

Progressive westward expansion of North American continental ice sheets during the Quaternary and implications for the timing of initial human overland migration into the Americas

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ABSTRACT

There is extensive and robust stratigraphic and geomorphic evidence of progressive enlargement of North American (NA) continental ice sheets in a westerly direction during the glaciations of Quaternary Period. This culminated with a one-time coalescence of the Laurentide ice sheet and valley glaciers from the Rocky and Mackenzie mountains and outlet glaciers from the Cordilleran Ice Sheet during marine isotope stage (MIS) 2. This singular coast-to-coast ice (CCI) event ended the pattern of broad ice-free corridors between Cordilleran and continental glaciers that was the norm during all previous Quaternary glacial maxima in North America. Recent discoveries of human settlements above the Arctic Circle in eastern Siberia during MIS 3 (~30 C14 ky BP) and an accumulation of archaeological sites in NA south of the limit of glaciation dating to MIS 3 (specifically <30 C14 ky BP to ~22 C14 ky BP) or contemporaneous with the CCI event during MIS 2 (specifically ~22 C14 ky BP to ~14 C14 ky BP) suggest that the limiting event for initial overland human migration into the Americas was the closing of the ice-free corridor rather than its opening as has been the orthodoxy.

PART 1-- INTRODUCTION

ORIGIN OF THE ICE-FREE CORRIDOR CONCEPT AS AN EXPLANATION FOR INITIAL PEOPLING OF THE AMERICAS



The discovery of the Folsom and Clovis sites in 1927 and 1932 respectively provided indisputable evidence of the co-existence of humans with extinct 'ice age' fauna. The question immediately arose as to how these hunters had reached the mid-latitudes of North America at a time when the northern half of the continent was apparently buried beneath the Laurentide and Cordilleran ice sheets. In 1933, W.A. Johnston (GSC) proposed that people could have reached the lands south of the ice via a passage between the montane and continental glaciers at the climax of the last glacial maximum (LGM). In 1935, Ernst Antevs coined the term *'ice-free corridor'*. Testing of the existence of an ice-free corridor at the LGM was not completely settled until the advent of cosmogenic exposure dating of the Foothills Erratics Train (Fig. 1; Jackson et al. 1997). This in turn begged the question: *"was to whether this coalescence was one of many coast-to-coast glaciations or a single unique event"*. This question is now resolved based upon applications of advances in glacial sedimentology, AMS ¹⁴C dating and paleomagnetic investigation of glacial sediments (Jackson, Andriashek and Phillips, 2011).

