PROJECT SUMMARY

SEDIMENT DYNAMICS IN LARGE DRAINAGE BASINS

renewal of NSF-9219487, Using Cosmogenic Isotopes to Determine Basin-scale Erosion Rates

n.b. This is a collaborative proposal between the University of Vermont, Bryn Mawr College and Cornell University

Large drainage basins are complex systems in which sediment is generated, transported, stored, and, after varying amounts of time, either buried beyond the depth of reworking or exported to the World's oceans. The rate at which sediment is generated in such drainage basins and the residence time of that sediment as it moves, grain by grain, down the fluvial transport system are poorly known; yet, measuring these rates is prerequisite to understanding dynamic interactions between the solid Earth and the hydrosphere.

Over the past decade, advances in mass spectrometry have allowed reliable measurement of extremely rare nuclides such as those produced as cosmic rays interact with rock. Because cosmogenic nuclide abundances (when normalized for exposure location) reflect the residence time of material within the uppermost several meters of Earth's surface, simple analytical models (beholden to a variety of assumptions) have been used to estimate "cosmogenic" exposure ages and erosion rates of bedrock outcrops and boulders.

During the past two years, we have been funded by Hydrologic Sciences to test an interpretive model (Bierman and Steig, 1992, 1995; Brown et al., 1995; Granger and Kirchner, 1994 a, b) which suggests that measurements of cosmogenic ^{10}Be and ^{26}Al in sediments can be used to estimate the rate at which drainage basins erode, and constrain the transport and storage history of sediment as it is moved off hillslopes, through the fluvial transport system, and out of the basin. Because our initial data (Bierman et al., in review; Bierman, 1995) and the data of others (Brown et al., 1995; Granger and Kirchner., 1994 a, b) suggest that cosmogenic nuclides are indeed useful tools by which to study hydrologic processes in small and moderate size drainage basins, we seek funding to expand our current research to larger scales and over longer time frames.

The overall objective of our proposed research is to determine at what scale and in what fluvial regimes, cosmogenic nuclides remain useful tools for 1) determining basin-scale, spatially-averaged erosion rates and 2) placing limits on the duration of sediment storage. In order to meet this objective, we seek funding for isotopic and other corollary measurements needed to determine the spatial variation in ^{10}Be and ^{26}Al abundances in approximately 80 samples collected from locations throughout the drainage networks of four tectonically and climatically distinct fluvial systems: the Ganges (Himalayas), the Apure (Andean Mountains), the Sagavanirktok (Alaska, North Slope) and the East Alligator (northern Australia). No other method to date has been able to determine basin scale rates of erosion over the 10^4 to 10^5 year time scales or to estimate directly average sediment residence time in large rivers. In order to approach these problems, we have put together a team of young scientists with a variety of complimentary skills and approaches: Paul Bierman (UVM), Louis Derry (Cornell), Mark Johnsson (Bryn Mawr), and John Stone (ANU).

Testing the spatial and temporal variation of ^{10}Be and ^{26}Al abundance in sediments of some of the World's major rivers will constrain the scale of applicability of existing interpretive models, a significant advance in Isotope Geochemistry. The data we generate regarding the relative duration of sediment storage and model rates of basin scale denudation will be of fundamental significance in the fields of Sedimentology, Hydrology, and Geomorphology. In the sense that we cannot anticipate the outcome of our measurements, some might consider our proposal "high risk science". In light of the success we and others have had using ^{10}Be and ^{26}Al to estimate erosion rates and constrain sediment storage times in smaller catchments (Bierman et al., in review; Bierman, 1995; Brown et al., 1995; Granger and Kirchner, 1994 a, b), and because of the fundamental nature of the questions we are addressing, we feel such a "risk" is minimal and worth taking.