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Early Paleozoic rifting and reactivation of a passive-margin rift: Insights from detrital zircon provenance signatures of the Potsdam Group, Ottawa graben: Reply

David G. Lowe[1,†], R.W.C. Arnott[2], Jeffrey R. Chiarenzelli[3], Robert H. Rainbird[4], and Godfrey S. Nowlan[5]
[1]*Atlantic Gold Corporation, 6749 Moose River Rd., Middle Musquodoboit, Nova Scotia B0N 1X0, Canada*
[2]*Department of Earth and Environmental Sciences, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada*
[3]*Department of Geology, St. Lawrence University, Canton, New York, 13617, USA*
[4]*Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada*
[5]*Geological Survey of Canada–Calgary, 3303 33 Street NW, Calgary, AB T2L 2A7, Canada*

We thank Landing et al. for their critique of our work and, based on their comments, address what we believe are the principal points of disagreement. Although their comments appear to be directed at this paper (Lowe et al., 2018), which outlines the provenance and lithotectonic record of the Potsdam Group, their comments are principally aimed at an earlier foundational paper published in the *Canadian Journal of Earth Sciences* (Lowe et al., 2017) that outlines the stratigraphy and facies of the Potsdam Group. The comments of Landing et al. range from minor nomenclatural discrepancies to objections to our stratigraphic framework and facies models, which we address next.

Differences of opinion regarding strata of the Potsdam Group are hardly surprising given its historical and jurisdictional context. The Potsdam Group, originally termed Potsdam Sandstone, was the first formally defined stratigraphic unit in North America (Emmons, 1838) and has since enjoyed the scrutiny of many researchers over the past almost 200 years. Unfortunately, this scrutiny has always been hampered by jurisdictional constraints, given that Potsdam strata in the Ottawa graben occur in two provinces (Ontario and Quebec) and one American state (New York), and therefore a comprehensive regional investigation by a single group of researchers has not been undertaken until very recently. As a result, local to semi-regional stratigraphic frameworks have been developed and misconceptions of the genetic relationship between units across borders have become engrained in the lexicon of early Paleozoic stratigraphy in the region. The first major attempt to provide a genetic basin-wide framework and unified stratigraphic nomenclature was that of Sanford (2007); later documented in Sanford and Arnott, (2010). The objective of subsequent work by Lowe (2016); published in Lowe and Arnott, (2016), Lowe et al. (2017), and Lowe et al. (2018), was to test that framework, make modifications where appropriate, and elucidate the stratal evolution of the Potsdam Group in the Ottawa graben. These basin-specific works outline, for the first time, the uniqueness of the stratigraphy of the Potsdam Group in the Ottawa graben that were previously unaccounted for and documents the profound tectonic overprint on the eustatic and climatic variations that controlled sedimentation here and on the coeval Laurentian shelf and slope. The comments of Landing et al. stem mainly from disagreements with our genetic, basin-wide framework that unsurprisingly contradict earlier subjective jurisdictional frameworks.

The first issue of Landing et al., that we have redefined earlier units "without comment," thus creating confusion, is inaccurate. Redefinitions of the Potsdam Group and its constituent units and discussion of how and why these replace earlier nomenclature are discussed and justified throughout Lowe et al. (2017). Secondly, the framework of Lowe et al. (2017) was not intended to generate confusion, but rather limit it by resolving some issues with earlier correlations stemming from local jurisdictional treatment of the succession and the incorrect correlation of units with different detrital composition, stratigraphic position, and depositional environments. The principal purpose of redefining the stratigraphy of the Potsdam Group was to provide a single, regionally consistent stratigraphic framework that would allow for a more comprehensive interpretation and deconvolution of the eustatic, climatic, and tectonic controls on sedimentation (in accordance with Article 7(e) of the North American Stratigraphic Code, "For geologic units that cross local and international boundaries, a single name for each is preferable to several"; NACSN, 2005). Stratigraphic terms that had historical precedence were chosen; for example, the terms Ausable (Alling, 1919; Fisher, 1968) and Keeseville (Emmons, 1841; Fisher, 1968) from New York were chosen to replace the later-named, but equivalent, Covey Hill (Clark, 1966) and Cairnside/Nepean (Wilson, 1946; Clark, 1966) in Canada.

