2.46 to 2.50 Ga Magmatism in the Queen Maud Block, northern Canada: An early phase of the Arrowsmith Orogeny or a separate rifting event preceding orogeny?

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Summary
We evaluate the origin of 2.46 to 2.50 Ga magmatism in the Queen Maud of northwestern Laurentia in light of geochemical and petrological data and conclude that these magmas most likely formed in an incipient continental rift. This rifting event preceded the ca. 2.35-2.40 Ga Arrowsmith Orogeny.

Introduction
Schultz et al. (2007a,b) documented a major pulse of 2.46 to 2.50 Ga granitic and subordinate mafic magmatism in the northern Queen Maud Block (QMB) of western Nunavut. This magmatism was followed closely by formation of a sedimentary basin, the Sherman basin, which received much of its detritus from erosion of 2.46 to 2.50 Ga granitoids. The basin was relatively short-lived as sediments were buried to mid-crustal depths and underwent migmatization and lower granulite-facies metamorphism at ca. 2.39 Ga. We infer that Sherman basin closure and associated high-grade metamorphism occurred in response to the ca. 2.35 to 2.40 Ga Arrowsmith Orogeny, which affected a large portion of western Laurentia at this time (e.g., Berman et al., 2005; Hartlaub et al., 2007). The current study aims to address whether 2.46 to 2.50 Ga QMB magmatism and subsequent basin formation were part of the Arrowsmith Orogeny (e.g., an early phase of arc/back-arc magmatism and sedimentation) or a separate event, possibly related to aborted continental rifting, which preceded orogeny.

Discussion
The following observations are relevant to this question. Geochronological data for western Laurentia in general and the QMB in particular indicate an abundance of magmatic or metamorphic ages between 2.46-2.50 Ga and 2.35-2.40 Ga, but few ages between 2.40-2.46 Ga. This observation suggests two discrete events separated by a 50-60 m.y. hiatus rather than a single, more continuous orogenic event. Secondly, QMB magmatism is distinctly bi-modal with SiO_2 contents between 46-50 wt. % and 59-68 wt. % SiO_2, but no samples yet identified in the intermediate 50-59 wt. % SiO_2 range. The bimodal character of magmatism is

suggestive of an extensional environment, either a back-arc or a continental rift setting. Thirdly, both the charnockitic nature of some of the granitoids and the complete absence of xenocrystic zircons in the granitoids despite Nd isotope evidence indicating derivation from Neoarchean crustal source rocks, suggest a high-temperature origin for the QMB granitoids. Hot, dry felsic magmas can be found in both arc and rift settings but are generally more common in the latter setting. Fourthly, limited available data for 2.48-2.50 Ga mafic igneous rocks from the QMB indicate that the majority of these samples are characterized by both high V (> 350 ppm) and Ti (>14000 ppm) contents. This is significant in that the simple bi-variate V-Ti plot of Shervais (1982) has been found to be effective in discriminating between mafic magmas generated in arc/back-arc, continental rift, and continental flood basalt settings. Specifically, the large GEOROC database of igneous rock compositions indicates that basalts with both high V and Ti (> 350 and 14,000 ppm, respectively) comprise < 0.5% of all analyzed samples in island arc, back-arc or continental arc settings but are 10 to 100 times more common in continental flood basalt or continental rift settings. Th-Nb ratios are also useful for discriminating between arc and rift basalts because the Nb-depleted nature of many arc magmas lead to higher average Th-Nb ratios in arc basalts (Th/Nb > 4) than in continental rift basalts (typically Th/Nb <2); back-arc basalts tend to have Th-Nb ratios intermediate between arc and rift basalts. The majority of the QMB mafic samples have Th/Nb < 1. Thus, a number of trace- and minor-element geochemical parameters suggest continental rift or flood basalt rather than arc/back-arc basalt affinities for QMB mafic rocks. Interestingly, the 2.52-2.45 Ga time period is characterized by the widespread development of large igneous provinces in other parts of Laurentia (e.g., Mistissini, Hearst/Matachewan, Kaminak dyke swarms). QMB magmatism may be another expression of this major thermal anomaly but, unlike these other large igneous provinces, the QMB is dominated by felsic rather than mafic magma compositions.

Conclusions

Our conclusion, based on the limited number of samples and geographic area of the QMB investigated thus far, is that the currently available data are more aligned with a continental rift setting than an arc or back-arc setting for 2.46-2.50 Ga magmatism in the QMB. An incipient rift model is consistent with the petrological and geochemical characteristics of QMB magmatism noted above and with the observation that QMB magmatism was followed closely by accumulation of sediments in the adjacent Sherman basin. If this interpretation is correct, the onset of the Arrowsmith Orogeny at ca. 2.4 Ga marks a switch from an extensional or tectonically quiescent environment to a compressional environment in western Laurentia.

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