Supplementary information - Geology

Iapetan Oceans, an Analog of Tethys?
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Figure DR1:

Figure DR1: Distribution of the late Tonian-Cryogenian (purple) and Ediacaran-early Cambrian (red) rift-related magmatic rocks in the Iapetan realm. The purple and red contours delimit the 750-680 Ma and 615-550 Ma rifting phases as displayed in Figure 1. Numbers are: (1) ca. 706 Ma volcanic clasts in Ordovician strata (Hanson et al., 2016); (2) 577 $\pm$ 2 Ma, 552 $\pm$ 7 Ma South Oklahoma aulacogen magmatism (Brueseke et al., 2016); (3) 539-530 Ma South Oklahoma aulacogen magmatism (Hanson et al., 2013); (4) 765 $\pm$ 7 Ma Brown Mountain granite (Fetter and Goldberg, 1995); (5) 758 $\pm$ 12 Ma Mount Rogers rhyolites (Aleinikoff et al., 1995); (6) ca. 754 Ma Crossnore metagranite (Su et al., 1994); (7) 748 $\pm$ 11 Ma Striped Rock granite (Essex, 1992); (8) 745 $\pm$ 6 Ma Beech metagranite (Su et al., 1994); (9) 742 $\pm$ 2 Ma Grandfather Mountain formation (Fetter and Goldberg, 1995); (10) 745-702 Ma Robertson River igneous suite (Tollo and Aleinikoff, 1996; Southworth et al., 2009; Fokin, 2003); (11) 745 $\pm$ 9 Ma White Oak Creek granite (Fokin, 2003); (12) 739 $\pm$ 4 Ma Lansing granite (Su et al., 1994); (13) 734-728 Ma Bakersville dikes (Goldberg et al., 1986; Ownby et al., 2004); (14) 706 $\pm$ 4 Ma Polly Wright Cove pluton (Tollo et al., 2004); (15) 695 $\pm$ 16 Ma Dillons Mill granite (Fokin, 2003); (16) 680 $\pm$ 9 Ma Rockfish River granodiorite (Fokin, 2003); (17) 680 $\pm$ 4, 727 $\pm$ 20 Ma Suck Mountain pluton (Fokin, 2003; Tollo et al., 2004); (18) 572-563 Ma Catoctin formation (Aleinikoff et al., 1995); (19) 614 $\pm$ 8 Ma Hare Hill granite (Van Berkel and Currie, 1988); (20) 615 $\pm$ 2 Ma, 614 $\pm$ 4 Ma Long Range dikes (Stukas and Reynolds, 1974; Kamo et al., 1989; Kamo and Gower, 1994); (21) 602 $\pm$ 2 Ma Reading Prong dikes (Smith, 2003); (22) 597-576 Ma Grenville dike swarm (Kamo et al., 1995; Halls et al., 2015); (23) 583 $\pm$ 2 Ma Baies des Moutons syenite (McCausland et al., 2011); (24) 581-576 Ma Gabbroic dikes (Miller and Barr, 2004); (25) 577 $\pm$ 1 Ma Callander complex (Kamo et al., 1995); (26) 571 $\pm$ 5 Ma Pinney Hollow volcanics (Walsh and Aleinikoff, 1999); (27) 565 $\pm$ 4 Ma Sept-Iles layered mafic complex (Higgins and van Breemen, 1998); (28) 563-562 Ma Pound Ridge and Yonkers gneisses (Tollo et al., 2004); (29) 565-556 Ma Lac Matapédia mafic volcanics (Hodych and Cox, 2007); (30) 554 $\pm$ 2 Ma Tibbit Hill formation (Kumarapeli et al., 1989); (31) 550 $\pm$ 7 Ma Mt. St.-Anselme basalts (Hodych and Cox, 2007); (32) 550 $\pm$ 3-5 Ma Skinner Cove volcanics (Cawood et al., 2001); (33) 532 $\pm$ 1 Ma Chatham-Grenville and Mont Rigaud intrusions (McCausland et al., 2007); (34) 601 $\pm$ 4 Ma (Dempster et al., 2002); (35) 599 $\pm$ 9 Ma (Kinny et al., 2003); (36) 597 $\pm$ 11 Ma (Pidgeon and Compston, 1992); (37) 595 $\pm$ 4 Ma Tayvallich volcanic formation (Halliday et al., 1989); (38) 594 $\pm$ 11 Ma Cairn Chuinneag granite (Oliver et al., 2008); (39) 588 $\pm$ 8 Ma Braeval augen granite (Kinny et al., 2003); (40) ca. 680; ca. 700 Ma anatectic melt in Kalak nappe (Kirkland et al., 2006; Corfu et al., 2007); (41) 616 $\pm$ 3 Ma Egersund dike swarm (Bingen et al., 1998); (42) 608 $\pm$ 1 Ma Sarek dikes (Svenningsen, 2001); (43) ca. 608-596 Ma Kebnekaise dikes (Baird et al., 2014); (44) ca. 608 Ma Corrovarre nappe dike swarm (Kjøll et al., 2019); (45) ca. 596 Ma Särvi dikes (Kumpulainen et al. 2016); (46) 583 $\pm$ 7 Ma Alnö carbonatite complex (Meert et al., 2007); (47) 583 $\pm$ 15 Ma Fen carbonatite complex (Meert et al., 1998); (48) 570-560 Ma, 530-520 Ma Seiland Igneous Province (Pedersen et al., 1989; Roberts et al., 2006, 2010); (49) ca. 570 Ma Volhyn large igneous province (Shumlyanskyy et al., 2016); (50) 577.8 $\pm$ 6.3/-9 Ma nepheline syenite (Mejía et al., 2012); (51) 619 $\pm$ 9 Ma dyke swarm in the Noville complex (Weber et al., 2019); (52) 750-690 Ma A-type granitoids (Mišković et al., 2009); (53) ca. 635 Ma dacite dykes (Loewy et al., 2004); (54) ca. 774 Ma A-type granitoid (Baldo et al., 2006); (55) ca. 570 Ma syenite-carbonatite (Casquet et al., 2008). Continental block abbreviations: Esp: Eastern Sierra Pampeanas, Wsp: Western Sierra Pampeanas, AA: Antofalla-Arequipa, RP: Rio de la Plata, Y: Yucatan, S: Sierra Madre, M: Mixteca Oaxaca.

