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2009 : May 2009 - New Hot Papers : Zheng-Xiang Li

NEW HOT PAPERS - 2009

May 2009



Zheng-Xiang Li talks with *ScienceWatch.com* and answers a few questions about this month's New Hot Paper in the field of Geosciences. The author has also sent along images of his work.



Article Title: Assembly, configuration, and break-up history of Rodinia: A synthesis

Authors: Li, ZX;Bogdanova, SV;Collins, AS;Davidson, A;De Waele, B;Ernst, RE;Fitzsimons, ICW;Fuck, RA;Gladkochub, DP;Jacobs, J;Karlstrom, KE;Lu, S;Natapov, LM;Pease, V;Pisarevsky, SA;Thrane, K;Vernikovskiy, V

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SW: Why do you think your paper is highly cited?

This paper represents the final outcome of the UNESCO/IUGS-sponsored IGCP-project 440 "Rodinia Assembly and Break-up." It summarizes 17 years of concerted global efforts in testing the validity of the supercontinent Rodinia. It provides a self-consistent geodynamic model for the assembly, configuration, and breakup history of Rodinia in the lead-up to a period of rapid changes in global climate and atmospheric composition, and the explosion of multicellular life on Earth.

The relevance of this synthesis, co-authored with 16 eminent geoscientists from around the world, to the broader geosciences community is nicely put by Professor Emeritus Eldridge M. Moores (ex-President of the Geological Society of America and ex-Vice President of IUGS) in his generous review of the work: "This is a very exciting, even historic, comprehensive synthesis of the work of many people on the assembly and breakup of Rodinia. This paper will be a major contribution to all of geology. It breaks revolutionary new ground. It will quickly find its way into the general textbooks and be quoted for years."

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

In writing this paper, we took a holistic approach in synthesizing all available data from various disciplines—including geology, geochronology, and paleomagnetism, and utilizing our knowledge of how tectonic plates interact in the process of supercontinent assembly and breakup, and how plate dynamics might interact with mantle dynamics. We were able to develop a feasible global paleogeographic history for the time interval of 1,100 million years to 530 million years

ago (Ma). This covers major global geodynamic events such as the formation and breakup of Rodinia, possible superplume activity and true polar wander (whole-Earth meridional motion relative to its rotation axis), possible snowball-Earth events, and the final formation of the well-known supercontinent Gondwanaland.

SW: Would you summarize the significance of your paper in layman's terms?

The global configuration of continents and oceans changes all the time in Earth's history. In particular, continents sometimes collide together to form a single continent—a supercontinent—and breakup later due to the Earth's internal forces and energy. This evolving continental configuration, along with the formation of mountain belts during supercontinent assembly and global volcanic events during supercontinent breakup, not only impacts on the formation of mineral and energy resources that we utilize today, they also impact on the atmospheric composition, the global climatic conditions, and the evolution of life.

For some time, geoscientists postulated the existence of a supercontinent that pre-dated Pangaea and Gondwanaland, but it was only in 1991 that convincing evidence was advanced for the existence of the supercontinent "Rodinia." This event revolutionized the geoscientific world, extending understanding of the evolution of supercontinents from around 540 million years to beyond 1,000 million years. Of particular importance, the hypothesis suggested that the breakup of this earlier supercontinent with its resultant continent-ocean configuration and climatic changes, created conditions that led to the explosion of life on Earth.

Although few now doubt the existence of Rodinia, there is still no consensus regarding the number of participating cratons, their relative configuration within the supercontinent and the chronology and mode of assembly and breakup of the supercontinent. In our paper we provide an overview of evidence for and against major Rodinian reconstructions, including the preferred model that we used for constructing the first Geodynamic Map of Rodinia (Fig. 1), and also an animated history of the formation and breakup of Rodinia and the subsequent birth of Gondwanaland (Fig. 2, a PowerPoint animation). The global paleogeographic configurations presented in this animation provide a set of more robust base maps for paleoclimatic modellers to simulate the causes for extreme global climate (a snowball Earth?) during Neoproterozoic time.