One of the main stratigraphic critiques of Landing et al. involves the revision of the Altona from formation to member status due to the similarity of its detrital composition and interfingering relationship with fluvial arkose of the Ausable Formation. We contend that the inclusion of the Altona in the Ausable is valid and underpinned by a shared lithotectonic affinity and sediment provenance, revealed by comparable detrital framework mineralogy (both containing generally 20–50% detrital feldspar, e.g., Brink, 2015) and detrital zircon ages (mainly ca. 1170 Ma, derived from local Adirondack sources, Lowe et al., 2018). Moreover, the presence of Ausable fluvial arkose above and below the Altona, with transitional and conformable contact relationships, further supports the idea that the Altona is a tongue of marine strata enveloped by the fluvial Ausable Formation. In New York, sub-Altona fluvial arkose is exposed along a river on a hanging-wall fault block near Murtaugh Hill Road (Brink, 2015; Lowe et al., 2015; see notes from stop 1 in the latter work, UTM 18T 0611739N, 4961998E). The section consists of 3.5 m of graded and tabular cross-stratified, coarse-grained fluvial arkose with 38% detrital feldspar (Brink, 2015) sitting directly on Precambrian basement. The lithology,

†daveglowe25@gmail.com

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facies, and detrital composition of these strata are consistent with the Ausable elsewhere. Landing et al. (2009) also describe the lowermost exposed strata on the Old Military Turnpike as "pink to whitish feldspathic quartz arenite" with "granule and small pebble quartz and feldspar grains" and "trough cross-bedding"; it is unclear how this differs from the Ausable as defined by Lowe et al. (2017). Landing et al. (2009) also note ~3 m of basal "sandstone" in their log of hydrological wellbore 1-02, although the detrital composition is not reported. Finally, Lowe et al. (2017) documented 16 m of coarse-grained, locally pebbly, cross-stratified fluvial arkose conformably underlying Altona strata in the Quonto-International St. Vincent de Paul No. 1 core, located ~95 km north of the New York stratotypes. As these sub-Altona strata thicken northward, the Altona Member thins from ~80 m in northern New York to just over 20 m near Montreal, outlining a regionally thinning tongue of marine strata sandwiched between fluvial strata of the Ausable Formation (Lowe et al., 2017, their fig. 6). In addition, both the upper and lower contacts of the Altona are gradational and marked by an intercalation of fluvial and marine facies. For example, Lowe et al. (2017) document a conformable intercalation of fluvial (Ausable) and marine (Altona) facies in the lower 0.5 m of the Altona Member in Quonto-International St. Vincent de Paul No. 1 core, suggesting a gradual drowning of the fluvial coastal plain during marine transgression (fig. 7a from Lowe et al., 2017). Similarly, an intercalation of coarse-grained fluvial (Ausable-like) and fine-grained marine (Altona-like) facies occurs in the upper 10–12 m of the Altona Member in the Quonto-International St. Vincent de Paul No. 1 core and in the Atwood Farm stratotype section in New York State (e.g., Lowe et al., 2015, 2017; Brink, 2015; Landing et al., 2009), recording regression and the gradual reestablishment of terrestrial floodplains over the eastern Ottawa graben.

Besides disagreement on the nature and nomenclature of the Altona Member, Landing et al. also allude to apparent contradictions between the frameworks of Lowe et al. (2017) and Sanford and Arnott (2010). This relates principally to changes in the subdivision of strata in the basal part of the Potsdam, including abandonment of the Abbey Dawn Formation, Chippewa Bay and Edwardsville members, and elevation of the Hannawa Falls from member to formation status. In the case of the Abbey Dawn Formation, which Sanford and Arnott (2010) considered to be an erosional remnant of an areally extensive Proterozoic sandstone, Lowe et al. (2017) showed that these generally anomalously coarse-grained strata occur at multiple stratigraphic horizons within the Potsdam succession, typically adjacent to (reactivated) basement faults. Accordingly, the term Abbey Dawn was abandoned. Furthermore, Lowe et al. (2017) recognized that Sanford and Arnott's Hannawa Falls Member (eolian quartz arenite as defined in the type section at Hannawa Falls, New York) is a separate unit occurring stratigraphically above alluvial and fluvial arkose of the Ausable Formation (e.g., locality 53 and fig. 9 from Lowe et al., 2017), and whose detrital composition and lithofacies, rather than red coloration, were better criteria for regional correlation. Furthermore, these criteria are also more reliable because red Potsdam strata are not necessarily restricted to Sanford's Hannawa Falls Member, and also not all Hannawa Falls strata are red. We did not rename this unit because it still corresponds to Sanford and Arnott's (2010) type section.

