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U–Pb geochronology of the Western Channel Diabase, northwestern Laurentia: Implications for a large 1.59 Ga magmatic province, Laurentia's APWP and paleocontinental reconstructions of Laurentia, Baltica and Gawler craton of southern Australia

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ABSTRACT

U–Pb baddeleyite ages of 1592 ± 3 and 1590 ± 4 Ma are reported for paleomagnetic sites in sheets and dykes of Western Channel Diabase (WCD) that intrude Proterozoic rocks of the flat-lying Hornby Bay Group in the Hornby Bay basin and the deformed volcanic-plutonic Great Bear Magmatic Zone of Wopmay orogen of northwestern Laurentia. A published WCD paleomagnetic pole at 9°N, 115°W (A_{95} = 6°) has been demonstrated primary. The new ages indicate that the WCD pole falls midway in time between poles for the 1.74 Ga Cleaver dykes and 1.48–1.42 Ga Elsonian-aged plutons, filling an important gap in the Proterozoic apparent polar wander path (APWP) for Laurentia. The WCD pole can be compared with poles reported from similar-aged magmatic units on other cratons in order to test paleocontinental reconstructions. A comparison of the Laurentian WCD pole with primary ca. 1.63 Ga and ca. 1.575 Ga poles for Baltica, along with an earlier comparison of precisely dated 1.27–1.255 Ga poles for Laurentia and Baltica, suggests that the two cratonic blocks drifted as a single entity with Baltica adjacent to eastern Greenland during the ca. 1.59–1.27 Ga interval. On the basis of less well constrained ca. 1.84–1.83 Ga poles from Laurentia and Baltica, it is possible that this reconstruction existed as early as ca. 1.83 Ga. The WCD is the same age as Wernecke breccias of the Wernecke and Ogilvie Mountains of northwestern Laurentia and bimodal Gawler Range Volcanics (GRV) and related Olympic Dam breccias of the Gawler craton. It has been proposed by others that the Gawler craton lay adjacent to northwestern Laurentia at 1.59 Ga, with the Olympic Dam and Wernecke breccias forming a large hydrothermal province. The primary WCD pole provides an opportunity to test Laurentia–Gawler craton reconstructions at 1.59 Ga. A paleopole has been reported for the GRV, although its primary or secondary nature is open to interpretation. If primary, or if acquired as an overprint during the later stages of 1.60–1.58 Ga Hiltaba-GRV magmatism, then a position for the Gawler craton adjacent to northwestern Laurentia is permitted. If the GRV pole is a later secondary overprint then a reliable comparison with Laurentian poles cannot be made.

1. Introduction

Although Laurentia plays a pivotal role in many post-1.8 Ga paleocontinental reconstructions, such reconstructions for the latest Paleoproterozoic and earliest Mesoproterozoic are uncertain because of a lack of well-defined and well-dated paleomagnetic poles for this period. A potentially important paleopole for helping to resolve reconstructions at this time is that of the Western Channel Diabase (WCD) of northern Wopmay orogen and the adjacent Hornby Bay basin (Fig. 1). A magnetic remanence from the WCD was reported by Irving et al. (1972). However, prior to this study, the WCD was poorly dated, and the significance of its paleomagnetic remanence not known.

In this study, U–Pb baddeleyite ages are reported for two WCD samples collected in an unpublished paleomagnetic study by W.F. Fahrig and archived at the Geological Survey of Canada in Ottawa. Implications of the WCD age for the apparent polar wander path (APWP) of Laurentia, and for the reconstruction of Laurentia with other continental blocks, namely Baltica and the Gawler craton of southern Australia, are considered.

2. Geological setting

The Western Channel Diabase is widely distributed near eastern Great Bear Lake (Fig. 1b), Northwest Territories, Canada. In the vicinity of eastern Hornby Bay, Western Channel and Echo Bay

