Methods to specify and quantify sediment source contributions and transport pathways

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Introduction: Our aim is to illustrate site-specific source and pathway modeling that can quantitatively connect river and sea sedimentation processes.

Provenance (source) identification is a traditional task for geologists and environmental sedimentologists. Mass balance studies in many studies attempt to identify sources and quantitatively partition their contributions in general. However, quantitative source partitioning for individual sites of accumulation is seldom achieved because of the complex variability within most natural environments regarding on-going processes, which are often difficult (and expensive) to measure and nearly impossible to reliably integrate over time, largely due to the natural variations in process intensity and effectiveness. In additional, most biological and geochemical parameters are highly volatile due to degradation and diagenesis. The focus here is upon the stable components of the "sediment archive", which offers a time-integrated, net-effect reflection of the combined processes of an entire environmental system, and recorded for each individual site of accumulation. Instrumental developments first now permit real quantitative modeling for fine-grained sediments, i.e. those most sensitive to change and most reactive with other environmental components.

Combining mass-flux studies with the identified transport pathways would help complete the source to basin modeling that many sedimentological studies aim toward. Spatial trends in grain size can complement mineralogical data for this purpose.

Methods: The methodology for quantitative provenance and pathway modelling can be separated into the 5 steps:
1) Mineralogical data of specific size fractions is interpreted to identify tentative source types,
2) Contributions from identified source types are then derived by simultaneous equations for each specific mineral or mineral ratio,
3) "Pure" end-members are resolved using multiple samples and calculating the maximum "activity" of each source types (step 1),
4) Total mineral contributions are modelled by combining grain-size and size-specific mineralogical data, and
5) Partitioned and quantified contributions are modelled to allow scenario testing.

Detailed mineralogical and grain-size distributions also allow interpretations of transport pathways and site dynamics. Independently of each other (in part due to language restrictions), two methods of specifying transport processes and pathways have been developed [1] [2]. Each method makes different assumptions for pathway identification, but together they provide complementary information about the sedimentary processes involved: site-specific pathway vectors [1], erosional/accumulation balance [2], and source-to-deposit relations [1]. The combination of these approaches from different "schools", together with the quantitative source partitioning with mineralogical data, will allow more specific and quantitative analysis than has been previously possible in sediment transport studies.

Results: Several projects applying these methods will be summarised, involving harbour silting [3], coastal bay circulation, shelf transport [4], and deep-basin sedimentation [5].

Discussion: The possibilities for quantitative source and transport pathway modelling have not yet been fully appreciated. This modelling would answer central questions regarding the origin and fate of the materials within environments impacted by human activities, providing essential knowledge for sustainable management. The "sediment perspective" is opposite to most environmental budgets, where mass-flux budgets are often done by measuring the inputs from known sources. However, because of rate uncertainties and erosional events, the net effects are difficult to model using the "source perspective". Using the time-integrate and net-effect perspective provided by sediment-based budgets avoids most of these problems.

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