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Questioning the age of the Moorhead Phase in the glacial Lake Agassiz basin

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Abstract

The stratigraphy of sites within the Lake Agassiz basin that constrain the timing of the onset of the Moorhead low-water Phase is reexamined. Stratigraphic interpretation of the oldest date (10,960 ^{14}C yr BP) from cross-bedded sand of the Ojata Beach is questioned, particularly in light of demonstrated long-distance transport and reworking of older organic material from elsewhere in the basin. A maximum onset age for the Moorhead Phase is suggested from a 10,675 ± 60 ^{14}C yr BP age from wood in gravel from the base of the southern outlet, whereas radiocarbon dates from in situ peat indicate a later minimum onset age of 10,340 ± 100 ^{14}C BP.

1. Introduction

The apparent temporal coincidence of the Younger Dryas cold period with the Moorhead low-water phase of Lake Agassiz has been used to establish a causal mechanism between Lake Agassiz outburst floods and rapid climate change (Broecker et al., 1989; Licciardi et al., 1999; Clark et al., 2001; Teller et al., 2002; Teller and Leverington, 2004). However, independent chronologic and physical evidence for meltwater routing from the Lake Agassiz basin is sparse, an eastern outlet at Younger Dryas time has not been documented, and current dating evidence suggests that deglaciation at the hypothesized eastern outlet was near the end of the Younger Dryas rather than the beginning (Lowell et al., 2005; Teller et al., 2005). Consequently, a reexamination of the data used to assign an 11,000 ^{14}C yr BP age for the beginning of the Moorhead Phase is in order.

2. Moorhead Phase

The Moorhead Phase is the period in time when the southern outlet was abandoned and lake levels were low, and it ended when levels rose to the Upper Campbell Beach, reopening the southern outlet (Clayton, 1983); see Fisher (2005) for a recent review and discussion of the Agassiz chronology. There are widespread stratigraphic data for the Moorhead Phase, consisting of peat, littoral, and fluvial deposits interbedded with lacustrine sediments (e.g., Upham, 1895; Harris et al., 1974; Arndt, 1977; Fenton et al., 1983). These deposits are a minimum of ~30 m elevation below the southern outlet. We review the relevant chronologic data for the beginning of the Moorhead Phase and hypothesize that it is younger than previously thought. For consistency with the previous literature, all ages are reported in radiocarbon years before present (BP).

3. Onset of the Moorhead phase

3.1. Rainy River lowland and Wampum

Numerous Moorhead-aged dates have come from the Rainy River lowland (Fig. 1). By examining pollen, plant macrofossils, insect and mollusc assemblages, Bajc et al. (2000) determined that long-distance transport and sediment reworking affected all of their sample localities. For example, Bajc et al. (2000) suggested that the oldest wood at site F87-33 (10,810 ± 240 BP, TO-1504) might be a