PART 2. EVIDENCE FOR ONE COAST-TO-COAST GLACIATION

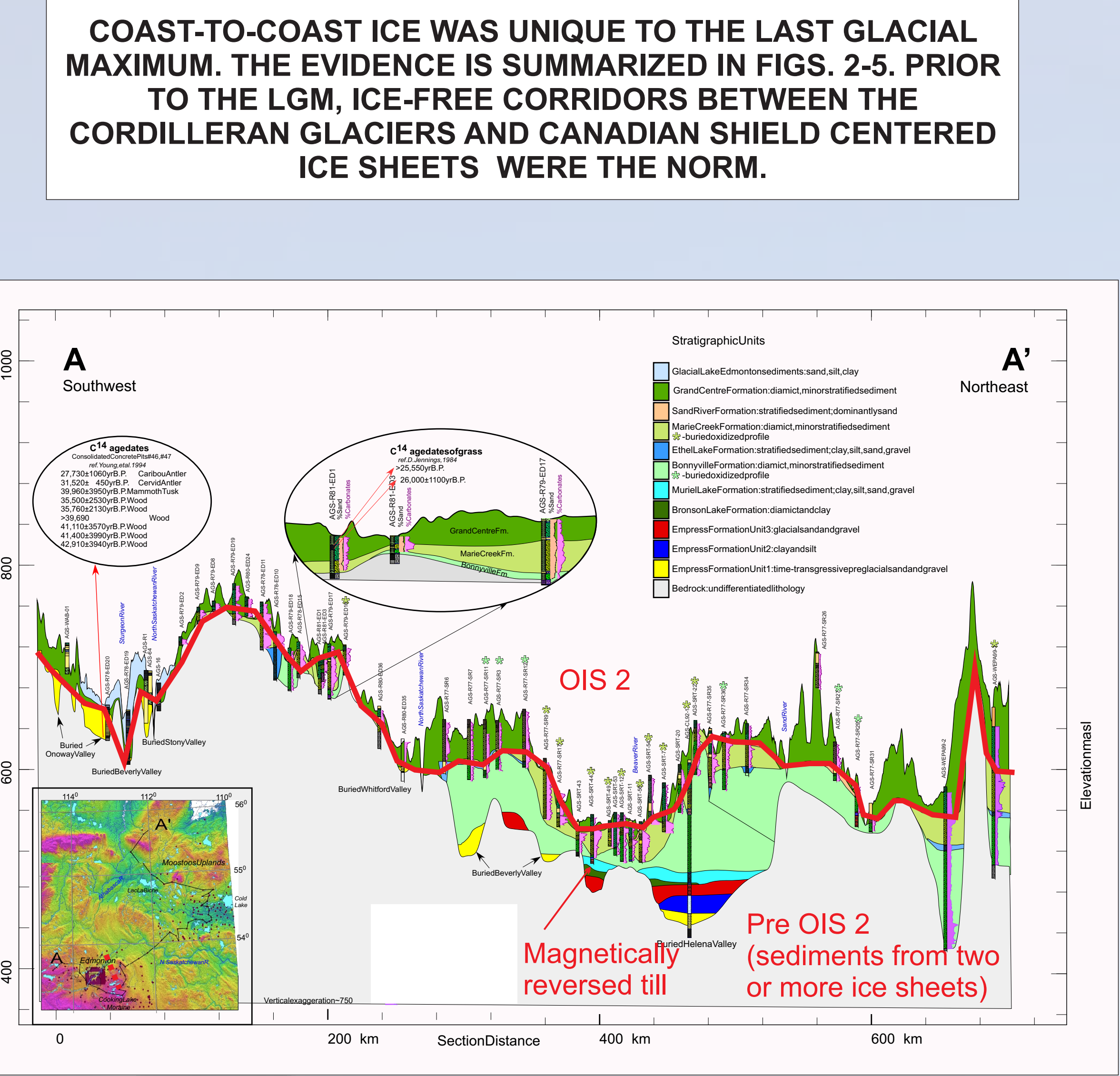
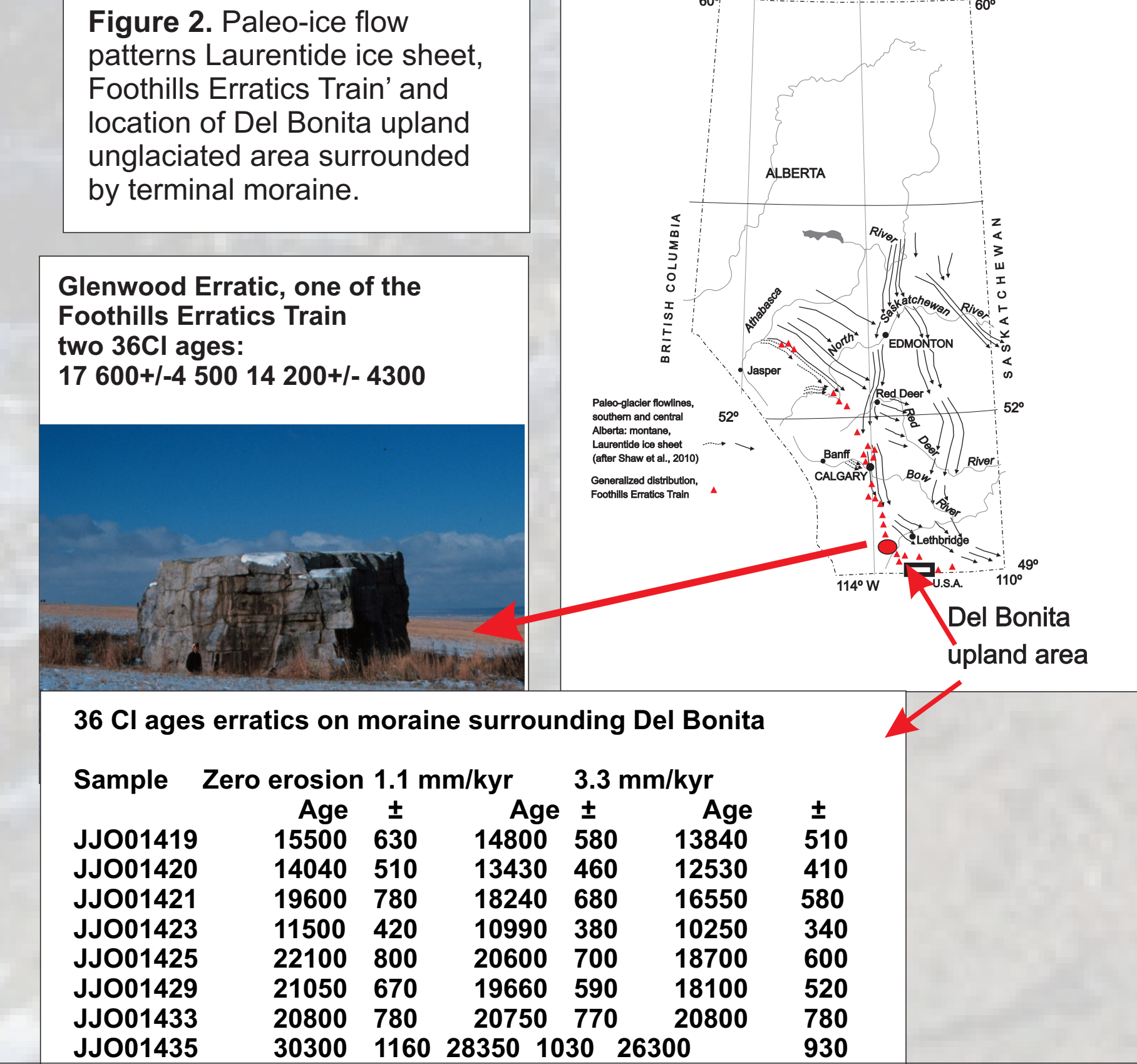


