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Sedimentation styles and depositional processes in a Middle to Late Jurassic slope environment, Bowser Basin, northwestern British Columbia, Canada

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A B S T R A C T

The Middle to Upper Jurassic Todagin assemblage in northwestern British Columbia, Canada, was deposited in the Bowser Basin above arc-related rocks of the Stikine terrane. Sedimentary structures indicate that a variety of gravity flow processes were involved in transport and deposition in deep-water slope environments. At Mount Dilworth, laterally continuous and channelized turbidites are interbedded with and overlain by mass-transport deposits in which sedimentary clasts are supported in a mudstone matrix. More than 50% of the succession consists of mass-transport deposits, indicating significant slope instability. A 300 m thick mass-transport complex exposed near the top of the succession is interpreted to result from tectonic activity, which triggered a major change in sediment supply from a local source area. At Todagin Mountain, a channel complex displays three successive channel-fills with associated overbank sedimentation units. Mass-transport deposits are rare, and confined to channel axes. Channels 1 and 2 are characterized by 40–50 m thick, ungraded pebble clast-supported conglomerate while the uppermost Channel 3 contains graded beds and occasional traction structures. The gradual change from erosive and amalgamated channel deposits at the base, to more aggradational channels at the top, is related to elevation of the equilibrium profile. Creation of accommodation favored aggradation on the mud-dominated slope succession and construction of well-developed channel-levee systems. The vertical succession exposed at Todagin Mountain is consistent with normal progradation of the slope under high sedimentation rates. In the Mount Dilworth area, extensional faulting associated with development of the restricted Eskay rift in the early Middle Jurassic produced a dissected basement above which the Todagin assemblage was deposited. These structures were inverted during collision of the Stikine and Cache Creek terranes, and likely played a major role in the stratigraphic evolution of the deep-water architectures.

1. Introduction

Deep-water channel complexes located in modern slope environments have received increased attention as exploration has demonstrated that coarse-grained submarine channel systems constitute important hydrocarbon reservoirs (e.g., Stelting, 1985; Mayall and Stewart, 2000; Kolla et al., 2001; Abreu et al., 2003; Deptuck et al., 2003). However, the spatial distribution and internal architecture of these deep-water bodies are difficult to observe in situ as bed-scale heterogeneities are beyond the resolution of most 3D seismic-reflection techniques (Mutti and Normark, 1991; Slatt, 2000). One approach to mitigate this problem has been to study outcrop analogues that allow characterization of individual beds and their depositional processes (e.g., Clark and Pickering, 1996; Hickson and Lowe, 2002; Beaubouef, 2004; Schwarz and Arnott, 2007; Crane and Lowe, 2008; Armitage et al., 2009; Fildani et al., 2009).

The Middle to Upper Jurassic Todagin assemblage of the Bowser Lake Group exposed in the tectonically active Bowser Basin of northwestern British Columbia, Canada, provides an excellent record of slope processes that characterize deep-marine siliciclastic depositional environments (Green, 1992; Ricketts and Evenchick, 1999; Evenchick and Thorkelson, 2005). The Todagin assemblage consists mostly of a fine-grained succession with isolated channelized conglomerate units. These lenticular conglomerate bodies occur at various stratigraphic levels throughout the succession and range from a few metres to tens of metres thick.

This study documents and compares two exceptional exposures of channelized deep-water systems of the Todagin assemblage in

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northwestern British Columbia. Compilation of detailed measured sections and observation of field relationships between channel-fill and inter-channel lithofacies provide new insights on the mechanisms of sediment transport and deposition that affected channelized systems of the Todagin assemblage. Furthermore, this work allows a better understanding of the stratigraphic evolution of deep-water architectures associated with variations of boundary conditions (e.g., provenance, sediment supply, basin configuration) in active tectonic regimes such as the Bowser Basin.

2. Geological setting

The Todagin assemblage is a thick (~3000 m) unit of deep-water siliciclastic sedimentary rocks deposited in the Bowser Basin of western Canada during the Middle to Late Jurassic (Fig. 1). It constitutes one of the many diachronous lithofacies divisions recognized within the Bowser Lake Group by Evenchick and Thorkelson (2005) (Fig. 2). Middle Jurassic to Lower Cretaceous sedimentary rocks of the Bowser Lake Group were deposited over the arc-related rocks of the Lower Jurassic Hazelton Group, which constitutes the last widespread volcanic phase of the allochthonous Stikine terrane (Anderson, 1993). Volcanic and associated sedimentary rocks of the Hazelton Group accumulated in an elongated, southeast–northwest oriented intra-arc basin referred to as the Hazelton trough (Tipper and Richards, 1976; Marsden and Thorkelson, 1992). Evidence of backarc rifting on the northwestern edge of the basin was also recorded in the early Middle Jurassic, and is represented by the Eskay Creek volcanogenic massive sulphide deposit (Barrett and Sherlock, 1996; McDonald et al., 1996; Roth et al., 1999; Sherlock et al., 1999; Alldrick et al., 2005) (Fig. 1B). Subsidence analyses have shown that tectonic extension in the northern portion of the Hazelton trough during Pliensbachian time generated a significant amount of accommodation prior to initiation of contractional deformation and deep-water coarse clastic sedimentation in the Bowser Basin in the Bajocian (Thorkelson et al., 1995; Gagnon et al., 2009). A similar transition from an early extensional phase followed by late basin inversion has also been observed in other Mesozoic basins. According to Fildani and Hessler (2005), the Late Jurassic Rocas Verdes Basin was generated in a backarc tectonic setting before evolving into the Magallanes retroarc foreland basin with deep-water deposits during the onset of Andean contraction in the Middle to Late Cretaceous.

