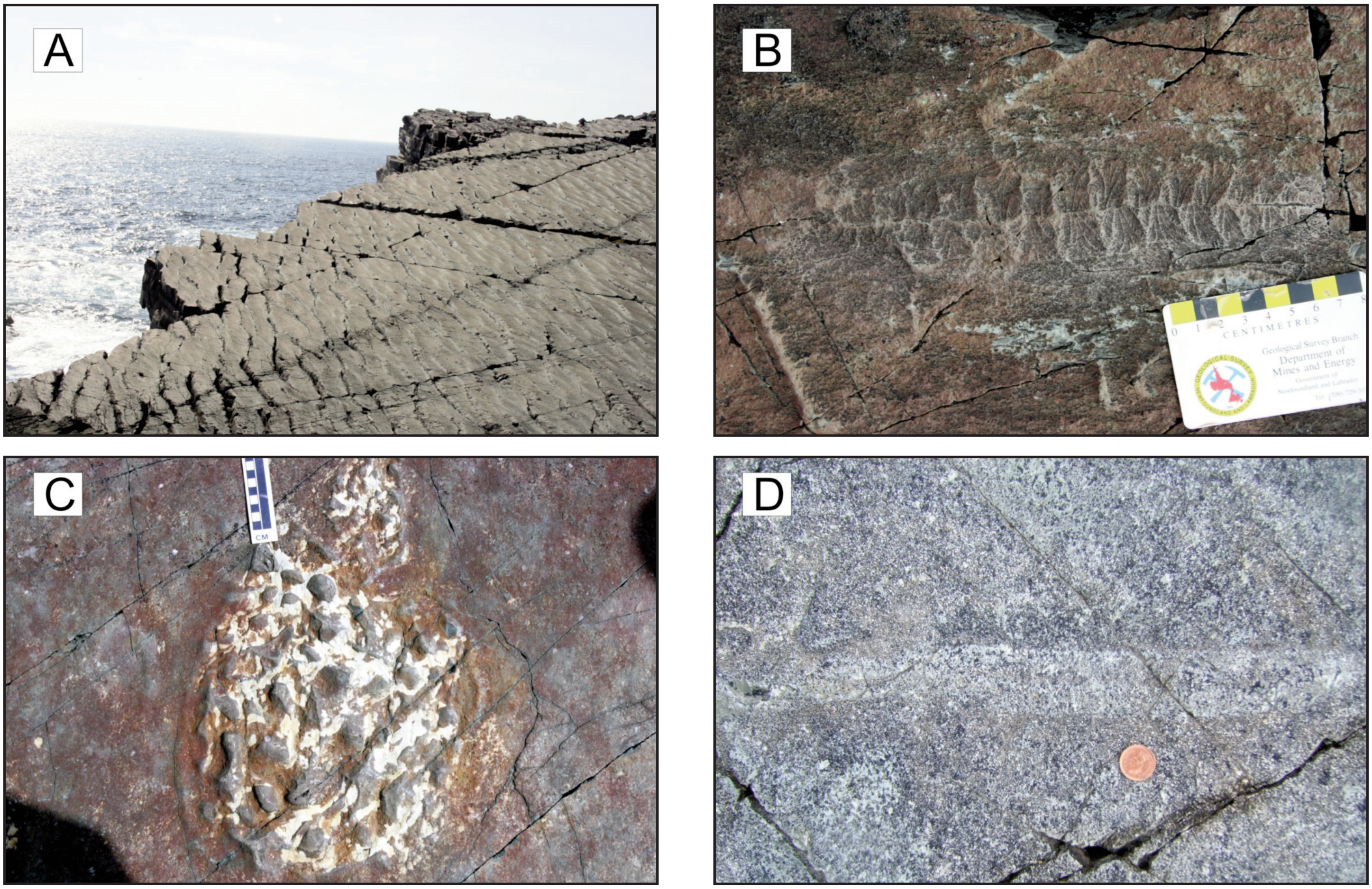

Figure 4. Images from Mistaken Point area, southeastern Newfoundland, a spectacular coastal location that is now a UNESCO World Heritage Site. A. General view of the "E Surface", which contains thousands of Precambrian fossils, even though they are not visible from a distance. The surface markings are not ripple marks, despite their suggestive appearance, but rather are structural features of the bedding plane. B. Exquisitely preserved frond-like fossil from the underlying "D Surface", which is probably the most famous area of the site. These elusive and beautiful survivors from a vanished world were preserved due to the deadly effects of volcanic ash, which forms the granular areas in the image. C. An interesting and very distinctive fossil known as *ivesheadia*, but invariably referred to as a "pizza disk" for obvious reasons. This was once thought to be a discrete organism of some strange type, but was later reinterpreted as the partially decayed remains of other creatures, which were left to the attention of bacteria, because this was a world that lacked megascopic predators or scavengers. D. An unusual linear trail on a bedding plane located tens of metres above the D and E surfaces, which is interpreted to represent the earliest trace fossil that can be ascribed to physical locomotion of an organism. The development of motility must surely be a prerequisite to the evolution of predatory behaviour, which was surely a critical control on evolution. Photos by A. Kerr, from several pilgrimages to this evocative site. For more information on the Ediacaran puzzles, see a previous article in Geoscience Canada by Liu and Matthews (2017; volume 44, p. 63–76). The Ediacaran period is one obvious candidate for a thematic review paper in a possible series to highlight critical chapters in Earth History.

evolution we can now trace for 540 million years? Moving forward through Paleozoic, Mesozoic and Cenozoic time, things seem almost familiar by comparison, but many puzzles remain for contemplation. Just look at *Four Billion Years and Counting* if you need an introduction to some of the more obvious examples, and do not forget the most recent, such as the PETM event and the nature and causes of Pleistocene glacial-interglacial cycles. So, perhaps we could consider starting a new thematic paper series entitled simply *Critical Chapters?* I am doubtless guilty of naïve optimism on this possibility, but optimism is surely something that we all need in this troubled spring of 2022.