Based on the reevaluation of existing outcrop data and presentation of new key outcrop and wellbore data (e.g., outcrop sections 86, 87, 100, 104, 112, 124 in northern New York State; 27 and 41 in Ontario; 176 in Quebec, from Lowe et al., 2017), Lowe et al. (2017) concluded that terrestrial and shallow-marine quartz arenite strata, which unconformably overlie the Ausable and Hannawa Falls formations across the basin, belong to the Keeseville Formation (e.g., figs. 10, 13, 14, and 16 in Lowe et al., 2017). This is in contrast to Sanford and Arnott (2010), who correlated some of these strata to the Chippewa Bay and Edwardsville members of the Ausable/Covey Hill Formation. The revisions discussed and presented in Lowe et al. (2017) are not "contradictions," but rather reflect an improved understanding of the contacts separating units; their depositional paleo-environments based on contemporary facies analysis (e.g., Lowe, 2016; Lowe and Arnott, 2016); and the stratigraphic significance of detrital composition, lithofacies, and grain size rather than a less diagnostic feature like stratal color. Although not considered in Lowe et al.'s (2017) definition of lithostratigaphic units, differences in the detrital zircon age distributions, as discussed in this paper, are consistent with these revisions. For example, samples of the Keeseville Formation across the Ottawa graben are characterized by 1100–1000 Ma detrital zircon grains recording mixed provenance from Grenville Province hinterlands to the south, west, and north of the Ottawa graben. Such ages are absent from samples of the Ausable and Hannawa Falls formations, which instead are dominated by ca. 1175 Ma zircon grains from more local Adirondack sources. Moreover, rounded ca. 1175 Ma Adirondack zircon grains also occur in Keeseville samples from the Ottawa graben, suggesting recycling of Ausable and Hannawa Falls strata (Lowe et al., 2018).

A final point of stratigraphic contention noted by Landing et al. regards our correlation of mixed siliciclastic-carbonate marine strata at the Rockland outcrop (locality 2 and fig. 17 in Lowe et al., 2017) and elsewhere in outcrop and core in the northern Ottawa graben with strata of the Rivière aux Outardes Member as defined by Salad Hersi and Lavoie (2000) from the Unimin Quarry near Mirabel, Quebec. Accordingly, the Rivière Aux Outardes Member is defined by marine clastic and lesser carbonate strata that cap quartzose strata in the lower part of the Keeseville Formation throughout the northern Ottawa graben, and, in turn, is overlain by a regressive unconformity. The Rivière aux Outardes Member occurs in numerous outcrops and cores in Ontario and Quebec (e.g., outcrop sections 2, 18; core from AMEC MW-301 Monitoring well, Dominion Observatory No.1, GSC LeBreton No.1, GSC McCrimmon No.1, Quonto-International St Vincent de Paul No.1, and Quonto-International Mascouche No.1; Lowe, 2016; Lowe et al., 2017). These strata clearly demonstrate the presence of an intra-Keeseville marine unit that is truncated by an unconformity beneath the top of the Keeseville. Moreover, a *Variabiloconus bassleri* specimen recovered from the Rockland outcrop provides the basis of an early Ordovician age for the Rivière aux Outardes, and thus of the upper Keeseville, at least in the northern part of the Ottawa graben (Lowe et al., 2017).

Landing et al. incorrectly claim that Lowe et al. (2017, 2018) have not related the Potsdam succession to other successions across eastern Laurentia or linked changes in lithostratigraphy to eustasy. A clear, detailed discussion of regional correlations across eastern Laurentia and the influences of eustasy, climate change and tectonics are included in Lowe et al. (2017; see their fig. 26) and summarized in Lowe et al. (2018). For example, sedimentation of our allounit 2, comprising basal strata of the Keeseville Formation capped locally by marine strata (in places carbonate-bearing) of the Rivière aux Outardes Member, is correlated to a eustatic rise that affected coeval Laurentian successions throughout eastern North America (e.g., the transgressive Danby–Little Falls succession in Vermont shelf succession, and the "Potsdam"–Galway–Little Falls succession along the northern margin of the Appalachian Basin). Similarly, the allounit 2–allounit 3 contact, namely the unconformity separating the Rivière aux Outardes Member from the upper part of the Keeseville Formation, is correlated to similar unconformities documented elsewhere in eastern Laurentia (e.g., Salad Hersi et al., 2002; Landing et al.,

2003) that indicate eustatic fall (i.e., regression) sometime between the Late Cambrian and Early Ordovician.

