Paleomagnetic Configuration of Continents During the Proterozoic with a Special Focus on Baltica

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Tiivistelmä

Tässä artikkelissa esitetään mantereiden asemat Proterotsooisella kaudella perustuen uusimpiin paleomagnettiisiin mittauksiin ja tulkintoihin. Erityispaino on Fennoskandian (Baltica) kilvellä. Artikkelissa pohditaan myös supermantereiden roolia planeetta Maan geologisessa kehityksessä.

Abstract

The configuration of continents during the Proterozoic are presented in the light of most recent globalwide palaeomagnetic data with a special focus on Fennosandia (Baltica). We also discuss of the role of supercontinents on the geological evolution of the Earth during the past.

Keywords: Baltica, Fennoscandia, palaeomagnetism, supercontinents, Kenorland, Hudsonland, Rodinia

1. INTRODUCTION

The importance of supercontinents in our understanding of the geological evolution of the Earth has been discussed recently (e.g., Pesonen et al., 2003, and references therein). Geological processes linked to the supercontinent formation include mantle superplume events, low latitude glaciations, the "Snowball Earth" or the 'high-obliquity' concept, carbon isotope excursions, fragmentation of continental dyke swarms, truncations of tectonic belts and major rifts, matching of orogenic belts, true polar wander, and peaked age distributions of geological events. Three supercontinent assemblies (Pangaea 350-165 Ma, Gondwanaland 550-400 Ma, Rodinia ~ 1050-750 Ma) have existed during or since the Neoproterozoic. The two younger assemblies have been constructed by sea floor magnetic data (Pangaea), and by palaeomagnetic and biostratigraphic results, supported by geology (Gondwanaland). A current debate concerns the relative positions of the continents in Rodinia, and the timing of its assembly and breakup. The consequences of supercontinents on geological evolution of the Earth have led some people to look for pre-Rodinian supercontinents. Palaeomagnetism, coupled with precise isotope age data, is the only method which provides direct knowledge of ancient latitudes of continents. Nevertheless, its role in many previous reconstructions has been limited. In this paper, we use good quality palaeomagnetic data, combined with isotope ages and geological information, to define the positions of the continents during 2.45-1.00 Ga.

2. KENORLAND

During the Proterozoic, the continents lie predominantly in low to intermediate latitudes. The sedimentological indicators of paleoclimate are generally cinsistent with the paleomagnetic latitudes, with the exception of the Early Proterozoic, when low latitude glaciations took place on several continents. The Proterozoic continental configurations are generally in agreement with current geological models of the evolution of the continents. The data suggest that three large continental landmasses existed during the Proterozoic. The oldest one is the Neoarchaean Kenorland, which comprised at least Laurentia, Baltica, Australia and the Kalahari craton. The protracted break up of Kenorland during the 2.45-2.10 Ga interval is manifested by mafic dykes and sedimentary rift-basins on many continents (Fig. 1).

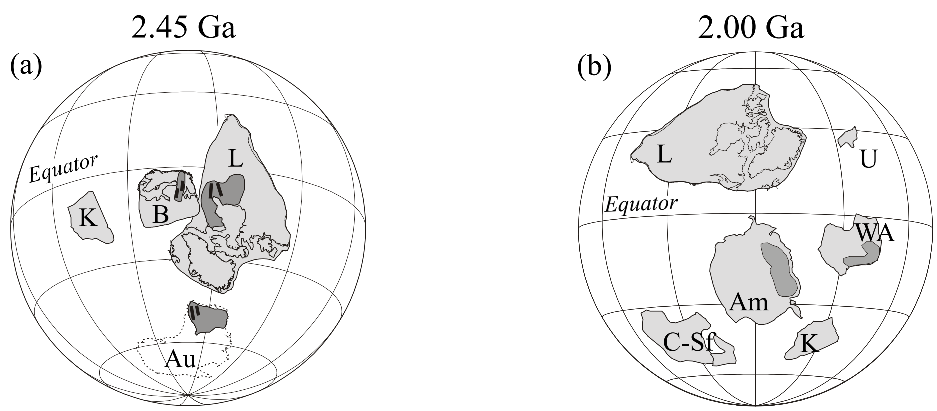

Fig. 1. (a). The paleomagnetic reconstruction of continents at 2.45 Ga. Karelia (Baltica), Superior (Laurentia) and West Australian (Australia) are shown in dark shading. Dyke swarms are shown as sticks and they are: Matachewan (Laurentia), Russian Karelian (Baltica) and Widgiemooltha (West Australia), respectively. Orthogonal projection with 20 degrees tilt. (b). The reconstruction of continents at 2.00 Ga.. The shaded areas are the West African craton and the Guyana Shield of Amazonia, respectively. Note the shallow to intermediate latitudinal locations of the continents.

