A History and Preview of Supercontinents Through Time
Outline

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The Oldest Supercontinents—A Brief Historical Perspective (PPT)

A series of papers in the early 1970s by Dewey, Burke and Colleagues noted the existence of previous zones of continental rifting and collision foreshadowing the possibility of previous supercontinental assemblages.

JDA Piper (1970’s) used the extant paleomagnetic database to propose the existence of a long-lived Precambrian supercontinent which he later dubbed Proto and Paleo-Pangea.

The main problem with the Paleo (and Proto) Pangea models is that the paleomagnetic data no longer support this long-lived reconstruction and there are numerous geological problems with the model.
In 1984, Gerard Bond and others proposed the existence of a Neoproterozoic supercontinent based upon the ubiquitous presence of passive margin sequences around the globe. They suggested that the supercontinent broke apart at the Precambrian/Cambrian boundary.

Passive margins form at locations where rifting of continents begins.
Subsequent supercontinental models have been forwarded throughout the 1990’s up to the present and include Vaalbara (Zegers and colleagues) “Ur” (Rogers), ProtoPangea (Piper), “Columbia” (Rogers and Santosh, Zhao and colleagues), “Rodinia” (McMenamin and McMenamin; Moores, Dalziel, Hoffman) and “Pannotia” (Powell).

That earlier supercontinents should exist is not surprising given the mobile nature of the Earth’s upper thermal boundary layer (e.g. lithosphere)
Vaalbara Supercontinent: Pre 2.7 Ga assembly of the Kaapvaal Craton (S. Africa) and the Pilbara Craton (W. Australia)

Cheney (1996) and later Zegers et al. (1998) noted that the sequence stratigraphic and chronostratigraphic data showed remarkable similarities between these two cratons.

Paleomagnetic tests initially supported the configuration (Zegers et al., 1998); however later work Wingate (1998) argued against Vaalbara at ~2.8 Ga.
Rogers (1996) also noted that the Kaapvaal craton, the Pilbara craton (India) and the Western Dharwar craton (India) and the Singhbhum craton (India) were all “stabilized” (e.g. accumulated platform sediments that were left undeformed) by 3.0 Ga. He linked these together in a single landmass which he named “Ur”. Subsequent growth of Ur occurred to form the East Gondwana landmass.

The Growth of “Ur” from 3.0 to 1.5 Ga according to Rogers (1996).
"Ur" in Younger Supercontinents—Piper’s ProtoPangea

Piper (1982, 1987, 2000, 2003) has argued repeatedly that the paleomagnetic data support a long-lived Precambrian supercontinent.

A careful examination of paleomagnetic poles with good age control shows gross inconsistencies with this model. This model needs to be considerably revised or completely discarded (Van der Voo and Meert, 1991; Meert and Torsvik, 2004).
The “Columbia” Supercontinent (Rogers and Santosh, 2002; Zhao et al., 2004)

Rogers and Santosh (2002) concluded that a supercontinent called “Columbia” was assembled during the interval from ~1.9-1.8 Ga. Key observations supporting their hypothesis were cited as:

- The existence of numerous 1.9-1.8 Ga orogenic belts
- A series of ~1.5 Ga rift basins associated with the breakup of the supercontinent.

Zhao et al. have detailed the evidence for Columbia in a series of papers, specific evidence cited by Zhao et al. for their version of Columbia includes:

• The formation of Nuna (Gower et al., 1990) composed of the North American protocraton and possibly Baltica (northern Europe) during the interval from 2.1-18 Ga.

• Presence of 2.1-1.8 Ga orogenic belts (these include the Trans-Hudson; Penokean; Taltson-Thelon; Wopmay; New Quebec; Torngat; Foxe; Makkovik-Ketilidian; Ungava; Nugssutoqidian; Kola-Karelian; Svecofennian; Volhyn; Palchema; Akitkan; Transantarctic; Capricorn; Limpopo; Transamazania; Eburnean; Trans North China; Central Indian Tectonic Zone; Central Aldan; Halls Creek).

• Continental Rift Basins and ‘anorogenic’ magmatism beginning ~1.6 Ga.
Distribution by continent of 2.1-1.8 Ga orogenic belts as described by Zhao et al. (2004)
The ‘*Columbia*’ Supercontinent of Zhao et al., 2004.
The Demise of the *Columbia* Supercontinent at 1.5 Ga (Zhao et al., 2004)
The *Rodinia* Supercontinent

First proposed by *McMenamin and McMenamin* (1990) as the birthplace for the *Cambrian explosion*. Later *Moores* (1991) proposed a link between the **SW US and East Antarctica and Australia** (SWEAT) during the Mesoproterozoic and called this the SWEAT fit. Shortly thereafter (*Dalziel*, 1991) proposed a supercontinent based partly on the SWEAT hypothesis. This was followed by a proposal from *Hoffman* (1991) and a decade long series of papers examining the evidence for Rodinia.