Another misunderstanding of Landing et al. is that our allostratigraphic data contradicts existing lithostratigraphic and biostratigaphic data. This stems from the fact that parts of the Ottawa graben succession have been historically, and in our opinion, incorrectly correlated with successions outside of the Ottawa graben. This has led to the assumption that the Potsdam succession in the Ottawa graben should conform to established lithostratigraphic frameworks in other areas, like the Appalachian Basin (e.g., Landing, 2007, Landing et al., 2009). Also, it is important to note that the lithological distinctiveness of the Ottawa graben succession as noted by Lowe et al. (2017, 2018) has been largely overlooked. Based on our interpretation of the data, sedimentation in the Ottawa graben was controlled profoundly by local tectonism, which underpins its distinctiveness from other parts of the Laurentian shelf and Appalachian Basin.

Landing et al. also contend that there are errors in our detailed lithofacies analysis that have led to a misrepresentation of the paleo-depositional environments of the Potsdam Group. Regrettably, our detailed lithofacies analysis and facies association interpretations were only summarized in Lowe et al. (2017, 2018) due to the imposed length-limit of a peer-reviewed journal manuscript. As stated in the text, an exhaustive treatment of lithofacies analysis and paleoenvironmental interpretations are available in chapters 2 and 3 of Lowe (2016), and in a previously published paper describing supercritical-flow fluvial deposits by Lowe and Arnott (2016). Landing et al. disagree with our interpretation of the Altona lithofacies, and in particular that hummocky cross-stratification (HCS) is restricted to the shallow-marine shoreface and water depths of 13–50 m (e.g., Dumas and Arnott, 2006). However, HCS, or at least stratification resembling oscillatory-flow HCS, has also been documented in modern shallow tidal flat environments (e.g., Yang et al., 2005, 2006), and even ancient fluvial deposits (Rust and Gibling, 1990; Fielding, 2006; Cartigny et al., 2014; Lowe and Arnott, 2016), and thus are not limited to the shallow-marine shoreface. Note also that the work of Dumas and Arnott (2006) refers to equilibrium large-scale wave ripples, which most probably are mechanistically different from features in other depositional settings that exhibit similar stratification patterns. Landing et al. also argue that normally graded, coarse-grained, ~5–25-cm-thick arkose beds near the top of the Altona are likely tempestites. However, these beds consist mostly of coarse sand with dispersed granules, all of which exceed the competence and most certainly suspension capability of storm-driven coastal currents (e.g., Myrow et al., 2002; Dumas et al., 2005). Additionally, the general lack of discernable stratification suggests that bedform growth and initiation was inhibited, which may reflect high near-bed sediment concentration and high rates of bed aggradation (Arnott and Hand, 1989; Leclair and Arnott, 2005; Sumner et al., 2008; Tilston et al., 2015). Moreover, the presence of up to 35% interstitial clay and silt matrix is interpreted to have originated by eluviation above the groundwater table, filling the pore space between the coarse and very coarse sand grains. Landing et al. (2009) interpreted the dolomite beds in the Altona as open-marine limestone that was later subjected to hydrothermal dolomitization. However, we observed no petrographic evidence for hydrothermal dolomitization, such as saddle dolomite, vugs, base metal sulphides, or remnant calcite. Instead, these beds consist almost entirely of sucrosic dolomicrite with an equigranular intergranular fabric consisting of ~5–50 μm anhedral to subhedral ferroan dolomite rhombs (e.g., Lowe et al., 2017, their fig. 8c). Smooth, bumpy or crinkly red and gray variegated laminae are common and consist of alternating "clean" gray dolomicrite and hematite + clay/carbon – rich red laminae. These are interpreted to have formed by successive redox fronts related to the growth and later decay of accreted microbial mats. Accordingly, the sucrosic dolomicrite that make up these beds is interpreted to have been precipitated by bacterial mediation in an evaporitic peritidal setting (e.g., Chafetz and Buczynski, 1992; Vasconcelos et al., 1995; Pratt, 2010). Additional features suggestive of peritidal conditions include rare vertical burrows, shrinkage and injection structures, bent and contorted laminae, intraclasts, silt grains and silt interlaminae, rare bioclasts, including sparse gastropod(?), lingulid brachiopod and trilobite fragments, and sparse bioturbation suggestive of stressed, restricted schizohaline conditions (Purser et al., 1994; Pratt, 2010). Additionally, the common occurrence of low-relief, narrowly spaced (<4 cm), straight-crested symmetrical wave ripples suggest very shallow water conditions with short-period, short-wavelength surface wind waves (i.e., depth-limited conditions of Clifton and Dingler, 1984).

