MARGINS Source-to-Sink Lake Tahoe Workshop Report: An Implementation Plan

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In September-October 1999, an NSF- and JOI-sponsored workshop at Lake Quinault, WA, allowed representatives from the scientific community to meet, discuss and create a science plan for a MARGINS initiative, termed Source-to-Sink, to solve fundamental problems in sedimentology and stratigraphy. The resulting science plan outlined important directions for future research, recommended strategies for accomplishing this research, and considered candidate sites for detailed interdisciplinary studies in light of the site criteria accepted at the workshop. The science plan is expected to provide a blueprint for taking geomorphologic, sedimentary and stratigraphic processes to a substantially higher level of understanding. The Lake Quinault meeting was followed by a second meeting, held at Lake Tahoe, CA, in September 2000, with the objective of examining the relationships among processes relevant to sediment production, transport, accumulation, and preservation on margins across a large range of temporal and spatial scales. In particular, experts were invited to present various aspects of the selected focus sites (Papua-New Guinea and New Zealand) consistent with the science plan, which in turn, should help maximize synergy and use of facilities between national and international researchers, minimize duplication and dilution of effort, and plan an implementation strategy. It is this strategy that is the subject of this report.

MARGINS Source-to Sink strategy

The Source-to-Sink effort, as formulated at the Lake Quinault meeting, encapsulates several conceptual innovations. The first of these involves the recognition that margins are impacted by processes extending from sediment source to sediment sink. This idea is best illustrated in terms of the physiographic curve, extending from eroding terrestrial uplands to the abyssal plains beyond the continental rise, which constitute the ultimate sediment sink (Figure 1).

The second conceptual innovation involves the division of this curve into units separated by discrete boundaries that are dynamic and shift in response to external and internal perturbations. These are delineated in Figure 1.

Thus, margins as conceived here, contain four boundaries separating two terrestrial units, two submarine units, and the continental shelf (whose existence is dependent on sea level). Each of the units may contain subunits, such as bedrock and alluvial sub-units within the terrestrial uplands zone. Each unit may produce sediment through erosion and/or act as a sediment sink through deposition, either temporarily or permanently. The zones are interlinked by the flux of sediment through the boundaries:

Unit:	Boundary:
Terrestrial upland	
	Transition from gravel-bed to sand-bed streams
Terrestrial lowland	
	Coast (shoreline, estuaries, and deltas)
Continental shelf	
	Shelf-slope break
Continental slope	
	Slope base
Continental rise and abyssal plain	

The third and perhaps most important of the conceptual innovations is recognition that all of the boundaries are in fact dynamic and shift in response to perturbations. This motion is most dramatically illustrated in terms of the major changes in shoreline position in response to sea-level change. For example, the shoreline of the East Coast of the United States has migrated over 100 km landward since the end of the last glaciation. It is essential to understand, however, that every other boundary is also dynamic. For example, the shelf-slope break can migrate outward due to clinoform progradation, and the gravel-sand transition can migrate downstream in response to tectonically-driven inputs of coarse sediment.

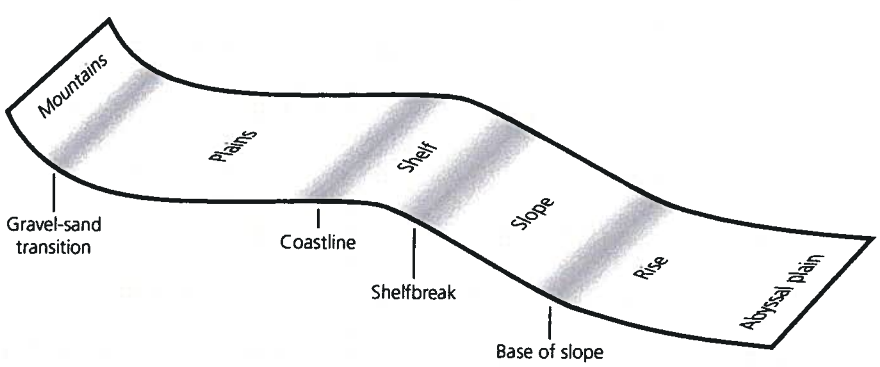

Figure 1. A simple schematic illustrating the different units and dynamic boundaries of the dispersal system.