Figure 3. Architecture of the Quaternary lithostratigraphy in central and northeast Alberta highlighting formations associated with multiple glaciations and illustrating the distribution of time-transgressive preglacial deposits of the Empress Formation (from Jackson et al. 2011).

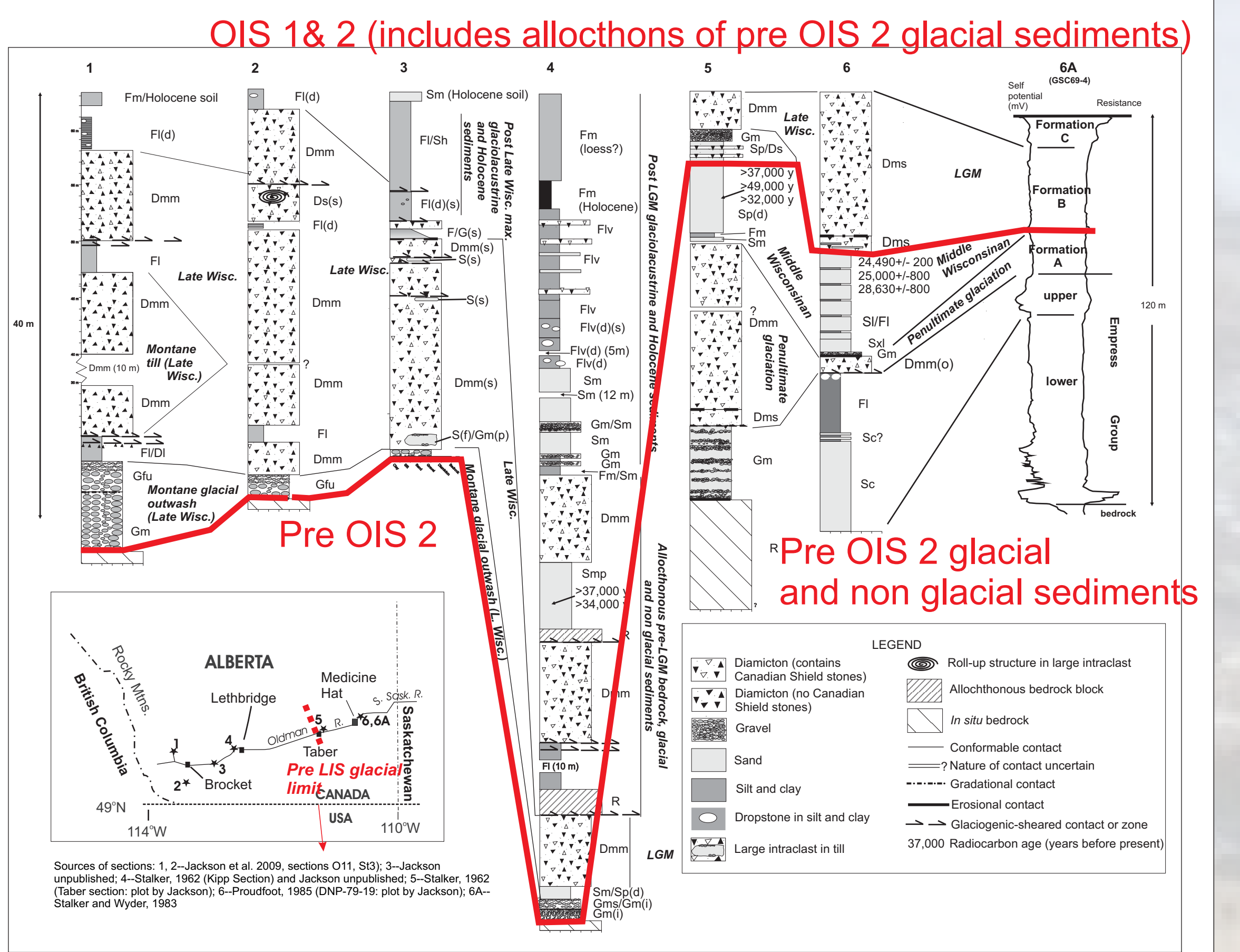
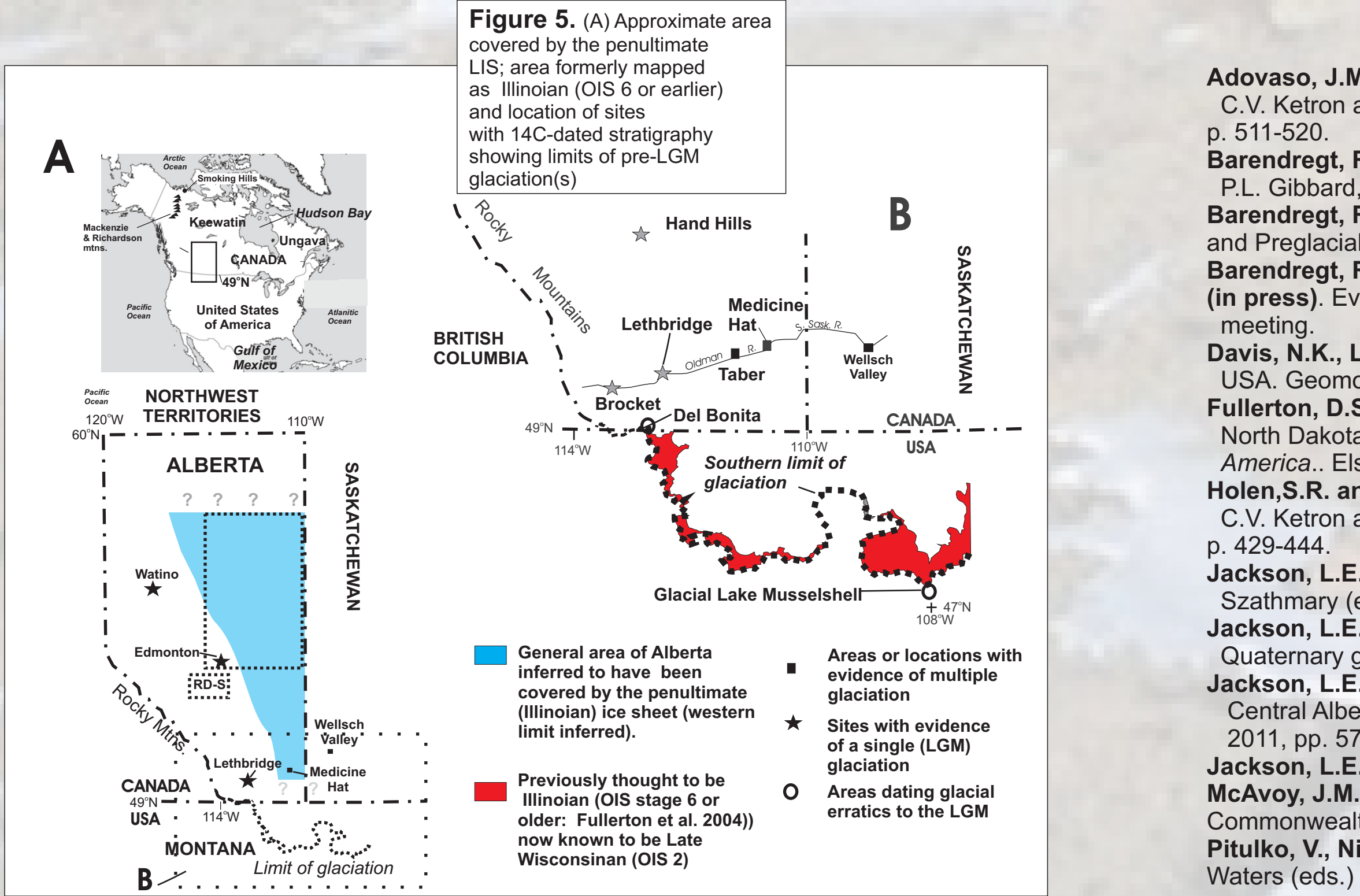


