Geochemistry of large river suspended sediments: what can we learn about present day weathering of silicates?

J. Gaillardet — Laboratoire de Géochimie et Cosmochimie, URA CNRS 1758, Institut de Physique du Globe, Université de Paris 7, 4 place Jussieu, 75252 Paris, Cedex 05, France

B. Dupré — Laboratoire de Géochimie, OMP, UMR-CNRS 5563, 38 rue de 36 ponts, 31400 Toulouse, France

C. J. Allègre — Laboratoire de Géochimie et Cosmochimie, URA CNRS 1758, Institut de Physique du Globe, Université de Paris 7, 4 place Jussieu, 75252 Paris, Cedex 05, France

Although it is clear that the chemical weathering of silicate minerals on Continents acts as a sink for atmospheric CO_2 on a geological time scale, the rate and control of present day chemical denudation remain to be documented. The geochemistry of large rivers is a powerful tool to get information on global scale weathering. In a companion paper, we applied an inverse method to the problem of extracting from river dissolved load the contribution of silicate weathering (Gaillardet *et al.*, 1998).

The alternative developed here is to focus on the solid products of weathering, essentially transported in large rivers as suspended sediments. These sediments are derived from the incongruent weathering of silicates and are released from soils by mechanical erosion.

In this paper, in order to favour a global scale approach, we have compiled the most recent data on the geochemistry of river-borne particles.

Global suspended sediment composition

In agreement with the well known mobility of elements during weathering of continental rocks, we confirm that river sediments are systematically depleted for Na, K, Ba with respect to the Upper Continental Crust (Taylor and McLennan, 1985). For each of these mobile elements, a systematics of weathering indexes of river-borne solids is attempted. A global coherence is found between all these indexes.

Chemical weathering intensities

Important variations in weathering intensities exist. A clear dependence of weathering intensities with climate is observed for the rivers draining lowlands. However, no global correlation exists between weathering intensities and climatic or relief parameters because the trend observed for lowlands is obscured by rivers draining orogenic zones. An inverse correlation between weathering intensities and suspended sediment concentrations is observed showing that the regions having the highest rates of physical denudation produce the least weathered sediments.

Trying to reconcile weathering intensities of river sediments and dissolved loads

Under the working hypothesis that erosion in large drainage catchments proceeds at steady state, we compared the chemical composition of both dissolved and solid products of silicate weathering for the world largest rivers. The clear conclusion that emerges from this comparison is that the degree of weathering of present day river particulates is not consistent with most of the river dissolved loads derived from silicate weathering. This apparent disagreement is due to the fact that river suspended sediments integrate the whole weathering history of the rocks within the drainage basin and not only the present day weathering. This conclusion has many important implications.

1. In most cases, it will be impossible to use directly river suspended sediment geochemistry to compute chemical weathering rates or associated CO_2 consumption. The use of suspended sediment geochemistry for relating weathering intensity and climatic parameters may also be a misleading guide. More generally, it precludes the use of sediment geochemistry as a proxy for palaeoweathering rates, except if the chemical composition of the source rocks is known.

2. Sedimentary rocks, formed of minerals inherited from one or several palaeoweathering cycles, are especially abundant in orogenic areas. Consequently, the idea that chemical weathering rates and associated CO_2 consumption is controlled by active orogenies (Edmond and Huh, 1997) must be moderated by the fact that part of the rocks submitted to weathering in mountains has already suffered previous weathering cycles. Recycled material are less able to produce cations than pristine igneous rocks are. The weathering history of the drainage catchment, i.e. sediment recycling, is therefore a parameter that should be taken into account for modelling the CO_2 consumption by silicate weathering.

3. The absence of correlation between the weathering intensity indexes and climatic parameters, especially in large rivers draining highlands is probably due to a variable contribution of sediment recycling from one basin to another.

4. Finally, we show that, provided that mechanical denudation within a drainage basin is known, it is possible to quantify the importance of recycling.

References

Edmond and Huh (1997) *Review of Geophysics* in press.

Gaillardet *et al.* (1998) *Chem Geol.* Submitted.

Taylor, S.R. and McLennan S.M. (1985) The Continental Crust: its Composition and Evolution. Blackwell, London, 312 pp.