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Glaciotectonic deformation and reinterpretation of the Worth Point stratigraphic sequence: Banks Island, NT, Canada

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ABSTRACT

Hill-hole pairs, comprising an ice-pushed hill and associated source depression, cluster in a belt along the west coast of Banks Island, NT. Ongoing coastal erosion at Worth Point, southwest Banks Island, has exposed a section (6 km long and ~30 m high) through an ice-pushed hill that was transported ~ 2 km from a corresponding source depression to the southeast. The exposed stratigraphic sequence is polydeformed and comprises folded and faulted rafts of Early Cretaceous and Late Tertiary bedrock, a prominent organic raft, Quaternary glacial sediments, and buried glacial ice. Three distinct structural domains can be identified within the stratigraphic sequence that represent proximal to distal deformation in an ice-marginal setting. Complex thrust sequences, interfering fold-sets, brecciated bedrock and widespread shear structures superimposed on this ice-marginally deformed sequence record subsequent deformation in a subglacial shear zone.

Analysis of cross-cutting relationships within the stratigraphic sequence combined with OSL dating indicate that the Worth Point hill-hole pair was deformed during two separate glaciotectonic events. Firstly, ice sheet advance constructed the hill-hole pair and glaciotectonized the strata ice-marginally, producing a proximal to distal deformation sequence. A glacioisostatically forced marine transgression resulted in extensive reworking of the strata and the deposition of a glaciomarine diamict. A readvance during this initial stage redeformed the strata in a subglacial shear zone, overprinting complex deformation structures and depositing a glaciotectonite ~20 m thick. Outwash channels that incise the subglacially deformed strata record a deglacial marine regression, whereas aggradation of glaciofluvial sand and gravel infilling the channels record a subsequent marine transgression. Secondly, a later, largely non-erosive ice margin overrode Worth Point, deforming only the most surficial units in the section and depositing a capping till.

The investigation of the Worth Point stratigraphic sequence provides the first detailed description of the internal architecture of a polydeformed hill-hole pair, and as such provides an insight into the formation and evolution of an enigmatic landform. Notably, the stratigraphic sequence documents ice-marginal *and* subglacial glaciotectonics in permafrost terrain, as well as regional glacial and relative sea level histories. The reinterpreted stratigraphy fundamentally rejects the long-established paleoenvironmental history of Worth Point that assumed a simple 'layer-cake' stratigraphy including the type-site for an organically rich, preglacial interval (Worth Point Fm).

1. Introduction

Previous investigations of Neogene and Quaternary deposits preserved at the surface and within purportedly *in situ* subsurface sections across Banks Island proposed the lengthiest framework of environmental change in the Canadian Arctic Archipelago (CAA; Vincent, 1982, 1983, 1989, 1990; Vincent et al., 1983, 1984; Barendregt et al., 1998). The framework documented up to eight continental glaciations and five interglaciations associated with multiple marine transgression/regression cycles that span the entire Pleistocene (Vincent et al., 1984; Vincent, 1990; Barendregt et al., 1998). Stratigraphic units exposed at Worth Point, southwest Banks Island, form a critical type section reported to include a 'layer-cake' sequence of preglacial organics assigned to the Worth Point Fm, till from the earliest glaciation on Banks Island, and marine deposits from a glacioisostatically forced marine

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transgression during an intermediate glaciation (Vincent, 1982, 1983, 1984, 1989, 1990, 1992; Vincent et al., 1984; Matthews et al., 1986; Barendregt et al., 1998). Magnetostratigraphic analyses of the Pleistocene units identified the Bruhnes–Matuyama magnetic reversal (0.78 Ma) at the contact between the Worth Point Fm and overlying till, forming an important marker horizon that permitted long–distance correlations between the Banks Island framework, magnetically constrained Arctic Ocean records, and widespread North American Quaternary marine and terrestrial records (Clark et al., 1984; Barendregt et al., 1998; Darby, 2003; Ehlers and Gibbard, 2004; Ehlers et al., 2011). This paper directly tests this elaborate and influential model.

Recently, the integrity of the Banks Island environmental framework has been challenged by a fundamental revision of the surficial geology of Banks Island (England et al., 2009; Lakeman and England, 2012, 2013). This research amalgamates all of the former multiple Quaternary till sheets (assigned to three glaciations, Vincent, 1982) into a single, island-wide Late Wisconsinan glaciation (England et al., 2009; Lakeman and England, 2013). Consequently, this revised surficial model on Banks Island warrants the reinvestigation of the subsurface stratigraphy, whose events were assumed to mirror those of the previous, multiple glaciation model, including their proposed pre and postglacial seas and intervening interglacials.