Figure 4. Western limits of pre-OIS 2 glacial ice and stratigraphy along the Oldman River (from Jackson et al. 2011).



PART 3--A PRE-LGM ICE-FREE CORRIDOR A VIABLE OPTION FOR OVERLAND ENTRY INTO THE AMERICAS

The Paleoamerican Odyssey conference in Santa Fe, New Mexico in October, 2013 marked the passing of the Clovis-first paradigm. At present, there is a consensus that we really don't know when and how people arrived in the Americas. What we do know is that people were present in the Americas when what is now Canada and the adjacent parts of the USA were covered by coast-to-coast glacial ice. Some controversial sites suggest the presence of humans prior to the closing of the last ice-free corridor. The duration of this glacial cover was short: between ca. 22 and ca. 14 ky. This was the culmination of westward expansion of ice sheets during the late Neogene glaciations (Barendregt and Duk-Rodkin, 2004). Subsequent work has shown that the western margins of continental ice sheets first reached Saskatchewan and eastern Alberta during a glaciation(s) prior to the last magnetic reversal (~0.78 Ma) (Barendregt et al. 2012; Barendregt and Enkin, 2012; Barendregt et al in press). What is notable is that throughout the Pleistocene, there was always unglaciated land connecting the Arctic with the interior of North America.



Figure 6. A speculative distribution of open land and glacial ice ca. 25 ka BP. Ice-free corridors open for habitation and entry into the Americas are indicated. Sites with yellow dots indicate approximate synchronicity with the opening of the post LGM ice-free corridor. Those indicated by red indicate synchronicity with coast-to-coast glacial cover or pre-LGM ice-free corridors (after Jackson and Duk-Rodkin, 1996).

ICE-FREE CORRIDORS ARE STILL OPTIONS FOR EARLY OVERLAND ENTRY OF HUMANS INTO THE AMERICA-- BUT DURING ITS CLOSING, NOT OPENING

Archaeological sites clearly predating the Clovis culture such as Paisley Cave in North America and Monte Verde in South America apparently predate the opening of a post-LGM ice-free corridor in the coast-to-coast ice covering Canada at the time. This has bolstered the idea that humans entered the Americas along the Pacific Coast.

However, older and, to some, controversial sites such as Meadowcroft (Adovasio and Peder, 2013), Cactus Hill (McAvoy and McAvoy, 1997) and clusters of sites in the mid-west summarized by Holen and Holen (2013) (Fig. 6) support the presence of humans south of the ice sheets during the the LGM or earlier during the mid-Wisconsin (OIS 3). Humans occupation north of the Arctic Circle in western Beringia is now well established (Pitulko et al., 2013). Lifeways capable of allowing humans to flourish in the most rigorous periglacial conditions had been achieved by that time. Westward radiation of these people to eastern Beringia would have brought them into one or both of the ice-free corridors (Fig. 6) and the Americas to the south. *If and when there is a consensus that humans were in the Americas prior to the LGM, ice-free corridors predating the coalescence of Cordilleran and Laurentide ice and indeed, the interior plateaux and valley systems of the Canadian Cordillera are viable overland routes of entry into the Americas (Jackson and Duk-Rodkin, 1996).* Such passages may have existed until ca. 23,000 years ago or even later based upon the youngest pre-LGM ice-free 14C ages from the Interior Plains and the Cordillera.

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