Landing et al. also contend that we have made numerous biostratigraphic errors in correlation. However, our framework uses age constraints from all available documented and newly published fossil ages from the Ottawa graben Potsdam succession (Walcott, 1891; Flower, 1964; Fisher, 1968; Greggs and Bond, 1972; Brand and Rust, 1977; Salad Hersi et al., 2002; Dix et al., 2004; Landing et al., 2009; Lowe et al., 2017), augmented with age constraints from available paleomagnetic (Seguin et al., 1981) and new radiometric ages (Gall et al., 2017). Precise depositional ages are lacking from most of the Ottawa graben Potsdam succession due to an absence of volcanic ash beds and fossils, leaving much of the stratigraphic age interpretation to be based on the relative ages of units, the nature of stratigraphic contacts, the thicknesses and thickness variability of stratal units, the distribution of depositional lithofacies, detrital composition, and sediment provenance, bracketed where possible by sparse age-diagnostic fossils. Upon close reading of Landing et al.'s comments, we cannot find any errors. Nevertheless, we address the main comments below.

Starting at the base of the Potsdam succession, Landing et al. claim that the upper Altona Member is ca. 503 Ma and suggest that our proposed timing of Ausable sedimentation and unconformity development to be too short (3 m.y.) based on a ca. 500 Ma age for the *Crepicephalus* Zone trilobites (Fisher, 1968) at the base of the Keeseville Formation. However, it is unclear how these precise ages were determined by Landing et al. or the uncertainty in their measurement (in ± Ma). The former date is presumably from their "middle Middle Cambrian" age determination based on *Ehmaniella*? specimens from the Atwood Farm section (Landing et al., 2009). Notably however, Landing et al. (2009) chose not to assign these specimens to the *Ehmaniella* Subzone (of the *Ehmaniella* Zone) of Sundberg (1994), which extends into the lower Middle Cambrian, because of a technicality concerning the naming rules of biostratigraphic zones and subzones (Landing et al., 2009, p. 558). Moreover, according to Peng et al. (2012) the *Ehmaniella* Zone coincides with ca. 505 Ma, whereas the *Crepicephalus* Zone corresponds to 497–498.5 Ma (in contrast to Landing et al.'s 503 Ma and 500 Ma ages, respectively), which would increase the hiatus between the upper Altona and the Ausable to ~8 m.y. Accordingly, the precision and accuracy of the depositional ages provided by Landing et al. are questionable.

In contrast to comments by Landing et al., Lowe et al. (2017) do mention the *Crepicephalus* Zone trilobites noted by Fisher (1968) and numerous earlier authors (Walcott, 1891; Flower, 1964; see Lowe et al., 2017, p. 15) at the base of the Keeseville Formation. These faunae occur in the lower part of an anomalously thick succession (~140 m) of mainly sabkha and coastal plain strata at the Ausable Chasm located in the southeasternmost part of the Ottawa graben, which are interpreted to record the earliest onset of diachronous Keeseville sedimentation in the Ottawa graben in an area of locally elevated subsidence.

Landing et al. also suggest that our exclusion of *Crepicephalus* Zone trilobites from the Potsdam Formation in the Appalachian Basin, located over 150 km south of the Ottawa graben (see Landing, 2007, stop 1.4), is an error in biostratigraphic correlation. However, as noted above, the error stems from attempts to force stratigraphic successions in the Ottawa graben to conform to those in the Appalachian Basin (e.g., Landing, 2007; Landing et al., 2009). The current biostratigraphy, lithostratigraphy, and contact relationships outlined in Lowe et al. (2017) suggest that Keeseville Formation strata in the Ottawa graben record a longer period of siliciclastic sedimentation compared to elsewhere along the Laurentian margin, where carbonate sedimentation generally dominated. This is consistent with the detrital zircon provenance outlined by Lowe et al. (2018), which shows evidence of local sediment supply from Adirondack and western Grenville Province hinterlands.

The conodont fauna reported by Lowe et al. (2017) from the Rivière aux Outardes Member exposure in Rockland Ontario, including a specimen of *Variabiloconus bassleri*, support an early Ordovician depositional age for the upper part of the Rivière aux Outardes Member, and thus for the upper part of allounit 2 of the Potsdam Group. The relatively well-preserved *V. bassleri* specimen indicates a late Skullrockian age in the *Rossodus manitouensis* Zone of the North American Ibexian series; or, lower Tremadocian in international terminology (Ross et al., 1997). This does suggest that it is potentially coeval with the Tribes Hill Formation in the Appalachian basin, which Landing et al. propose as the correlative unit to the Rivière aux Outardes Member in the Ottawa graben.

