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Ediacaran sedimentology and paleoecology of Newfoundland reconsidered

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ABSTRACT

Ediacaran fossils of Mistaken Point and other localities in Newfoundland have been reconstructed as denizens of a deep, dark ocean, based on a turbidite interpretation of their sedimentary context. Objections to this view include geochemical indications of fresh water and volcanological and sedimentological evidence that they lived in soils of coastal plains and tidal flats. Two distinct assemblages of these fossils are recognized: a low-diversity *Aspidella–Heimalora* community on sulfidic grey paleosols (Sulfaquent) and a high diversity *Fractofusus–Charniodiscus* community on red ferruginous paleosols (Fluvent and Udept). These two assemblages and their paleosols were comparable in habitat with Phanerozoic intertidal salt marsh and coastal woodlands, respectively. Paleosol chemical composition is also evidence that Ediacaran communities of Newfoundland lived in humid, cool temperate paleoclimates, unlike arid paleoclimates of the classical Ediacaran biota of South Australia.

1. Introduction

Ediacaran fossils of Newfoundland have been considered algae, fungi, or marine invertebrates with photosymbionts in the photic zone (Fischer, 1965; Seilacher, 1984, 1989; McMenamin, 1986; Peterson et al., 2003). Other plant-like and lichen-like features of these fossils include fractal branching (Cuthill and Conway Morris, 2014), nutrient-acquiring root-like systems (Antcliffe et al., 2015), and both sexual and vegetative reproduction (Mitchell et al., 2015). An alternative view of these famous fossils of Mistaken Point and other localities in Newfoundland (Figs. 1 and 2) is that they were deep marine osmotrophic metazoans, perhaps anemones, jellyfish, or sea pens, because enclosing beds have been interpreted as turbidites (Anderson and Misra, 1968; Misra, 1971; Clapham et al., 2003; Narbonne et al., 2005; Hofmann et al., 2008; Liu et al., 2015). This study re-examines these divergent hypotheses of deep versus marginal marine habitats in two ways. First is comparative sedimentology, in which polished slabs of fossiliferous beds in the Mistaken Point Formation are compared with polished slabs and outcrops of known Phanerozoic turbidites versus intertidal–supratidal paleosols and tsunamites. Second is paleoecology, in which individual beds with fossils growing in place are evaluated as distinct kinds of communities.

Distinguishing marine from non-marine Precambrian sedimentary rocks is difficult because the biological affinities and thus habitat preferences of Ediacaran fossils remain problematic (Retallack, 2013b; Retallack, 2014b-d; Antcliffe et al., 2015; Mitchell et al., 2015). Shallow-water deposition of the Mistaken Point Formation of Newfoundland is supported by hummocky bedding, oscillation ripples, carbonate nodules, and purple-red color (Misra, 1971; Benus, 1988; Dalrymple et al., 1999). The Mistaken Point Formation also includes spindle bombs, accretionary lapilli, gas-escape structures, and ungraded crystal tuffs that could only be deposited on land, as well as trace element compositions of tuffs unique to forearc basins (Retallack, 2014a). Geochemical indices from the Mistaken Point Formation (Fig. 3), such as high (>2.8) C/S ratios (Canfield et al., 2007), are evidence of low-sulfate, freshwater paleoenvironments (Berner and Raiswell, 1984; Raiswell and Berner, 1986; Canfield et al., 2010). Furthermore low ratios (<0.2: Canfield et al., 2007) of highly reactive iron (Fe_{HR}, mainly pyrite or hematite iron) over total iron (including iron still within silicates, Fe_{TOT}) are more like soils than modern marine or lacustrine sediments (Ku et al., 2008). It could be that Ediacaran oceans and soils were totally unlike modern (Canfield et al., 2007, 2010), but scatter of these indices between freshwater and marine within the Mistaken Point Formation (Fig. 3) more likely reflects facies changes than repeated whole ocean freshenings (Retallack, 2013a). Finally, rates of sediment accumulation for the Mistaken Point Formation (0.16 ± 0.08 mm a^{-1}) were much higher than observed in distal turbidite fans (0.012–0.026 mm a^{-1}) or the deep ocean (0.002–0.009 mm a^{-1}; Retallack, 2014a). To these general indications, this contribution adds bed-scale sedimentological interpretations of the Mistaken Point Formation, and their relevance for understanding the paleoecology of fossils which grew in these beds.