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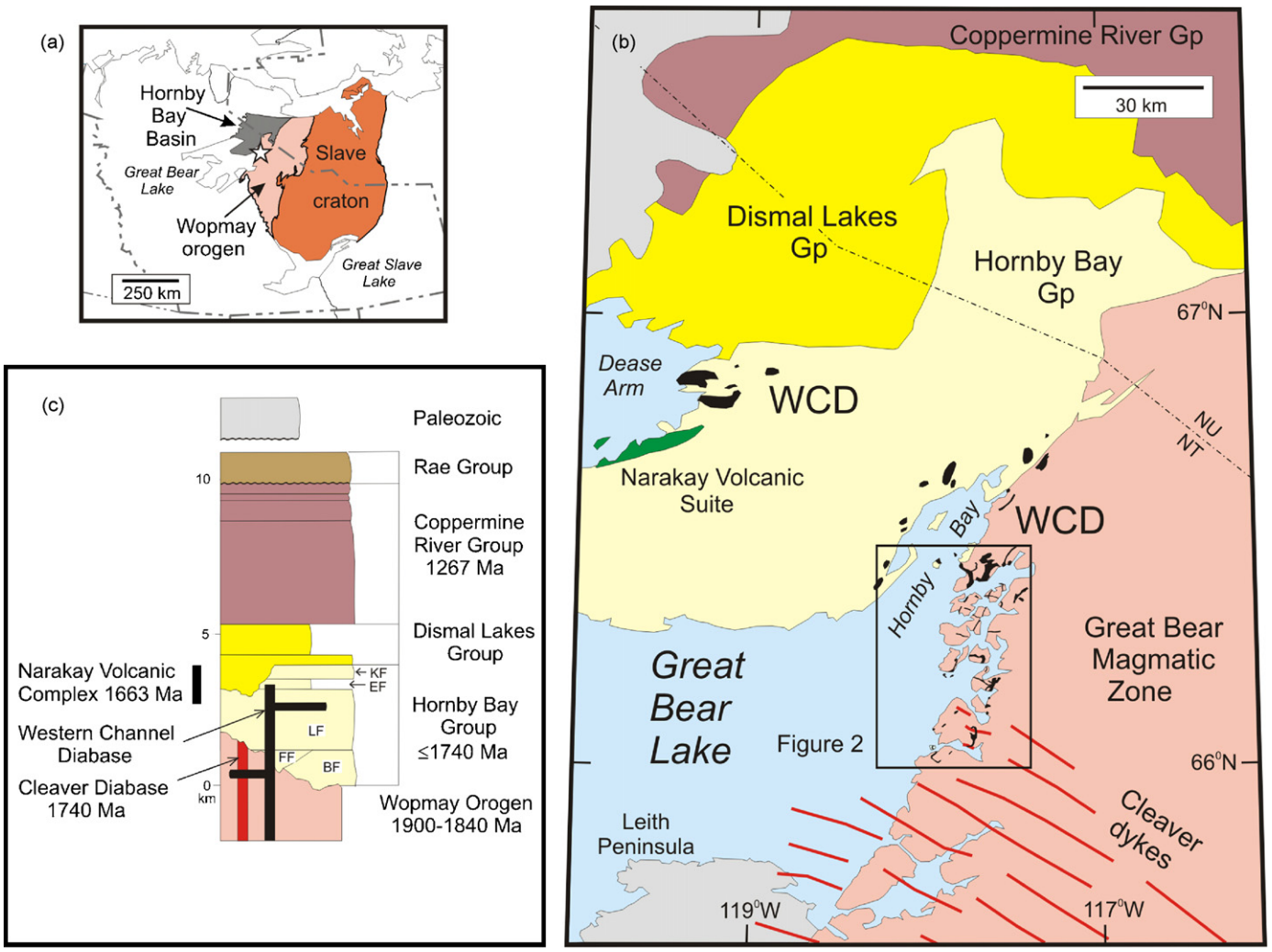

Fig. 1. (a) Location of study area (star) in northwestern Laurentia. (b) Geology in the vicinity of northeastern Great Bear Lake (modified after Hoffman and Hall, 1993; Ross and Kerans, 1989; Hildebrand, 1982; Feniak, 1952). Diabase sheets and dykes, mainly of Western Channel Diabase (WCD) shown in black. NU: Nunavut; NT: Northwest Territories. (c) Stratigraphy of the Hornby Bay basin (modified after Bowring and Ross, 1985). BF: Bigbear Formation; EF: East River Formation; FF: Fault River Formation; KF: Kaertok Formation; LF: Lady Nye Formation.

(Fig. 2), it occurs as sheets, sills and dykes that intrude the ca. 1890–1840 Ma Great Bear Magmatic Zone of Wopmay orogen and cuts 1740 +5/−4 Ma Cleaver dykes (Hildebrand, 1982; Irving et al., 2004). Immediately to the north it occurs as sheets within the overlying sedimentary rocks of the undeformed Hornby Bay Group in the Hornby Bay basin. Sheets also intrude strata of the Hornby Bay Group near Dease Arm (Ross and Kerans, 1989).

To date, the age of emplacement and crystallization of the WCD has been poorly constrained. A K–Ar age of 1405 ± 75 Ma (recalculated using the standardised tables of Harland et al., 1989) was reported by Wanless et al. (1970), and a Rb–Sr age of 1392 ± 48 Ma (recalculated using $\lambda^{87}\mathrm{Rb} = 1.42 \times 10^{-11}\ \mathrm{y}^{-1}$) was determined by Wanless et al. (1978). Because the WCD crosscuts the Cleaver dykes as noted above, the former must be younger than 1740 Ma. The WCD sheets have been observed to occur in the Hornby Bay Group up to the lower member of East River Formation (unit He1; Ross and Kerans, 1989), recently shown to contain detrital zircons as young as 1660–1620 Ma (Rainbird et al., 2009). This implies that the WCD can be no older than approximately 1620 Ma. Furthermore, the Narakay Volcanic Complex (Fig. 1; Ross, 1982), which contains bimodal volcanic rocks, also comprises shallow-marine sediments considered to be time-equivalent to the Lady Nye, East River and Kaertok formations of the upper Hornby Bay Group. Felsic volcanics in this complex have been dated at 1663 ± 8 Ma (Bowring and Ross, 1985). This age places an additional maximum age constraint on the WCD.

3. Previous paleomagnetic results

Irving et al. (1972) reported stable paleomagnetic remanences at 35 WCD sampling sites (Fig. 3a). The mean remanence direction is $D = 356°$, $I = -50°$ ($\alpha_{95} = 6°$, $k = 35$), with dyke sites yielding a significantly shallower mean direction than sheets (Fig. 3b). The paleopole corresponding to the overall WCD mean direction is 9°N, 115°W ($A_{95} = 6°$).

The number of separate intrusions that were sampled by Irving et al. (1972) is uncertain. They noted that six stably magnetized sites appear to belong to a single NNE-trending dyke extending ~40 km from Western Channel to Echo Bay (Fig. 2). These sites yielded the shallower inclination. Two sites from a separate NNE-trending dyke yielded a distinct (steeper) direction. Irving et al. (1972) pointed out that the distinct directions observed in the two dykes indicate that they did not cool at the same time. This suggests that they were emplaced at different times, with primary remanences that record secular variation or a small amount of APW. Because 8 of the 10 sites used to calculate the "dyke" mean come from these two intrusions, it is unlikely that the dyke mean pole averages out secular variation.