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Pinning northeastern Australia to northwestern Laurentia in the Mesoproterozoic

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ABSTRACT

Two supercontinents have been proposed for the latter half of the Precambrian: Columbia (or Nuna) from ca. 1.9 to 1.3 Ga, and Rodinia from ca. 1.1 to 0.75 Ga. In both supercontinents, Laurentia and Australia are regarded as probable neighbours, although their relative positions are contentious. Here we use detrital zircons ages from unit PR1 of the lower Fifteenmile group in Yukon, Canada, to demonstrate that northeastern Australia and northwestern Laurentia were firmly connected in the Mesoproterozoic. The zircon ages define a near-unimodal population with a peak at 1499 ± 3 Ma, which lies in an interval of magmatic quiescence on Laurentia, known as the North American magmatic gap (NAMG), and abundant magmatism in Australia. Sediment compositions and textures suggest the sediment was derived from a proximal metaplutonic source. We suggest that the Williams and Naraku batholiths in the Mt. Isa inlier in northeastern Australia, with crystallization ages ranging from 1493 ± 8 Ma to 1508 ± 4 Ma, are the most probable sources of sediment for the PR1 basin. The plutons were exhumed between 1460 and 1420 Ma, and likely formed an active, eroding highland in the Australian part of Columbia. Sediment derived from these plutons was carried eastward by a short, direct river system and deposited into the PR1 marine basin. Formation of the PR1 basin coincides with the formation of the southern Cordilleran Belt-Purcell, Hess Canyon, and Trampas basins. These basins, formed on the western margin of Laurentia, also have detrital zircon populations that fall into the NAMG, suggesting that sediment was derived from a non-Laurentian westerly source. The PR1 basin is herein correlated with the Belt-Purcell, Hess Canyon, and Trampas basins to the south, and together these basins record the onset of Columbia breakup along the length of the western margin of Laurentia from as far north as Yukon to as far south as Arizona.
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1. Introduction

Supercontinental configurations are proposed, disputed, and refined. Some of the proposed Precambrian supercontinents are Rodinia (1.1–0.75 Ga), Columbia (1.9–1.3 Ga), and Nunavutia (2.45–2.05 Ga; Torsvik, 2003; Evans and Mitchell, 2011; Pehrsson et al., 2013). The proposed supercontinent Columbia, which broadly coincides with Nena and Nuna, has undergone many iterations based on a range of geologic and paleomagnetic evidence (Rogers and Santosh, 2002; Meert, 2002, 2012; Sears and Price, 2002; Zhao et al., 2002; Hou et al., 2008; Evans and Mitchell, 2011). Rogers and Santosh (2002) proposed the first testable reconstruction of Columbia by incorporating all of the cratons and linking rift basins along the western margin of Laurentia to those in India. Using a paleomagnetic approach, Meert (2002) refined Rogers and Santosh's reconstruction by providing latitudinal constraints to the paleo-configuration. Sears and Price (2002) proposed an alternative reconstruction, placing Siberia adjacent to Laurentia's western margin. Zhao et al. (2002) proposed another configuration for Columbia by linking 2.1–1.8 Ga orogens and Archean cratons and connecting eastern Australia to Laurentia's western margin. Another reconstruction moved Australia away from Laurentia and,

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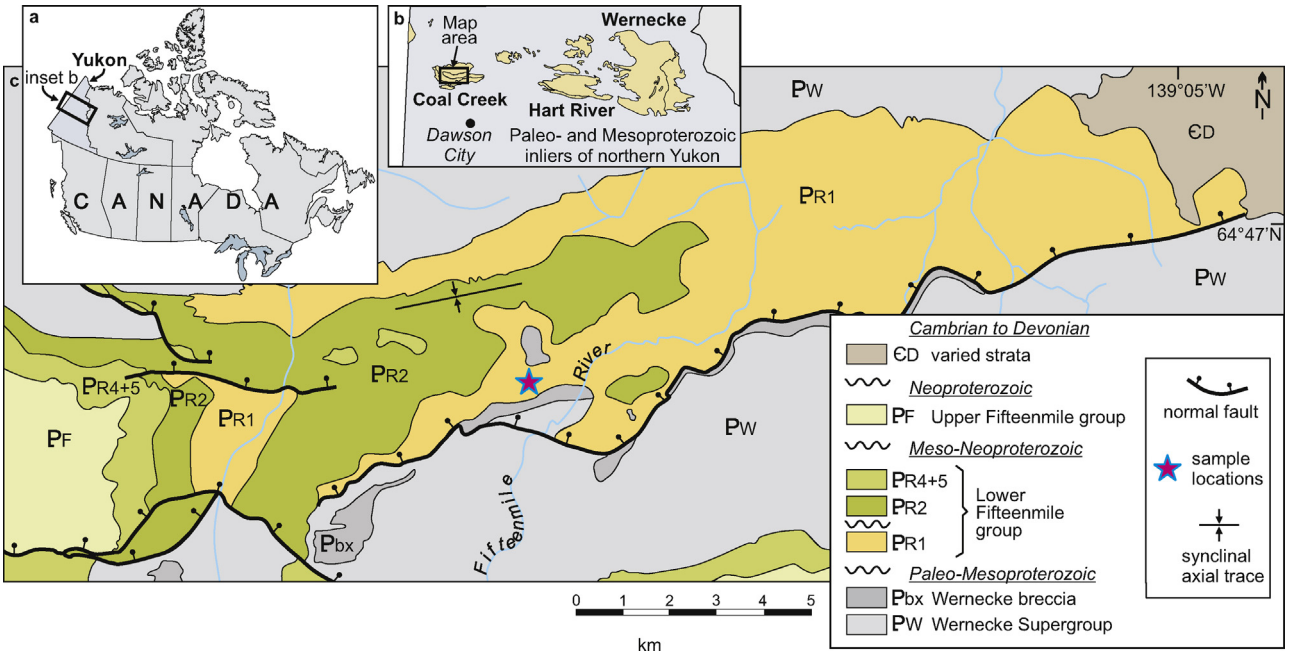

