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When sink becomes source: Importance of sediment recycling in linked orogen-basin systems

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Much of the recent research on sedimentary system dynamics has focused on extant systems where the linkage of sediment production from eroding highlands can be directly linked to deposition in lowlands and/or offshore basins. Studies of such systems, typically late Pleistocene to Holocene in age, are especially valuable for quantitative constraints such as system morphometrics (e.g., longitudinal profiles, basin volumes, etc.) and rates of processes (e.g., erosion/denudation, sediment accumulation, etc.), which can be measured directly or estimated with relatively high certainty. Moreover, information about climate and tectonic forcings that are independent to the system is explicitly known for extant systems. However, an understanding of longer-term (>10^5 yr) evolution can only be gained through the investigation of ancient systems. Such systems are either buried in the subsurface, which requires geophysical remote sensing and/or drilling, or exposed at the Earth's surface as outcrops as the result of uplift and exhumation. The dynamic linkage of mountain belt and adjacent basin makes foreland basin systems ideal natural laboratories to address long-term sedimentary system evolution.

In this presentation, we highlight important issues and challenges that sedimentary systems research is currently facing, with an emphasis on sediment recycling during progressive stages of basin development. In this context, we focus on sedimentary systems in which multiple episodes of uplift and erosion of the primary depocenter led to a history whereby basin material was repeatedly recycled. The spatial and temporal aspects of sediment recycling have implications for how provenance signals (based on composition, crystallization or metamorphic age information, thermal history, etc.) are used. Additionally, improved constraints regarding the timescales and magnitude of sediment recycling have implications for system-scale modeling. Key parameters such as total sediment volumes and differences in rock erodibility between original basement source and sedimentary source must be accounted for in these models if budget closure is to be considered. Sediment recycling has long been considered by basin analysts and recognized using numerous provenance indicators; however, new analytical tools allow us to further quantify the impact of recycled source terranes. The Magallanes Basin of South America provides an appropriate example to discuss these issues because of its long-lived convergent basin history and proximity to distinctive source terranes. A robust and growing database of compositional (e.g., sandstone composition, shale geochemistry), detrital age (zircon geochronology), and time-temperature (detrital thermochronology) information is used to help constrain source-area configuration and evolution. These data are placed within a multi-scale stratigraphic framework that addresses basin geometry and depositional system evolution, thereby enabling us to test geologic models based on sediment transport pathways, maturation of sediment-sources, and post-depositional thermal history.