Biogeochemical limits on greening of the Earth

A. LERMAN[1], L. M. B. VER[2], AND F. T. MACKENZIE[2]

[1] Geological Sciences, Northwestern Univ., Evanston, IL, 60208, USA (abe@earth.northwestern.edu)
[2] Oceanography, SOEST, Univ. of Hawaii, Honolulu, HI, 96822, USA (lmver@soest.hawaii.edu,, fredm@soest.hawaii.edu)

The pathways of carbon between the domains of land, atmosphere, oceanic coastal zone, and open ocean, as well as of two other nutrient elements, N and P, that drive the carbon cycle and ultimately control bioproduction on land and in the ocean have been, and are likely to continue to be, affected by human forcings (atmospheric emissions from fossil-fuel burning and changes in land-use practices; additional but less powerful forcings so far are the fertilization of land, organic sewage disposal, and global temperature rise). In the past 300 years of human forcings, there was net loss of carbon from land to the atmosphere and, by riverine transport, to the coastal zone. This loss as a whole reflects the changing dynamics of the two main reservoirs of organic carbon on land: the phytomass and humus. Fluctuating gains and losses in one of the reservoirs (phytomass) have been generally exceeded by the losses or gains in soil humus. The main source of N and P for primary production on land is remineralization of soil humus (weathering of crustal minerals and atmospheric deposition of N are much smaller fluxes in the whole budget). The bioavailability of the released N and P is modified by their removal from land by runoff to the coastal zone and, for N, by denitrification. Approximately 80 to 85% of N are taken in primary production, 18 to 13% denitrified, and 2% exported in runoff to the coastal zone. For P, bioutilization from remineralized humus and weathered regolith is >99%, and the remaining 0.4% are exported in runoff. The bigger reservoirs of humus in the temperate and boreal zones, as compared to the tropics, represent potentially bigger reservoirs of N and P for increased bioproductivity on land and their inputs to the ocean coastal zone. Increased bioproductivity on land, however, does not necessarily result in greater *net storage* of carbon because of its concomitant loss from the humus reservoir. The ocean coastal zone is a small but significant reservoir controlling the dynamics of the interacting C-N-P cycles. The external sources of driver nutrients N and P in it are inputs from land and from the open ocean by coastal upwelling. Although the latter process is quantitatively more important than riverine input, the two have different effects on carbon balance of the coastal zone and its exchange with the atmosphere because rivers bring a higher fraction of organic carbon that contributes to the heterotrophy of the coastal zone. The C:N:P ratios combined for the riverine flux (dissolved inorganic and reactive organic, ≈360:11:1) and coastal upwelling (≈1010:23:1) are greater than the Redfield ratio of 106:16:1 in marine primary production. The dissolved phosphate limitation results in underutilization of carbon and build-up of N in surface waters. Bioavailability of P is also limited by its storage and remineralization rates in sediments.

Geochemical, mineralogical, textural, and fluid dynamic constraints on endogenous growth in differentiated komatiite flows

C.M. LESHER[1], M.G. HOULÉ[1], M. LÉVESQUE[1], H.L. GIBSON[1], D.A. WILLIAMS[2], AND R.C. KERR[3]

[1]Laurentian University, Sudbury, ON, P3E 6B5 Canada, lesher@sympatico.ca
[2]Arizona State University, Tempe, AZ, 85287USA, williams@dione.la.asu.edu
[3]Australian National University, Canberra, ACT, 0200 Australia, ross.kerr@anu.edu.au

It has been suggested that differentiated Archean komatiite flows were generated by inflationary processes, similar to those observed in modern pahoehoe flows and inferred for continental flood basalts, and that the cumulate zones grew by accumulation of intratelluric phenocrysts or suspended primocrysts beneath a thickening spinifex-textured crust. Although some degree of endogenous growth must have occurred at some stage, as flows up to 100m thick could not have been emplaced with vertical flow fronts, textural, mineralogical, and geochemical variations in many differentiated flows are inconsistent with the process and timing in the proposed models: 1) whole-rock Mg contents decrease systematically downwards through spinifex-textured zones, corresponding to changes from Ol through Ol+Chr and Pyx+Chr to Pyx+Plag crystallization, 2) whole-rock Mg contents and Fo contents (where preserved) decrease upwards through the upper parts of cumulate zones, 3) whole-rock Cr contents decrease strongly in the lowermost (Pyx-rich) parts of spinifex-textured zones, and 4) Chr has accumulated in the uppermost parts of cumulate zones. Only the uppermost parts of the spinifex-textured zones could have been in equilibrium with the Ol that formed in the central parts of the cumulate zones and only the lowermost parts of the spinifex-textured zones could have been in equilibrium with the Ol and Chr that formed in the uppermost parts of the cumulate zones. Mass balance requires Ol in thin (non-cumulate) flows to have crystallized *in situ* and that in thick (cumulate) flows commonly exhibits systematic textural and/or geochemical variations, including in some cases reverse zoning and delicate crescumulate textures. These data indicate that most of the Ol in komatiite flows crystallized *in situ*, not via accumulation of intratelluric phenocrysts or primocrysts, and that the majority of the spinifex-textured zones of differentiated flows crystallized *after* the cumulate zones. Theoretical models suggest that turbulently and laminarly-flowing lava channels should have thin upper crusts, as observed in many thick komatiite flows. It seems likely that inflation occurred early and that channelization in pre-existing or self-generated (thermomechanical erosional) topographic lows may have been equally important in producing many thick komatiite flows.