Fig. 1. Location and distribution of Proterozoic strata in the Coal Creek inlier, Western Ogilvie Mountains, Yukon, Canada (after Thompson et al., 1992). (a) Location of Proterozoic inliers (black rectangle) in Yukon, Canada. (b) Distribution of Paleo- and Mesoproterozoic inliers in northern Yukon. Map area highlighted by black rectangle north of Dawson City. (c) Paleoproterozoic to Devonian strata in the Coal Creek inlier. Samples were collected above the Wernecke Breccia near the base of unit PR1 (pink star). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

based on a proposed radiating dyke swarm, placed North China along the margin of western Laurentia (Hou et al., 2008). Studies involving sedimentary provenance have generally favoured connections between western Laurentia, Australia and Antarctica (Ross and Villeneuve, 2003; Payne et al., 2009; Doe et al., 2012; Daniel et al., 2013).

The ongoing refinement of supercontinental configurations endures because most single pieces of evidence, and even groups of evidence, typically yield non-unique solutions that are open to debate (Buchan, 2013). In this study, we address the configuration of western Laurentia in the context of the supercontinent Columbia. Using new detrital zircon data from the lower Fifteenmile group unit PR1 in Yukon, Canada, we explore potential sediment source areas in Laurentia and on other continents, demonstrate a compelling new linkage between Australia and Laurentia, and provide a tightly constrained continental configuration for the early Mesoproterozoic.

2. Geologic setting and unit description

2.1. Regional geology

Unit PR1 is the lowest formation of the Meso-Neoproterozoic Fifteenmile group and is exposed in the Proterozoic Coal Creek inlier in the western Ogilvie Mountains of Yukon, Canada (Fig. 1). The Coal Creek inlier is one of three inliers of Proterozoic rocks exposed within the predominantly Phanerozoic cover in Yukon and is within the northwestern margin of the Cordilleran fold-thrust belt (Thompson et al., 1992). Proterozoic rocks in Yukon are exposed in contractional structures in successions that are as much as 22 km thick representing over 1 Ga of strata (Thorkelson et al., 2005). Crystalline basin rocks are nowhere exposed in Yukon and the age and composition of these rocks are not known (Thorkelson et al., 2005). The Coal Creek inlier is bound to the south by the north-verging Dawson Thrust which marks the boundary between the predominantly carbonate Paleoproterozoic to Ordovician strata of the Mackenzie platform to the north of the fault and finer clastic Neoproterozoic to Triassic strata of the Selwyn Basin to the south of the fault (Thompson et al., 1992; Rainbird et al., 1997). Unit PR1 unconformably overlies the regolith of the Paleoproterozoic Wernecke Supergroup (<1640 Ma) and zones of early Mesoproterozoic Wernecke Breccia (1599 Ma; Fig. 2 and Fig. 3a and b) (Thompson et al., 1992; Furlanetto et al., 2013). The underlying Wernecke Supergroup is comprised of two siliciclastic-to-carbonate grand cycles; including the Fairchild Lake Group, the Quartet Group and the Gillespie Lake Group, that have a cumulative minimum thickness of 14 km (Thorkelson et al., 2005). The Wernecke Supergroup underwent three phases of deformation, referred to as the Racklan Orogeny, prior to emplacement of the hydrothermal Wernecke

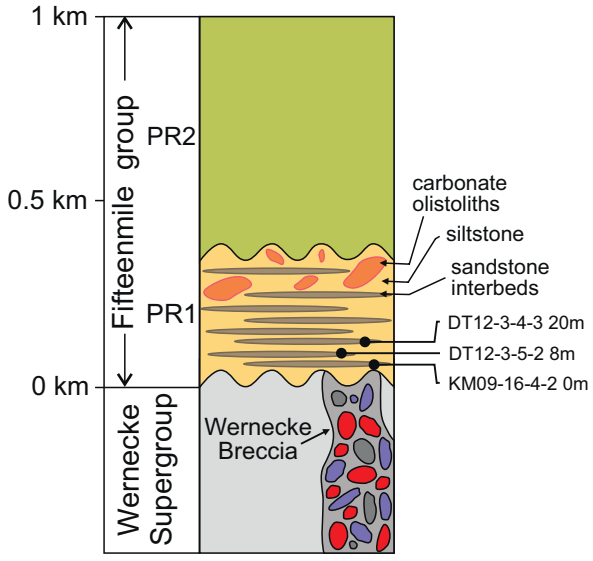

Fig. 2. Stratigraphic column of the Proterozoic Wernecke Supergroup and the lower Fifteenmile group in the Coal Creek inlier. Sample locations noted on right with height above the unconformity.

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