The fourth conceptual innovation of the Source-to-Sink project is the power of analogy between the subaerial and submarine world. The terrestrial uplands are in many ways loosely analogous with the submarine continental slope. Alluvial fans are likewise loosely analogous to the submarine fans found on the continental rise. More specifically, the following analog structures stand out:

Subaerial:	**Submarine:**
Meandering rivers	Meandering submarine-fan channels
Alluvial fans	Submarine fans
Subaerial debris flows	Submarine debris flows
Incised bedrock channels	Submarine canyons

This unified conceptualization of the problem necessitates an interdisciplinary approach. Field research provides the empirical base and the overall perspective. Experimental research allows for the testing of hypotheses that cannot be directly tested in the field. Theoretical and numerical research builds the basis for predictive capabilities. The framework requires cooperation among geomorphologists, stratigraphers and oceanographers, and requires them to cross the shoreline between the subaerial and submarine environments. The potential for synergism is unprecedented among communities that have not normally been in close communication with each other.

MARGINS Source-to-Sink approach

Margins are the Earth's principal locus of sedimentary accumulations and provide one of the best preserved global records of Earth history. Because these accumulations record lithospheric deformation, geochemical cycling, sea-level variations, and climatic fluctuations, they provide a high-resolution record of variations in the earth-ocean-atmosphere system essential to evaluating today's models for global change. The Source-to-Sink project is designed to advance our understanding of the processes that form and modify continental-margin geomorphology and stratification at all scales, and the events that trigger those processes. The traditional approach to continental-margin research has been primarily to describe and to classify. The Source-to-Sink project, instead, seeks to identify a small number of natural laboratories where large-scale, interdisciplinary experiments, involving field, laboratory and theoretical components, can be designed. The Source-to-Sink project seeks to change the long-held view of margin sediment prisms as "frozen" records, even though they contain the convolved story of Earth's past. In fact, margin sediments are complex physical/chemical/biological systems, subject to a changing variety of driving forces. Using a finite number of natural laboratories, this program will establish the parameters that describe these systems, define the laws that relate the parameters to one another, and improve predictive quantitative models that can be rigorously tested by a series of integrated case studies.

Implementation and duration of Source-to-Sink

We are looking at 10 years of funding for the MARGINS program with reassessment of the science plan and focus areas at the 5-year mid-point. It is important to note that the evaluation process initiated at Lake Quinault and finalized at Lake Tahoe prioritized which areas should move forward now to maximize synergy, maximize use of facilities, and minimize dilution of effort. Other research areas that are not focus or allied field studies offer great opportunities and the community is encouraged to continue to submit proposals for these areas to NSF core programs under the heading of MARGINS-related research. As previously mentioned, the MARGINS Source-to-Sink web site and AGU Town Meeting provided the community information to evaluate potential sites in light of the criteria identified at the Lake Quinault workshop. New Zealand (http://www.indstate.edu/gomez/margins.html) and Papua-New Guinea (http://www.vims.edu/margins) were selected as the focus sites and SE Alaska (http://depts.washington.edu/qrc/margins) was selected as the allied field study. EOS editors have given approval for a series of brief articles to be run: one devoted to the general science plan of Source-to-Sink, two devoted to each focus site, and one for the allied field study.

NSF has nominally fixed the duration of the Source-to-Sink project as a decadal program. At Lake Tahoe, implementation was the focus of the third and fourth days at the workshop. Participants were asked to set as our 10-year goal to figuratively and literally "write the book" on Earth surface processes. The workshop participants identified what should be in the book, in terms of processes and environments. The sequence of examination and implementation is extremely important given financial constraints. The focus at the Tahoe workshop was on the first five years of research, specifically to outline a logical sequence to examine the dispersal systems in Papua-New Guinea, New Zealand, and SE Alaska (Figure 2). In addition, participants were tasked with identifying the strengths of dispersal systems (e.g., signal to noise) to address fundamental questions across a variety of time scales. Figure 2 illustrates the implementation strategy for Source-to-Sink research. On the basis of input from NSF and the MARGINS Steering Committee the strategy has evolved slightly from that which emerged from the Lake Tahoe.

The proposed strategy will allow us to compare and contrast tropical (Papua-New Guinea) and temperate (New Zealand) dispersal systems. In addition, we will examine dispersal systems that efficiently transfer sediment to the ocean (Waipaoa & Markham) versus systems with more deposition/sequestering along the lower reaches of the fluvial system (Fly River and South Island of New Zealand (SINZ)). Evaluation of the proposed strategy will be conducted yearly, with a mid-program evaluation in the fifth year.