The final disagreement of Landing et al. is the age of the upper part of the Keeseville Formation across the Ottawa Embayment and the nature of the upper contact of the Potsdam Group with the overlying Theresa Formation, which is comprehensively documented by Lowe et al. (2017). This is probably because Landing (2007) and Landing et al. (2009) placed the Upper Cambrian Galway Formation above the Keeseville in the Ottawa graben, based on correlations to the Appalachian Basin. However, there is no evidence to support this correlation. Although lithologically similar to the Theresa, the Galway is an older unit confined to the Appalachian Basin. Paleontology, paleomagnetic data, and U-Pb geochronology (e.g., Fisher, 1968; Greggs and Bond, 1972; Brand and Rust, 1977; Seguin et al., 1981; Salad Hersi et al., 2002; Dix et al., 2004; Landing et al., 2009; Gall et al., 2017; Lowe et al., 2017) suggest that coeval strata in the Ottawa graben were deposited in mainly terrestrial to marginal marine environments and thereby represent a depositional continuum from hinterland terrestrial sedimentation (the Ottawa graben) to marine shelf carbonate and clastic sedimentation during the Late Cambrian (northern Appalachian Basin; e.g., Lowe et al., 2017).

Landing et al. also claim that the westerly diachronous nature of the Potsdam Group is not supported. However, the local expression of the Keeseville–Theresa contact (conformable versus unconformable) and the biostratigaphic age constraints suggest that the facies change from siliciclastic to mixed carbonate-siliciclastic sedimentation was diachronous across the Ottawa graben, starting first in the southeastern graben and moving progressively northwestward through the Early Ordovician (e.g., Lowe et al., 2017). In the southeastern Ottawa graben, the change from clastic (Keeseville) to carbonate-clastic strata (Theresa) is conformable and gradational, whereas in the west it is sharp and conformable, but locally unconformable in areas on the hanging-wall blocks of regional normal faults (e.g., the Gloucester and Ste. Justine faults) throughout the northern Ottawa graben (Sanford and Arnott, 2010; Lowe et al., 2017). Conodont biostratigaphy from the basal Theresa across the Ottawa graben also support the diachronous relationship, with the facies change as early as the Early Tremadocian in the southwest, but mid-to-late Arenig in the northwest (Lowe et al., 2017, fig. 25). Together, the contact relationships and biostratigraphy of the lowest Theresa strata across the Ottawa graben suggest early Early Ordovician flooding of the deeper southwestern part of the Ottawa graben, followed by protracted drowning of the remainder of the Ottawa graben over faulted topography with limited accommodation space through the Early Ordovician (Lowe et al., 2017, 2018). Evidence of such pre-, syn-, and post-sedimentary faulting and early Paleozoic faulted topography in the Ottawa graben has been documented for many years (e.g., Otvos, 1966; Lewis, 1971; Selleck, 1975; Wolf and Dalrymple, 1984; Salad Hersi and Dix, 2006; Sanford and Arnott, 2010; Lowe and Arnott, 2016; Lowe et al., 2017, 2018) and underpins the differences in early Paleozoic stratigraphy between the Ottawa graben and elsewhere in northeastern North America.

In summary, we believe that the comments of Landing et al. are a product of confusion stemming from the fact that the historic stratigraphic frameworks of the Potsdam Group in the Ottawa graben were mostly developed within the confines of international and provincial borders, resulting in the correlation of the early Paleozoic Ottawa graben succession to other Laurentian shelf and craton successions that were not affected to the same extent by tectonic reactivation. The work of Lowe (2016), Lowe et al. (2017), and Lowe et al. (2018) represents the most comprehensive, most objective, and most systematic study of the Potsdam Group in the Ottawa graben to date, having incorporated facies, stratigraphic, petrographic, detrital zircon, and biostratigraphic data from more than 300 outcrop locations and over 1500 m of drill core. The critiques of Landing et al. do not expose any equivocal flaw that would undermine our stratigraphic framework for the Ottawa graben, which best fits the existing lithologic, stratigraphic, facies, mineralogical, and faunal data. Nevertheless, we welcome this opportunity to clarify our interpretations and await new data that will help refine the lower Paleozoic stratigraphy of the Ottawa graben and coeval Laurentian shelf and cratonic hinterland.

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