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Growth and Disruption of Supercontinents: The Rodinia and Gondwana Puzzle

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This presentation synthesises the dynamics of growth, evolution and disruption of supercontinent assemblies during the earth's history.

It specifically addresses the lack of voluminous juevenile contributions to the continental crust during the assembly of Rodinia and Gondwana supercontinents.

The superplume model for continental growth is evaluated and discussed.

Supercontinents play a very important role in the growth of earth's continental crust with time, since they trap and preserve large volumes of juvenile continental crust from being recycled into the mantle (Condie, 2000). Recent advances in continental dynamics have led to the identification of a series of supercontinent assemblies which existed during various periods of earth s history: Ur at ca. 3.0 Ga, Rodinia at ca.1.0 Ga, Gondwana at ca. 0.55 Ga and Pangea at ca. 0.3 Ga (eg: Rogers, 1996; Dalziel, 1997). The possibilitiy of a very short-lived supercontinent Pannotia (Powell, 1995) has also been suggested. A recent proposal has configured a Mesoproterozoic supercontinent Columbia at 1.8-1.5 Ga (Rogers and Santosh, 2001). Recent models and their revisions by Condie (1998, 2000, 2001) provide important clues on the dynamics of supercontinental assemblies. Juvenile continental crust is generated through either "superevent" cycles or "superplume" events. Superevents are believed to generate large amount of juvenile continental lithosphere which is trapped and preserved in a growing supercontinent, faster than it can be recycled into the mantle. On the other hand, superplume events occur when many mantle plumes bombard the base of the lithosphere in short periods of time, leading to the production of continental crust. Condie (2000) correlated each maxima of continental growth to individual superplume events in the mantle caused by catastrophic slab avalanching. Finally, supercontinents break apart because of the convection in the mantle in response to thermal shielding of a large volume of mantle by lithospheric plates (Condie, 2000). Correlation of the superplume events with the volume of juvenile crust production, however, indicates only two major events, at 2.7 and 1.9 Ga, with two minor events also traced in the Phanerozoic at 300 Ma and 110 Ma (Condie, 2001). This poses a major problem with regard to the application of superplume tectonics to the growth history of Rodinia and Gondwana, two of the principal continental assemblies. Juvenile contribution to the continental crust during the Grenvillian (Rodinia) and Pan-African (Gondwana) periods are volumetrically minor. Thus it has to be inferred that superplume tectonics did not operate during the growth of both Rodinia and Gondwana. An explanation provided by Condie (2001) for the lack of superplume event during Rodinia formation is that the pre-Rodinia supercontinents were not large enough to provide adequate lithospheric shielding for the production of mantle upwellings sufficient to break the continental lithosphere. However, the pre-Rodinia supercontinent Columbia is regarded as one of the two largest assemblies which contained most of the earth s continental crust, the second being Pangea (Rogers and Santosh, 2001). Therefore, if we go by the superplume theory, there is no reason why the breakup of Columbia failed to trigger mantle avalanche and plume bombardment. Superplume events can abort in cases where only a small portion of the supercontinent is fragmented (Condie, 2001). However, the amalgamation history of both Rodinia and Gondwana suggest the suturing of large volumes of continental fragments disrupted from their parent assemblies. This problem therefore needs to be addressed by detailed geochemical and isotopic studies on the various magmatic suites identified in different terrains of the Rodinia and Gondwana crustal segments which were responsible for adiabatic heat input (Santosh et al., 2001). The generation of these magmas could well be related to mantle upwelling in response to plume tectonics, though on a limited scale. Until more data are gathered, the dynamics of growth and evolution of both Rodinia and Gondwana remain enigmatic.