Rapid progradation of fan deltas in Middle to early Late Jurassic time was responsible for transfer of a huge volume of gravel, sand and mud to the deep portions of the Bowser Basin (Ricketts and Evenchick, 1991, 2007). According to Evenchick and Thorkelson (2005), the distribution of fossils in deep-marine to marginal marine lithofacies illustrates that the shelf remained relatively narrow throughout that period. This particular shelf width configuration was probably a major control for deep-water sedimentation in the early history of the Bowser Basin. Description of modern analogues situated along the tectonically active California margin by Covault et al. (2007) indicates that the narrow shelf between the canyon head and the littoral zone is the primary control on canyon-channel system activity and delivery of sediments to the deep-water.

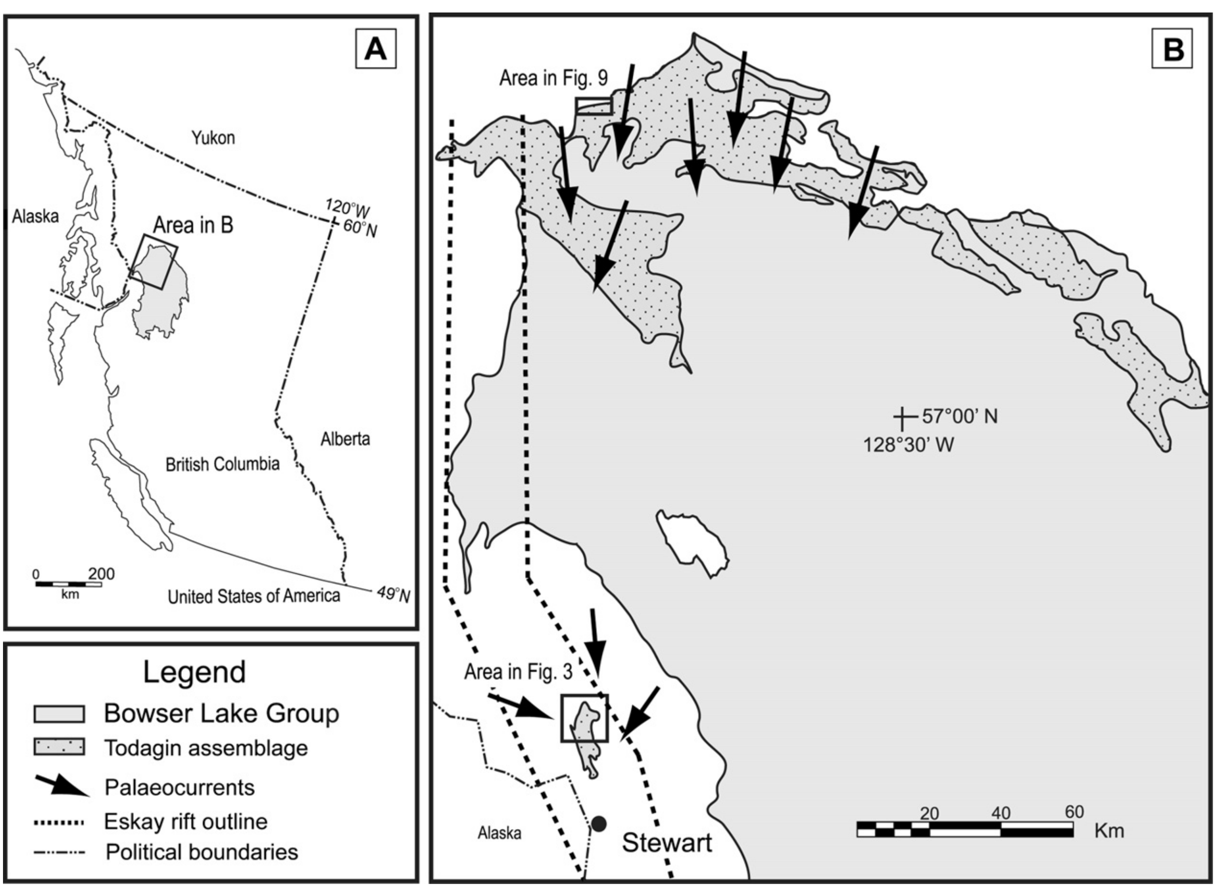

Fig. 1. A) Regional location map of the Bowser Basin in northwest British Columbia, Canada. Solid black square delineates the area shown in (B). B) Geographic distribution of the Middle to Upper Jurassic Todagin assemblage within the Bowser Lake Group. Palaeocurrent data for the Todagin assemblage after Evenchick and Thorkelson (2005) and this study. Solid black squares delineate the extent of the two study areas. Source: Modified from Evenchick et al. (2009).