Source-to-Sink Implementation Strategy

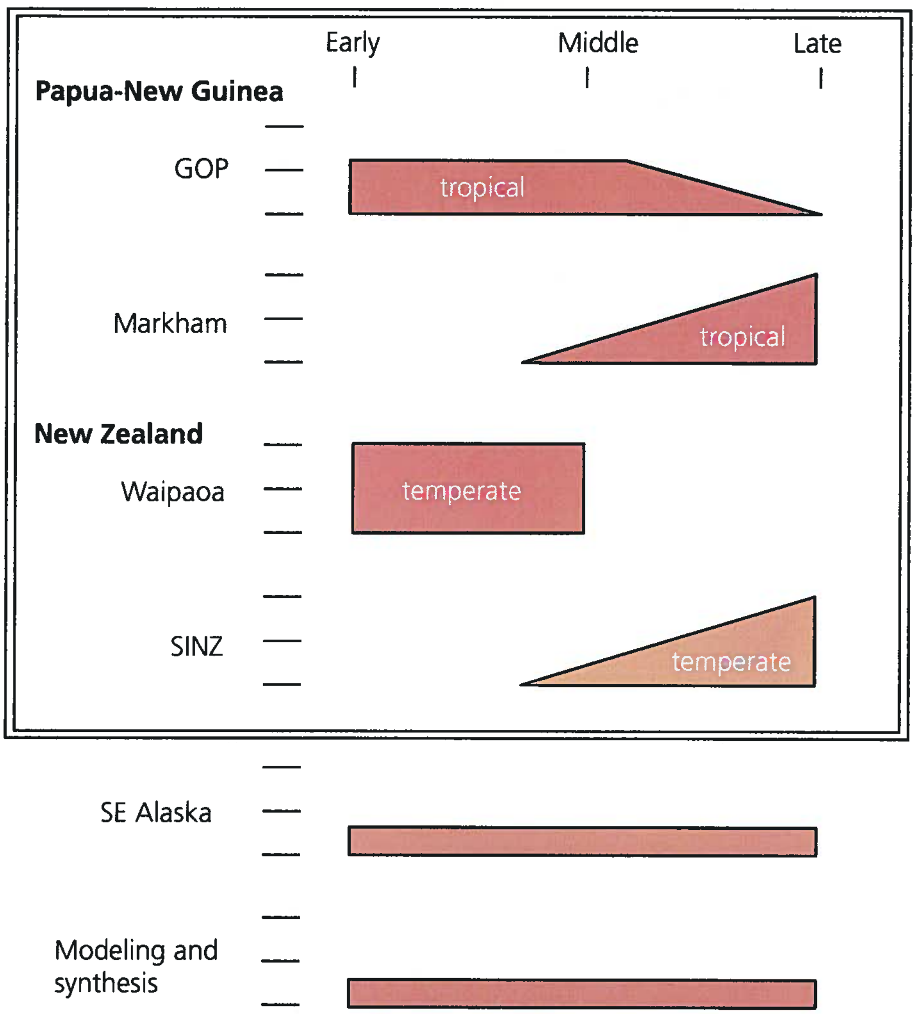

Figure 2. Schematic diagram showing the implementation strategy for the two focus areas and the allied field study.

The implementation strategy will provide better insights about whether a course correction is required at the mid-program evaluation and if so, how substantial. Communication and interaction also will be cornerstones of this implementation policy, to provide opportunities for increased synergy through collaboration and piggy-back research campaigns. If a large correction is required at the mid-term juncture of the initiative, then using this strategy will ensure that the Source-to-Sink Program hits the ground running because a framework will be established in other dispersal systems. This implementation strategy also will enfranchise more international scientists, who can become involved in Source-to-Sink research because of the phased approach. The sequence of examination and the relative effort illustrated in Figure 2 was designed to build on the strengths of each dispersal system to yield new insights and understanding of the dispersal system in a realistic time frame given the length of the NSF MARGINS program.

A large initial effort would focus on the Waipaoa dispersal system to build on the existing data, infrastructure, and knowledge of the system. The Waipaoa drainage system is small and manageable with a large short-term perturbation to the landscape (anthropogenic). The efforts in the Waipaoa dispersal system, together with previous and ongoing studies, should yield new insights and understanding of dispersal systems early on in the Source-to-Sink program that will help constrain modeling efforts as well as investigations of other systems. The effort in the Waipaoa dispersal system would end after five years. A lower level of effort would be maintained in the Gulf of Papua during the initial 5-year period. The Gulf of Papua represents a complete dispersal system with multiple sediment sources (terrigenous and carbonate). The lower reaches of the Fly River are characterized by a low-relief plain, which will allow us to examine how perturbations are transmitted across the deltaic/estuarine system. Only about 30% of the 75,000-km^2 Fly River drainage catchment is in the rapidly eroding uplands. In addition, the low-relief lower reaches of the Fly River will provide an end member to compare and contrast to other dispersal systems.

