Paper Number: 5506

Detrital Zircons as a Next-Generation Tool in Source-to-Sink Sedimentological and Stratigraphic Analysis

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The past two decades have seen significant advances in the use of detrital zircons (DZs) to address provenance and geochronology for terrigenous clastic sediments and sedimentary rocks. This presentation discusses the application of DZs to three types of questions in source-to-sink sedimentological analysis that can be addressed with large, systematically collected datasets.

Source-to-sink routing of sediments from hinterlands to depositional basins is a fundamental issue. Sediment flux scales to contributing drainage area, and reconstruction of paleodrainage areas can be used to predict flux, routing and dispersal to depositional basins at various times in the past. These principles have been tested in the US Gulf of Mexico (GoM) basin, where DZ samples were collected across the fluvially-dominated Cenomanian and Paleocene outcrop belts of the coastal plain. DZ data show that through the late Cretaceous, GoM drainage was restricted to the area south of the Appalachian-Ouachita Cordillera, fluvial systems were regional scale only (<<10^6 sq. km drainage areas), and the largest system was the paleo-Tennessee River of the eastern GoM. By the Paleocene, southern North America was routed to the GoM through a series of major fluvial axes: these included the paleo-Tennessee and its Appalachian source terrain, and an ancestral Mississippi River, but the largest axes drained the Sierra Nevada, Sevier fold and thrust belt, and the Rocky Mountains of the western US, and discharged to the western GoM in Texas. These changes in paleodrainage from DZs correspond to changes in the scale of basin-floor fans in the deepwater GoM.

The contributive vs. distributive nature of fluvial deposits in the stratigraphic record has received much attention in recent years, and is a topic that bears on paleogeographic position within a source-to-sink routing system. DZ data can be used to test contributive vs. distributive hypotheses for individual stratigraphic units. For example, one view of the Aptian McMurray Formation in the Western Canada Sedimentary Basin interprets tidally-influenced fluvial deposits within a distal estuarine setting where distributive channel belts are common, whereas another view places the McMurray farther upstream, removed from marine influences, and within the contributive part of a paleovalley system where amalgamated channel belts are common. DZ data show bimodal and statistically distinct populations within the McMurray, which demonstrates a tributary-trunk stream contributive relationship, and supports a more upstream paleogeographic setting. In this same vein, ongoing work is examining the Jurassic Morrison Formation of the US Western Interior, where recent studies argue for a distributive fluvial system (DFS). If the Morrison is a large DFS with a single apex, all samples along the strike of the outcrop belt should have statistically indistinguishable DZ populations, whereas statistically distinct populations would indicate a contributive system.

DZs can improve geochronology in terrestrial strata, which makes it possible to quantify accumulation rates and develop robust updip-downdip correlation models. The youngest U-Pb ages define maximum depositional ages (MDAs) for a stratigraphic unit, but can approximate true depositional age only if syndepositional volcanogenic zircons are available in the drainage area. Two issues are important in this context. First, young volcanogenic zircons are abundant in some stratigraphic units, but are often not present at all, or in small populations only. Increasing the number of analyses per sample (n=300 grains) increases the chance of recovering small populations of young volcanogenic zircons that approximate true depositional age. Second, finer-grained volcanogenic zircons (medium to fine silt size) travel farther in ash clouds, and are more likely to be present in distal drainage basins. Ongoing work is testing whether preferential sampling from fine-grained fluvial facies (channel fills, overbank strata, etc.), rather than coarse-grained channel sands, increases recovery of young volcanogenic zircons, and MDAs that approximate true depositional age.