**Data supporting a supercontinent during the Meso-Neoproterozoic:**

1.1-0.9 Ga Orogenic Belts

Neoproterozoic rift basins and passive margin sequences around the globe.

Geologic, geochronologic and paleomagnetic evidence are supportive but often highly divergent on the exact makeup of the SC.
What did Rodinia Look Like?

‘Traditional’ Rodinia(?)

- How were continents distributed along the western margin of Laurentia?

- Where does Siberia fit?

- What continents occupied the SW and E Laurentian margins?

1: Meert and Torsvik
Issues with the Northern and Western Margins of Laurentia

- **SWEAT, AUSWUS, AUSMEX, SIBCOR or ??**

- **When did rifting occur?**
  Subsidence data says ~550 Ma, most models posit an earlier 700-800 Ma rifting.

From: Meert and Torsvik (in press)

Meert and Torsvik, 2003
Siberia

• 3 Distinct fits
  - Arctic Margin with a variety of orientations (e.g. Pelechaty, 1996; Rainbird et al., 1998; Frost et al., 1998; Condie and Rosen, 1994)
  - Cordilleran Margin (e.g. Sears and Price, 2000)
  - Not part of younger Rodinia (e.g. Hartz and Torsvik, 2002; Meert and Torsvik, 2003)
There have been any number of fits proposed for the Kalahari & Congo Craton. These myriad fits are primarily based on:

A. ‘Need’ for a southern continent to collide with S-SW US during Grenvillian times (Dalziel et al., 2000).

B. Comparison of APWP’s from Laurentia-Congo and Kalahari (Weil et al., 1998; Powell et al., 2001; Meert and Torsvik, 2003)
Amazonia: New paleomagnetic data from Tohver et al. (2002) hint that Amazonia might be the ‘southern’ continent.
This fit is made by using paleomagnetic data from Baltica (Pesonen et al., in press) at 1225 Ma and fitting the 1.55-1.60 rapikivi suites from Amazonia and Baltica (Geraldes et al., 2001).

“SPUEG” Fit (750 Ma; Hartz & Torsvik, 2002).

Note: Fit works for 1100-1000 Ma poles, but not for 930-850 Ma suggesting some readjustments between Baltica-Laurentia.
Issues W/Rodinia

1. Mesoproterozoic to Early Neoproterozoic Fits between continental blocks are critically dependent on choice of paleomagnetic data (including polarity) and choice of geologic links.

2. New paleomagnetic data challenge ‘traditional’ Rodinia models—especially with respect to the Australia-Antarctic blocks and Amazonia.

3. The new paleomagnetically based models leave significant lengths of Neoproterozoic Laurentian passive margin sequences with no conjugate.

4. Geologic links can be used to argue for nearly any fit (or no fit) between the various cratons thought to compose Rodinia.

5. Nearly 20 years since the Bond et al. proposal and a dozen years since the McMenamin and McMenamin proposal, we still have no definitive configuration for Rodinia.
The existence of Pannotia is predicated on the notion that Gondwana assembly was completed prior to the opening of the Iapetus Ocean along the eastern margin of Laurentia.

Timing is crucial- Gondwana assembly appears to have culminated somewhere between 570-530 Ma (Meert, 2003). Rifting in northeastern Laurentia and Baltica began around 615 Ma (Kamo et al., 1989; Svenningsen, 2001).

Paleomagnetic data are somewhat equivocal, but at best this supercontinent would have existed for no more than 15-20 Ma.

The breakup of Pannotia may have been quite rapid. This rapid transition has led to numerous hypotheses regarding the dynamics of plate driving mechanisms and/or episodes of true polar wander (Kirschvink et al., 1997; Evans, 1998; Meert, 1999; Meert and Tamrat, 2003; Evans, 2002, Meert and Lieberman, 2004).
The Key to solving this issue is to acquire high quality paleomagnetic data from Laurentia and Baltica.
Pangea

The most recent supercontinent reached maximum packing around 250 Ma and began to break apart shortly thereafter (225-175 Ma).

From Torsvik, 2003
Does the Pacific Persist? If so, you get Pangea-Ultima (Scotese, 2000)

Does the Atlantic become the next superocean? If so, you get Amasia.

AMASIA (250 Ma in the future!)

The Future Supercontinent
+250 Ma
Supercontinental Cyclicity?

Given many caveats regarding the timing of supercontinental assembly in the Proterozoic, it would appear that supercontinents will form, on average, every 500-700 million years.

Why?