3. HUDSONLAND

The second 'supercontinental' landmass is Hudsonland (also known as Columbia). On the basis of purely palaeomagnetic data, this supercontinent consisted of Laurentia, Baltica, Ukraine, Amazonia and Australia and perhaps also Siberia, North China and Kalahari. Hudsonland existed from 1.83 to ca. 1.50-1.25 Ga (Fig. 2).

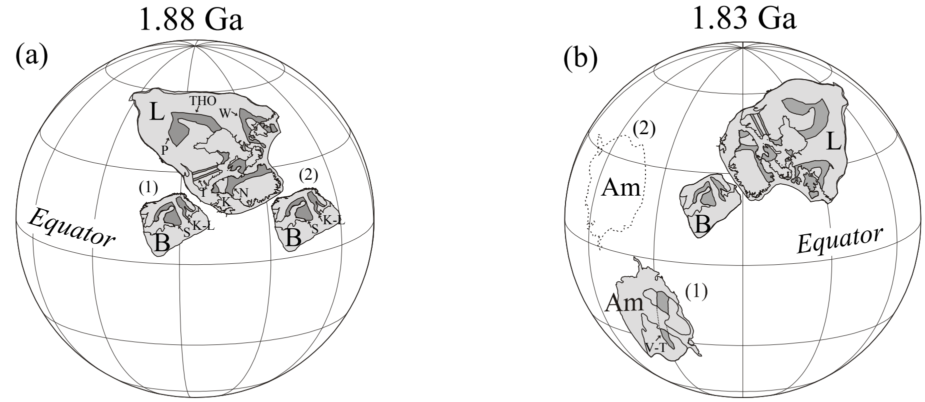

Fig. 2. (a). The paleomagnetic reconstruction of continents at 1.88 Ga. Baltica is shown in two possible positions. The ca. 1.90-1.80 Ga orogenic belts in Laurentia are shown with darker shading and they are: N Nagssugtoqidian, T Torngat, THO Trans-Hudson Orogen, P Penokean, W Woopmay, K Ketilidian. The corresponding belts in Baltica are: K-L Kola-Lapland, S Svecofennian. (b). The reconstruction of continents at 1.83 Ga. The 1.90-1.80 Ga Svecofennian, Hudsonian and Ventuari-Tapajós orogenic belts in Laurentia, Baltica and Amazonia are shown. Amazonia is shown in two possible positions (1) and (2) depending of the polarity choise of the 1.83 Ga Amazonian pole (see Pesonen et al., 2003).

4. RODINIA

The youngest assembly is the Neoproterozoic supercontinent of Rodinia, that was formed by continent-continent collisions during ~ 1.10-1.00 Ga and which involved most of the continents. A new model for its assembly and configuration is presented, which suggest that multiple Grenvillian age collisions took place during 1.10-1.00 Ga. (Fig. 3)

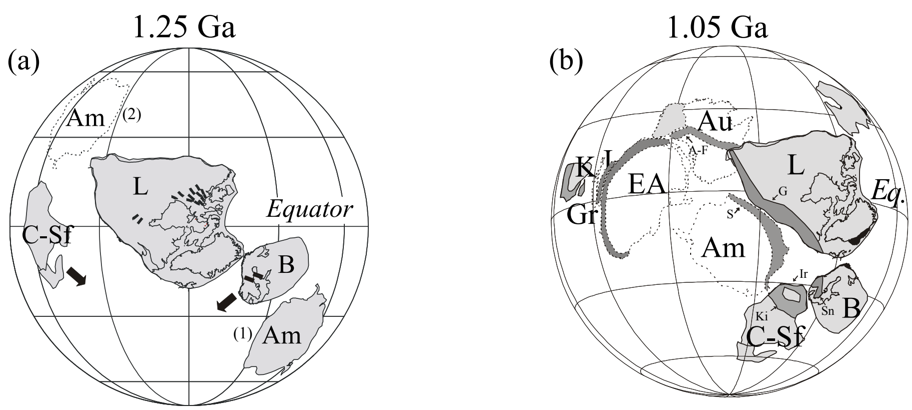

Fig. 3. (a). The paleomagnetic reconstruction of continents at 1.25 Ga. The ca. 1.25 Ga dyke swarms in Laurentia (Mackenzie) and Baltica (Jotnian) are shown as black sticks. The thick arrows shows the drift direction of Congo/São Francisco and Baltica with respect to their subsequent positions (b) The reconstruction of continents at 1.05 Ga showing the Rodinia supercontinent configuration.

5. SUMMARY

The configurations of Kenorland, Hudsonland and Rodinia depart from each other and also from the Pangaea assembly. The tectonic styles of their amalgamation are also different reflecting probable changes in sizes and thicknesses of the cratonic blocks as well as changes in the thermal conditions of the mantle through time.

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