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The specific case of the Mid-Proterozoic rapakivi granites and associated suite within the context of the Columbia supercontinent

J.L. Vigneresse *

CREGU, UMR CNRS 7566 G2R, BP 23, F-54501 Vandoeuvre Cedex, France

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Abstract

Rapakivi granites and the associated suite (anorthosite, mangerite and charnockite) that developed during the Mid-Proterozoic escape the global rules that control usual granitic magma formation. About 40 points that characterise the Proterozoic magmatism confirm the originality of the magmatism. Rapakivi granites developed without a global orogenic context within the supercontinent Columbia. The intrusions extend from the East European shield to the western US, through Fennoscandia, Greenland and Labrador. Other occurrences in the Amazonian shield, Australia or South China are less well documented. They show no definite trend in age or chemistry that would explain large-scale (mantle plume) effects. A mantle upwelling of material is contradictory with the re-assembly of a supercontinent because it occurred before this magmatic episode (1.9–1.8 Ga). At ∼1.7 Ga, the supercontinent Columbia amalgamated with the collision of the Yapavai and Mazatzal Provinces. A model is suggested that takes into account the supercontinent re-assembly, defining a downwelling flow in the mantle that anchors the continent above it. In contrast to a material flow, heat is still delivered to the base of the continental lithosphere, and is focused toward the juvenile suture zone. The base of the crust must reach 1200–1300 °C before producing anorthosite magmas. Under such a high temperature gradient lasting over a long time, magmas are transferred toward the upper crust, giving the thin (5 km) and square-shape (100 km) that the intrusions presently have. Heat delivery is essentially conductive, leading to long time-spans for intrusions. The presence of the supercontinent, immobile over a descending cell (poloidal mode of convection) developed a tangential force (toroidal mode of convection) that partly split the continent through strike–slip deformation due to plate rotation. It developed progressively between 1.57 and 1.3 Ga, starting from Fennoscandia, and then passing to Amazonia, western US and Labrador in a clockwise sense. The associated rotation induced sinistral shear manifested by small-scale shear zones and the orientation of late magmatic facies (topaz-bearing granites) in each province. The Proterozoic magmatism appears to be unique because it requires a supercontinent with a zone of juvenile crust surrounded by older cratons. The present Moho still shows remnants of this process, having bumpy undulations that may reach 22 km in amplitude over a distance of 200 km.

Keywords: Columbia; Mid-Proterozoic; Rapakivi granite; AMCG suite; Mantle convection

* Tel.: +33 3 8368 4737; fax: +33 3 8368 4701.
E-mail address: jean-louis.vigneresse@g2r.uhp-nancy.fr.

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1. Introduction

Granites have been observed in many tectonic environments ranging from extensional to contractional, within plates or at plate margins (Pitcher, 1993). A broad classification distinguishes between I- and S-types granites, depending on the source material they involve (White and Chappell, 1988). A third type, or A-type, has been added (Collins et al., 1982) that considers peralkaline granites. This classification remains in common use, although present models of granite generation are based on different premises related to the source (Thompson, 1982; Clemens, 2003).

Rapakivi granites constitute a specific case of A-type granites, ranging from quartz syenite to peralkaline granites (Collins et al., 1982). The rapakivi texture, as initially described (Sederholm, 1891), typically consists of ovoid megacrysts of alkali-feldspar mantled with a thin shell of oligoclase. Rapakivi granites are commonly part of a suite of variously evolved magmas. The suite is alkaline to peralkaline in character. Rock composition extends from anorthosite up to peraluminous granites, defining a broad range (Fig. 1). The range attests that such magmas require a large mantle component. Their chemical composition falls into the field of within-plate magmatism in diagrams relat-

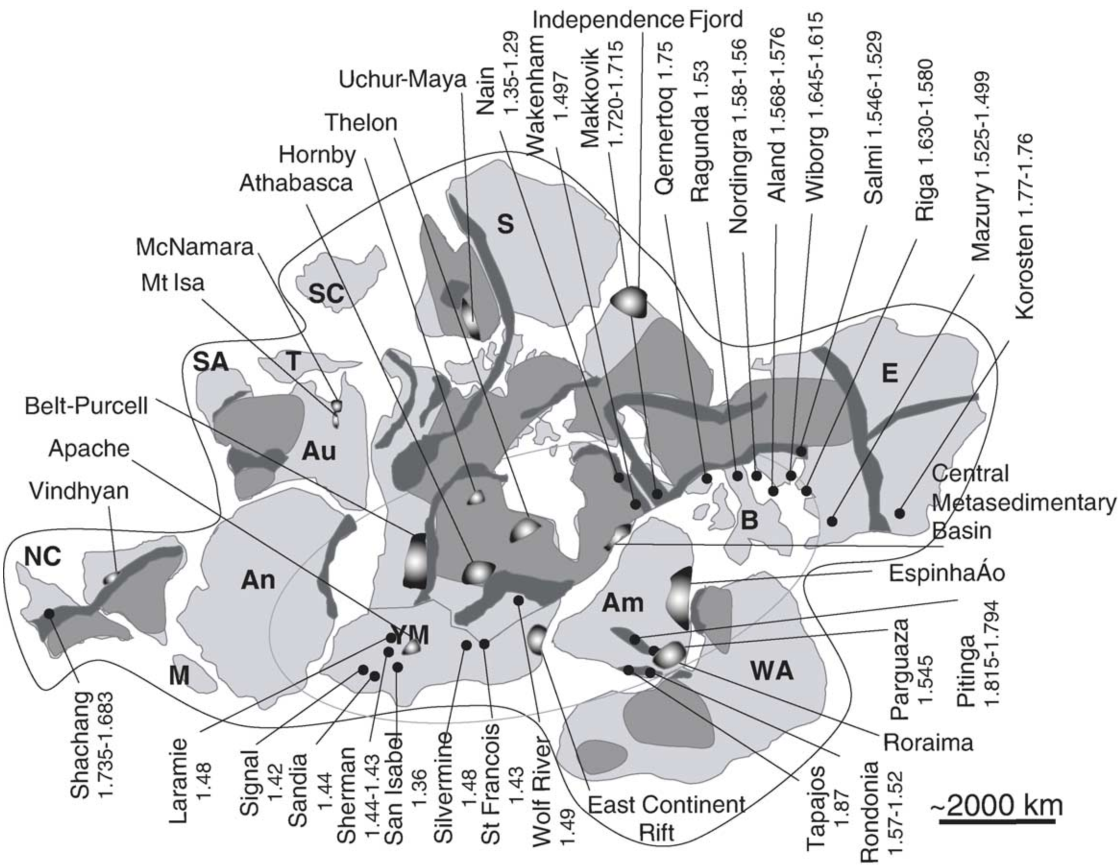

Fig. 1. Map showing a reconstruction of the respective positions of Laurentia, Fennoscandia, Ukrainian and Amazonian shields between 1.8 and 1.3 Ga. The model is redrawn from a Columbia reconstruction (Zhao et al., 2002). Former orogenic belts that fit together are in dark grey. Archean cratons are indicated by dark grey. Sedimentary basins from that period (1.7–1.3 Ga) are with black and white and italic names aligned horizontally. Letters refer to shields: Siberia, Greenland, Fennoscandia, east European, Amazonia, North America, Australia, Antarctica, Tasmania, South Africa, South China, North China, India, Madagascar, Yavapai–Mazatzal and West Africa. Rapakivi granites are indicated with ages. Names of rapakivi granites are aligned vertically, with ages.