Supplementary information about paleomagnetic data from 750 to 600 Ma:

From 750 to 600 Ma, a few reliable paleomagnetic poles are available from the continents we are concerned with, but their temporal sparsity and associated age uncertainties usually preclude a rigorous comparison of poles from the different continental blocks at a given time. An exception to this is ~615 Ma, at which time paleomagnetic constraints are available from Laurentia, Baltica, Amazonia and West Africa. The 615 ± 2 Ma Long Range dyke pole of Laurentia (Murthy et al. 1992; Hodych et al. 2004; Kamo et al. 1989) and the 616 ± 3 Ma Egersund dyke pole of Baltica (Walderhaug et al. 2007; Bingen et al. 1998) are both supported by a positive contact test, which demonstrates their primary origin. The ~609 Ma Planalto da Serra complex pole of Amazonia (Garcia et al. 2013, De Min et al. 2012) and the 616 ± 11 Ma Adma diorite pole of West Africa (Morel, 1981) are not supported by paleomagnetic field/stability tests, but are found to be directionally similar when Amazonia and West Africa are restored to their relative positions in a west Gondwana reconstruction. That observation is at least permissive of the possibility that those poles could be of primary origin. A further discussion of the reliability of the Long Range dyke, Egersund dyke and Adma diorite poles can be found in Robert et al. (2017).

Treating these four paleomagnetic results as representative for Laurentia, Baltica, Amazonia and West Africa at ~615 Ma, we find our proposed scenario to be consistent with the existing paleomagnetic constraints (Figure 3a).

Table S1: Paleomagnetic data at ~615 Ma. A95 is the circle of 95% confidence of the poles.

Pole/Unit (craton)	Age (Ma)	Pole Latitude (°)	Pole Longitude (°)	A95 (°)	References (pole)	References (age)
Long Range Dykes (Laurentia)	615 ± 2	19	355	17.4	Murthy et al. (1992), Hodych et al (2004)	Kamo et al. (1989)
Egersund Dykes (Baltica)	616 ± 3	31.4	44.1	15.6	Walderhaug et al. (2007)	Bingen et al. (1998)
Planalto da Serra Complex (Amazonia)	604 ± 16.2 615 ± 4.5	49.7	-46.6	10.8	Garcia et al. (2013)	De Min et al. (2013)
Adma Diorite (West Africa)	616 ± 11	32.5	-15.3	15.9	Morel (1981)	-

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