In the paper we also proposed a mechanism that links the formation of the supercontinent to the subsequent formation of a mantle superplume beneath it (Fig. 3), which in turn caused the breakup of the supercontinent. We argued that, like the supercontinent Pangaea, Rodinia only lasted about 150 million years after final assembly. Mantle avalanches, caused by the sinking of stagnated oceanic slabs accumulated at the mantle transition zone surrounding the supercontinent, plus thermal insulation by the supercontinent, led to the formation of a mantle superplume beneath Rodinia 40-60 million years after its final assembly (Figs. 2 & 3). As a result, widespread continental rifting occurred between ca. 825 Ma and 740 Ma, with episodic plume events at ca. 825 Ma, ca. 780 Ma, and ca. 750 Ma.

We argued in our paper that Rodinia assembled through worldwide orogenic events between 1,300 and 900 Ma. Likewise, the breakup of Rodinia was also a protracted and diachronous process. The first major break-up event occurred along the western margin of Laurentia (North America and Greenland), possibly as early as 750 Ma. Rifting between the Amazonia craton and the southeastern margin of Laurentia started at approximately the same time, but only led to break-up after ca. 600 Ma. By this time most of

Figure 1



Simplified Geodynamic Map of Rodinia

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Figure 2



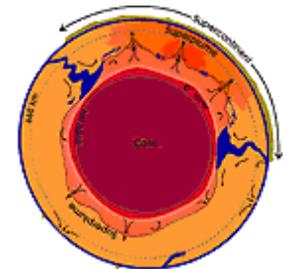
An animated history of the assembly and breakup of Rodinia, and the formation of Gondwanaland

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(PPT file is zipped)

Figure 3



Cartoon showing the formation of bipolar superplumes due to circum-supercontinent mantle avalanche

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the western Gondwanan continents had joined together, although the formation of Gondwanaland was not complete until ca. 530 Ma.

SW: How did you become involved in this research, and were there any problems along the way?

My involvement in Rodinia-related research started from the "Gondwana Eight" conference held in Hobart, Australia, in 1991. I presented a paper there with a co-worker, the late Professor Chris Powell, on the assembly of Gondwanaland, and we were excited to hear Professor Ian Dalziel's talk on the new hypothesis of a supercontinent called Rodinia, the predecessor of Gondwanaland and all later continents. We immediately started testing the hypothesis using both paleomagnetic and geological observations, leading to the establishment of the Australian Research Council-funded Tectonics Special Research Centre (1997-2006).

Expanding global-scale international collaborations further led to the establishment of the IGCP 440 project (1999-2004) with the late Professors Rafael Unrug and Chris Powell being the co-leaders and me as the project secretary. With the untimely passing away of both founding leaders, the leadership team later included Professor Svetlana Bogdanova (co-leader), Dr. Sergei Pisarevsky (project secretary), me (co-leader), and the late Professor Henri Kampunzu (co-leader). The project involved over 300 scientists from around the world, and it has been regarded as one of the most successful IGCP projects.

SW: Where do you see your research leading in the future?

My continued research in this field may lead in two related directions. One is further examination of the nature and evolutionary history of Rodinia and older supercontinents in Earth's history. The other is to examine the Earth's record of superplume events and their relationships to supercontinent events. Both will involve extensive international collaborations and, through working with mantle dynamists, we hope to achieve a better understanding of how the Earth works.

SW: Do you foresee any social or political implications for your research?

Apart from helping people to understand how the Earth evolved and how the Earth's deep mantle interacts with the tectonic plates, my research also helps in understanding the processes controlling the formation and location of mineral and energy resources, and how geological processes impact on our climate and environment.

For instance, the identification of the timing, extent, and geographic location of past mountain ranges, major volcanic provinces, and continent-ocean configurations during Earth's history helps us to understand what caused the occasional catastrophic climatic events like icehouse (even snowball Earth) conditions. The extensive international collaborations that my research involves also bring scientists from all cultural background to work together toward common goals.

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KEYWORDS: DRONNING-MAUD-LAND; TRUE POLAR WANDER; SIBERIA-LAURENTIA CONNECTION; PB ZIRCON GEOCHRONOLOGY; LARGE IGNEOUS PROVINCE; ARABIAN-NUBIAN SHIELD; WESTERN NORTH-AMERICA; NEOPROTEROZOIC TECTONIC EVOLUTION; GRANULITE-FACIES METAMORPHISM; LATE PROTEROZOIC STRATIGRAPHY.

Related information:

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