Paleogeology of continental drainage

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Interaction of the hydrologic cycle with the continental crust exerts a strong influence on the chemical composition of the ocean and atmosphere. Advanced models of long-term ocean/atmosphere evolution therefore critically depend on reconstructions of the hydrologic cycle and bedrock geology in the geologic past.

Here, I argue that important aspects of past surface geology can be reconstructed from radiogenic isotope records of seawater. These reconstructions rely on linear correlations between bedrock age and lithology with the isotope composition of continental runoff (Peucker-Ehrenbrink, submitted). Global and regional bedrock lithology and ages are quantified using GIS technology and digital geologic maps at resolutions of 100 to 10,000 square kilometers per polygon, whereas chemical characterization of runoff relies on literature compilations. Inverting the marine Sr isotope record in this fashion yields average bedrock ages of the continental drainage in the geologic past. This new paleo-age record indicates older mean bedrock ages in the early Paleozoic, bedrock rejuvenation from the Paleozoic into the Mesozoic and an aging trend that started in the Cenozoic. In general, aging corresponds to greater exposure of igneous and metamorphic rocks whereas rejuvenation is driven by greater exposures of sedimentary and/or volcanic rocks.

The general validity of this bedrock-age record can be independently tested with paleo-geologic reconstructions by Ronov and coworkers (as quantified by Bluth & Kump, 1991), as well as the Nd isotope evolution of sedimentary rocks from large-scale continental drainage regions (e.g. Patchett *et al*., 1999). Both are suggestive of a trend towards younger bedrock from early to late Paleozoic, broadly similar to the paleo-bedrock record.

The application of this concept to the marine Os and Hf isotope records requires investigating the relationships between river isotope chemistry and drainage basin geology (Peucker-Ehrenbrink & Miller, in press). Marine paleo-records for Nd need to be spatially averaged due to the short residence time of Nd in seawater and the large isotope variability in continental Nd sources (e.g., Jeandel *et al*., 2007); alternatively, they may yield insights into regional changes in continental drainage geology in the geologic past.

References

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Fractionation processes in the layered Ilimaussaq nepheline syenite

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The 1.16 Ga Ilímaussaq intrusion is part of the Proterozoic Gardar Province, S Greenland, and type locality of agpaitic rocks. The latest of these agpaites crystallized from floor to center of the magma chamber and involve bottom kakortokites and central lujavrites (Sørensen *et al*., 2006). Similar in terms of chemistry and mineralogy, kakortokites and lujavrites are distinguished texturally. Kakortokite is strongly laminated, subdivided in 29 layered units, each of which consists of a three-layer sandwich (a lower arfvedsonite-rich black layer, a central red eudialyte-rich layer and an uppermost white layer rich in nepheline and feldspar). Lujavrites are divided into two main groups (green and black), depending on the prevalence of aegirine or arfvedsonite, respectively. Aegirine lujavrites are further divided into two textural varieties (I and II), where aegirine lujavrite II is more fine-grained and lamination and fissility are not as extreme as in aegirine lujavrite I.

Kakortokites and lujavrites were investigated by microscopy, electron microprobe and LA-ICP-MS. We present crystallisation sequences, main and trace element variations and distribution coefficients between eudialyte, amphibole and pyroxene. The mineral chemistry of amphibole and eudialyte reveals a continuous evolution within this series in terms of increasing Mn/Fe and decreasing Ca/REE ratios, whereas whole rock chemistry remains almost constant. Evolutionary trends are hardly recognized in the lower kakortokite sequence, but very well in the upper kakotokites and lujavrites. Central vertical profiles show significant element variations, which are not observed in marginal or horizontal profiles.

Magmatic assemblages are partly altered by post-magmatic hydrothermal fluids. In accordance with results from Pilanesberg, South Africa (Mitchell and Liferovich, 2006), five different alteration stages are observed, which are related to fluid pH variations. Interestingly, the assemblages alternate between agpaitic and miaskitic. Alteration starts with the breakdown of eudialyte and the formation of a miaskitic mineral assemblage of mainly katapleiite, britholite and analcime. After the breakdown of nepheline, the Na/Cl ratio (and hence, pH) increases and an agpaitic mineral assemblage including sodalite and analcime is stable again. Subsequently, a miaskitic albitization and formation of nepheline II follows leading to a drop in the Na/Cl ratio. Finally, the last stage is represented by the reaction of amphibole to pyroxene and biotite and the formation of cancrinite.

References

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