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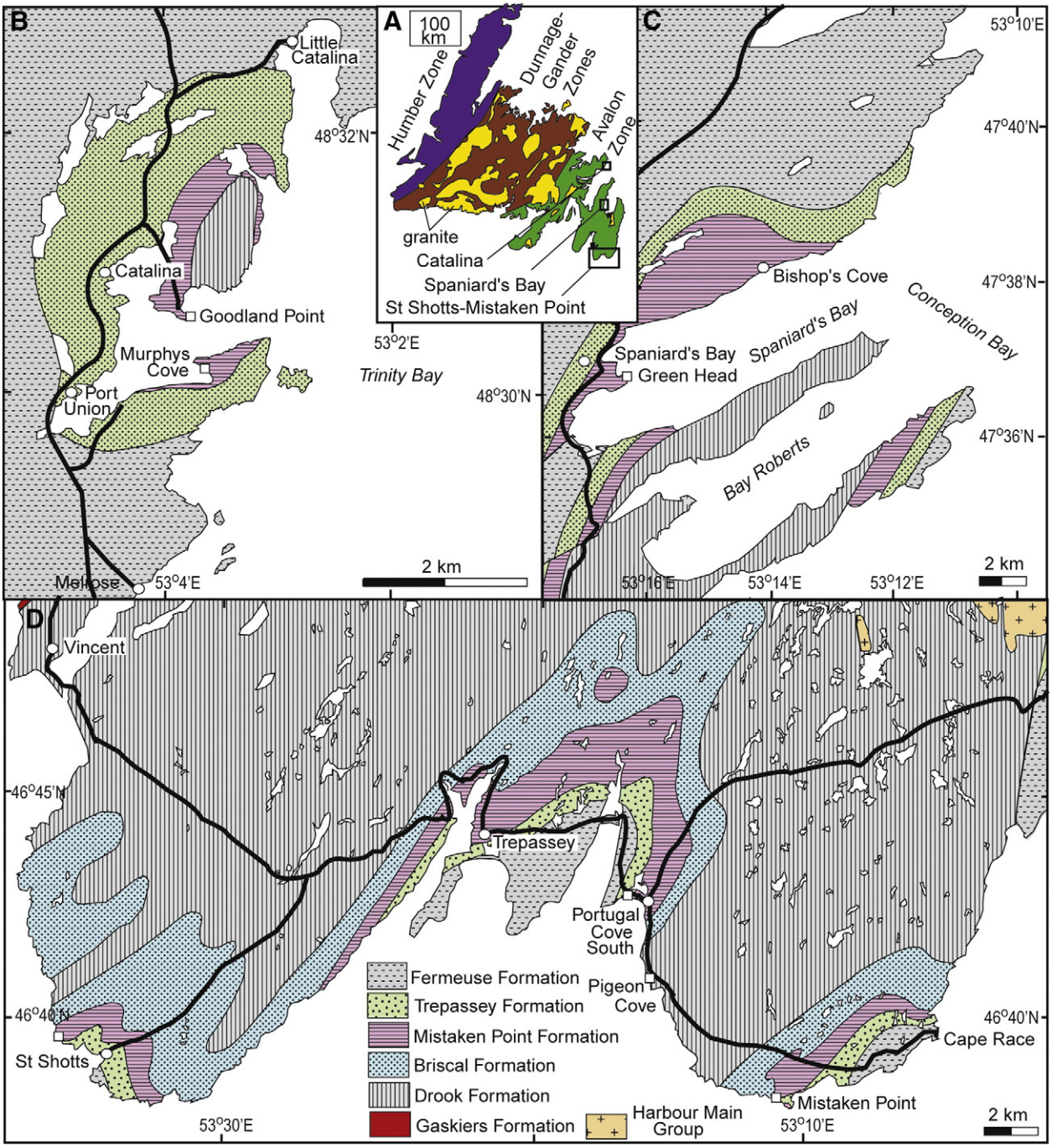

Fig. 1. Geological maps of study sites in the Avalon Peninsula of Newfoundland; A, overview of Newfoundland; B, Catalina area, eastern Bonavista Peninsula (Hofmann et al., 2008); C, Spaniards Bay, northwest Avalon Peninsula; D, Trepassey area, southern Avalon Peninsula (King, 1988).

2. Geological background

The Conception Group of the Avalon Zone of Newfoundland (Fig. 1) is well known for a variety of Ediacaran fossils, but they are most diverse in the Mistaken Point Formation (Fig. 2). Four high-precision radiometric dates within the Conception Group provide an age model for the whole sequence, with the Mistaken Point Formation dated at 565 Ma (van Kranendonk et al., 2008; Noble et al., 2015). All examined localities were within the forearc basin of the Trinity Synclinorium on granitic crust, between the Holyrood Granite (Fig. 2) exposed in the Holyrood Horst to the east and the ancient continental calcalkaline volcanic arc exposed to the west (Retallack, 2014a).

Cambrian (ca. 525 Ma) deformation metamorphosed the Conception Group to prehnite-pumpellyite facies (Papezik, 1974). Paleomagnetic directions of hematite and magnetite in the Conception Group were reset by metamorphism (Evans and Raub, 2011), but paleomagnetic directions of Marystown and Musgravetown Volcanics nearby were less severely affected and are evidence of peri-Gondwanan midlatitude locations: S34.6 ± 8.0°, S23.6 ± 8.3°, S19.1 ± 11.1°, and S24.5 ± 11.9° successively between 570 and 550 Ma (Pisarevsky et al., 2012; Thompson et al., 2012).

3. Materials and methods

To determine the sedimentological context of Ediacaran fossils in Newfoundland, this project studied the four most productive fossil