Research efforts would be phased for both the SINZ (Clutha, Waitaki and Rangitata rivers) and the Markham dispersal system, Papua-New Guinea. According to input from NSF and MARGINS, workshop proposals for the SINZ and the Markham dispersal systems can be submitted for consideration to the November 1, 2002 MARGINS RFP. The workshops will address fundamental questions concerning the dispersal systems in light of knowledge gained from the ongoing Source-to-Sink studies. The dispersal systems along the South Island of New Zealand provide access to longer time scales for examination of transport and dispersal processes that were operative during lowstands of sea level. Prior to November 1, 2002, proponents of the SINZ and Markham dispersal systems are encouraged to submit proposals to NSF core programs to initiate studies in these regions. The stratigraphic record preserved offshore is excellent with minimal post-depositional deformation of the clinoform geometry. This will be one of the ideal candidates for offshore sampling with a non-riser ODP vessel. Anthropogenic changes (e.g., dams) to the South Island dispersal systems provide an opportunity to examine how drainage systems respond to perturbations. The Markham River system has large, rapid transport along the entire dispersal system, from actively deforming upland regions to mass flows of coarse material in the deep sea. It provides an unparalleled opportunity to examine an active deep-water portion of a dispersal system analogous to many systems during lowstands of sea level.

suffice. The model would require a host institution with the appropriate long-term interest and infrastructure, but would be developed by, and available to, the entire community.

Our goal is to conduct Source-to-Sink projects, as outlined above, in New Zealand, Papua-New Guinea, and SE Alaska. The major and most expensive scientific activities probably will not be simultaneous in all regions. Proposal excellence will determine which localities receive initial focus and how the dispersal system is investigated. Development of a large program in one locality will hopefully draw related investigations to

Time (years)	1	2	3	4	5	6	7	8	9	10
1. Monitoring Dispersal System	●	●	●	●	●	●	●	●	●	●
2. Onshore/Offshore Imaging	●	●	●	●	●					
3. Onshore Sampling and Dating		●	●	●	●	●				
4. Sediment Properties/Rates		●	●	●	●					
5. Offshore Non-Riser ODP Drilling						●	●	●		
6. Experimental Studies	●	●	●	●	●	●	●	●	●	●
7. Quantitative Modeling	●	●	●	●	●	●	●	●	●	●
8. Alternate Platforms/New Drilling								●	●	●

Table 1. Logical progression of studies within focus areas.

A small amount of funding will be maintained in SE Alaska, an allied field study, to examine the importance of glacial processes in sediment production, transport, and accumulation. This research will complement the longer-term examination of the dispersal systems along the South Island of New Zealand. Finally, a modest level of effort would be devoted to the development of Community Sediment Model (CSM). The goal here would be to produce a unified framework model, analogous on some levels to a GCM. The CSM would be aimed at problems for which nothing less than a comprehensive, highly resolved, three-dimensional model will

realize the full synergism of Source-to-Sink. An integrated analysis of dispersal systems requires at least a ten-year program. The ordering of certain elements of the program are undeniable, for example, extensive surveys both onshore and offshore (Table 1, item 2) are required prior to sampling and dating techniques. Other aspects of the program are completely interwoven with results from one area potentially triggering further studies in another. Thus, this time sequencing is a preliminary model that would be subject to revision as the program progresses. The first years of Source-to-Sink will focus on developing the morphologic and stratigraphic framework for the respective focus areas. Monitoring of river discharge, sediment fluxes, erosion and deposition is required for the full duration of Source-to-Sink, in order to understand the processes that shape landscapes and seascapes. Modeling will be necessary throughout, to guide the data acquisition, focus the questions, and to evaluate results. During the final years of the program, shallow-water and non-riser drilling, and subsequent data analysis, will ultimately test predictions about the nature of the dispersal system.

Monitoring the dispersal system (1) would constrain the river discharge, sediment fluxes, erosion and deposition rates. Onshore/offshore imaging (2) would define the morphologic and stratigraphic framework and would locate targets for detailed imaging and sampling. Onshore sampling and dating (3) would help provide constraints on age of surface exposure and material properties. Non-riser drilling (5) will determine the history and rates of incoming material to the sink. Experimental studies (6) and quantitative modeling (7) will provide insights and predictions about the dispersal system that can be tested. Alternate platforms and new drilling technology (8) will provide key samples from diverse environments to test model predictions.

Planning a workshop? ...TEI?
...any other MARGINS activity?

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