New investigations of the stratigraphy at Worth Point indicate that the deposits are pervasively glaciotectonized, thereby contradicting the previously proposed 'layer-cake' stratigraphy and implicitly their former palaeoenvironmental interpretations. This paper presents the sedimentology, structural geology and chronology of the Worth Point section and provides a revised architectural framework that constitutes the first detailed reconstruction of glaciotectonism on Banks Island, CAA (Figs. 1 and 2).

1.1. Objectives and methods

The objectives of this paper are: (1) to describe the geomorphology, stratigraphy, sedimentology, glaciotectonic architecture and deformation structures at Worth Point; (2) to reconstruct the glacial stress regimes responsible for glaciotectonism and to differentiate between deformation in proglacial, ice-marginal and subglacial environments; (3) to determine the number of

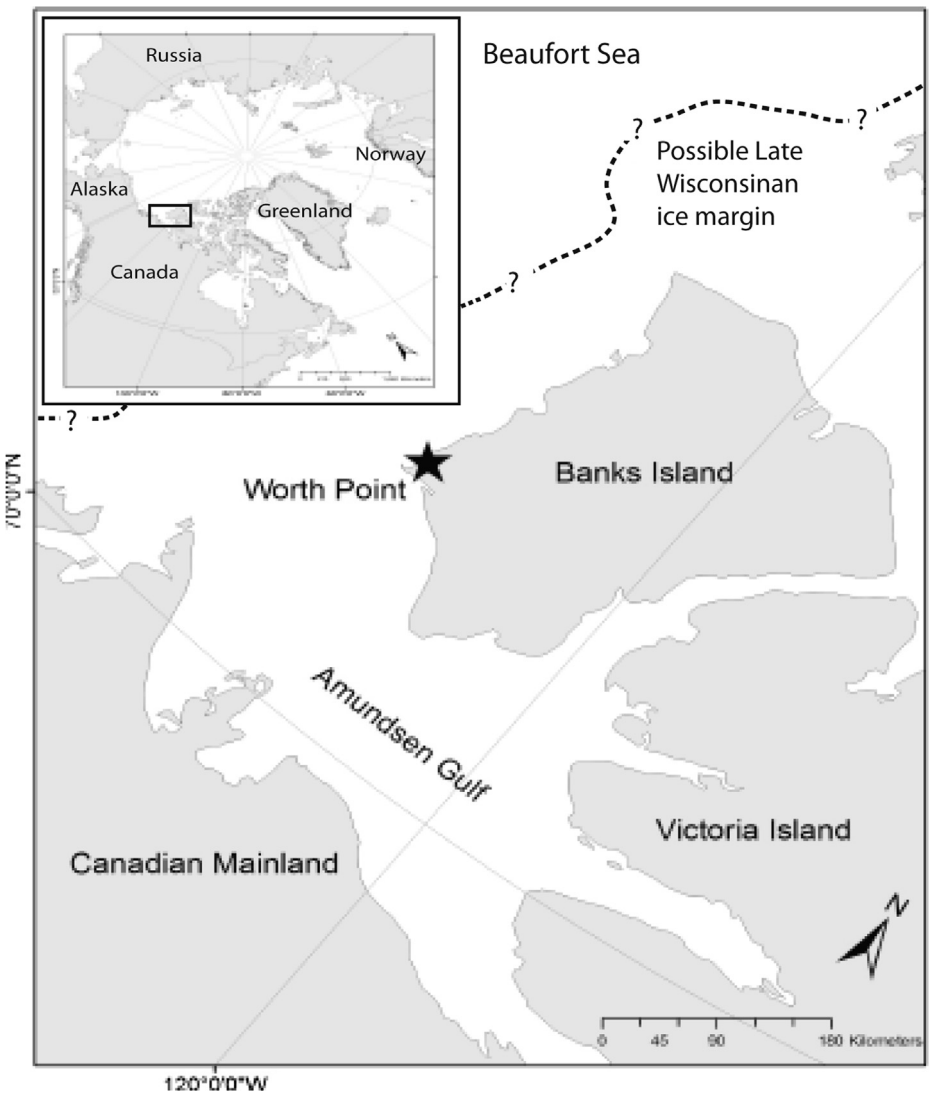

Fig. 1. Location map of Worth Point, Banks Island, western CAA, showing possible Late Wisconsinan ice margin after England et al. (2009), Lakeman and England (2012, 2013) and Vaughan and England (in prep).

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