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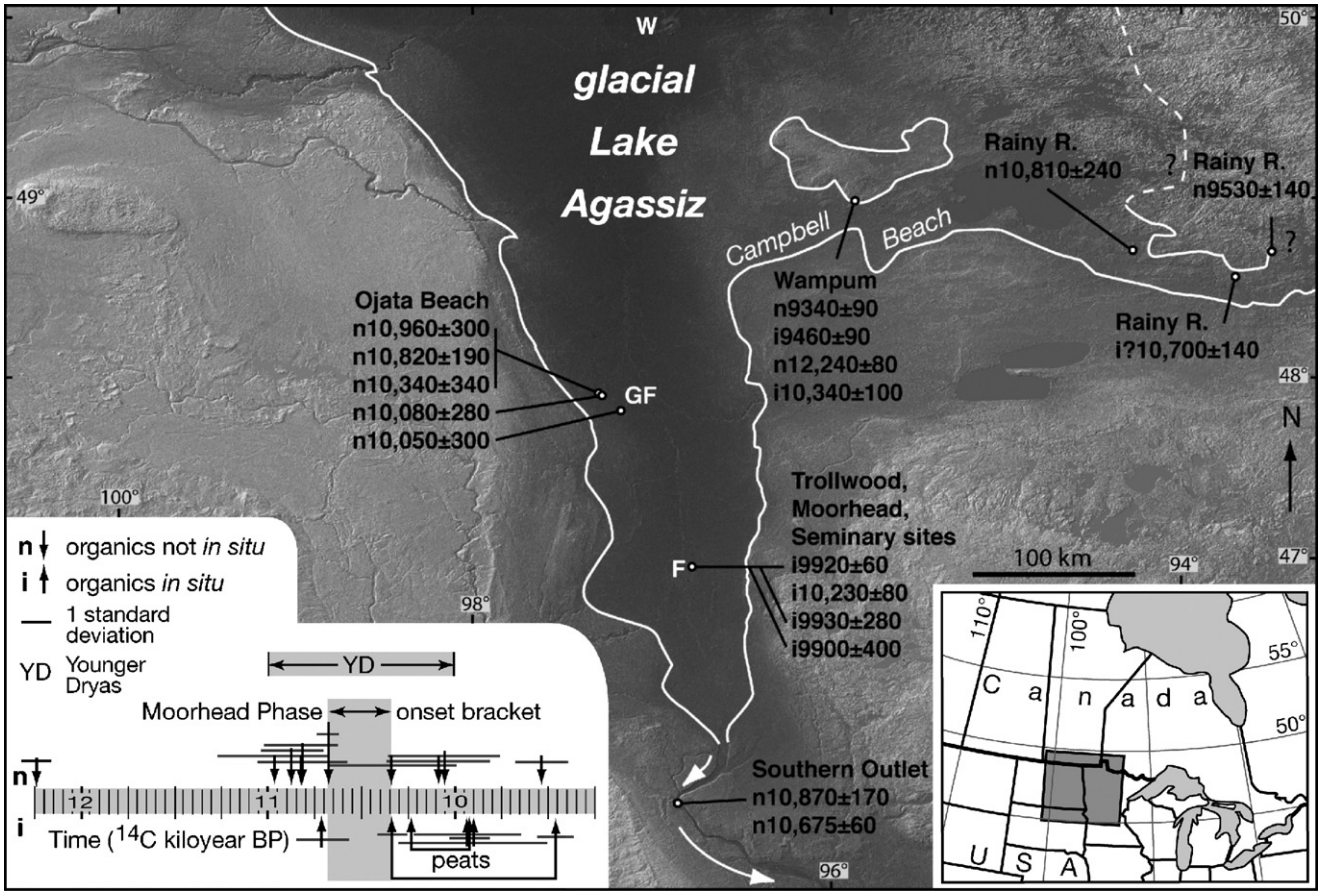

Fig. 1. Digital elevation model of the southern Lake Agassiz basin with locations noted in text. Radiocarbon ages discussed in the text are located on the map and plotted in chronological context as black arrows on the inset graph. W–Winnipeg, GF–Grand Forks, F–Fargo.

minimum age for the Moorhead Phase if its origin was local. Overall, wood dates from cores and outcrops in the Rainy River lowland range between 10,810±240 BP (TO-1504) and 9530±140 BP (WAT-1934). A possible in situ age comes from Mud Lake where a 6 cm thick bulk sample of fine organic detritus (peat?) yielded an age of 10,700±140 BP (WAT-1910). Otherwise, Bajc et al. (2000, p. 1338) conclude "Most Moorhead Phase organic remains are detrital and possibly reworked from older deposits." Presently there is no way to distinguish between Moorhead-aged organic deposits originating in the basin from organic material transported from outside the basin. Similar evidence for reworked material is found at the Wampum site 200 km to the west (Fig. 1).

Teller et al. (2000) proposed a similar interpretation for clasts of organic material (possible wood fragment, 12,240±80 BP, TO-4870) ~3000 years older than the Campbell Beach sediment at the Wampum site. Most dates from the Wampum site are younger than 10,100 BP, clustering around 10,000 BP. The youngest age in the upper Campbell Beach sediment is 9340±90 BP (TO-4855). Below the Campbell Beach in the Rainy River lowlands, and in the Upper Campbell Beach at Wampum, Moorhead-aged sediment from a variety of depositional environments contains reworked wood making an age assignment for the low-water phase problematic from these data.

3.2. Ojata Beach deposits

The oldest wood age commonly cited for the beginning of the Moorhead Phase is 10,960±300 BP (W-723). This sample comes from cross-bedded sand over till, overlain by <1 m of pebbly, clayey silt and 1.3 m of massive sand from west of Grand Forks, ND (Fig. 1) on the Ojata strandline (Moran et al., 1973). This site lies about 35 m below the modern elevation of the Upper Campbell Beach at the southern outlet. Its elevation has been used to argue for an eastern outlet open at that time (Upham, 1895). The same sample was redated at 10,820±190 BP (TAM-1). Two other sites <1.6 km away, apparently on the same landform, reveal similar stratigraphy with a wood date in cross-bedded sand between till and clay of 10,080±280 BP (W-900) and a wood date in sand of 10,340±340 BP (I-5213). Moran et al. (1973) report a date of 10,050±300 BP (W-1005) on abraded wood within the top of a clay unit below 1.5 m of sand and gravel from the same Ojata strandline 23 km away (Fig. 1). Interpreting these ages to reflect the age of the beach requires 900 ^{14}C years for