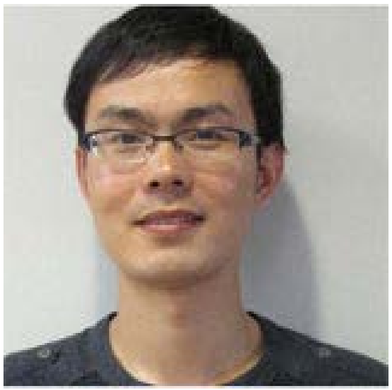

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Lower Miocene Gulf of Mexico Basin Source to Sink – New Insights from Novel Isotopic Provenance Analysis

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Detrital zircon (DZ) U-Pb has become a widely employed method to constrain detrital provenance to reconstruct sedimentary evolution and hydrocarbon reservoir evaluation in basins. However, the DZ U-Pb method has clear limitations due as zircon recycling, insufficient source variance, or source ambiguity. U-Pb ages also provide little direct information on the tectonic controls of the detrital source region adjacent to basins. Recently DZ (U-Th)/He (ZHe) dating represents a new powerful approach that in combination with DZ U-Pb not only defines sedimentary provenance, but also the exhumation history of a detrital source region (Reiners et al., 2005). Combined DZ U-Pb-He double dating is a novel approach that has the ability to capture both provenance and tectonic activity in the source area and to shed more conclusive light on the sedimentary provenance and the tectonics controlling basin evolution, Several studies have recently used DZ U-Pb-He double dating to better constrain provenance, sediment dispersal, tectonic controls, and hydrocarbon reservoir characteristics of basin deposits using the dual criteria of crystallization ages and cooling ages. While sparse DZ U-Pb studies (e.g., Mackey et al., 2011), no U-Pb-He double dating has been undertaken in the Gulf of Mexico (GOM).to more fully elucidate the complex sediment provenance and dispersal history in the GOM.

Background: The lower Miocene of the GOM Basin is a transitional unit as it is a time of major tectonic reorganization in the western interior (Rocky Mountains), shifting from the Oligocene thermal phase with abundant volcanic activity recorded in the thick Frio/Vicksburg succession of the GOM, to the Basin-Range tectonic phase in the Miocene (Galloway et al.

2011). Climatic conditions changed from relatively arid Oligocene to wetter Miocene climates, resulting in increased sedimentary yield from exhumed tectonic structures. Local uplift of the Edwards Plateau likely caused diversion of rivers, forming the modern Red River drainage system, and/or created local input from source area. Globally, the lower Miocene is a time of considerable tectonic, climatic, and oceanographic change (Potter and Szatmari, 2009). Outboard, the *Planulina* embayment developed with major collapse of the shelf margin in Louisiana. The lower Miocene is also marked by the first appearance of deep-water fans (post-Eocene), as such fan systems are absent in the upper Eocene-Oligocene of the GOM (Galloway, 2009). The lower Miocene gave way to development of large (GOM-wide) abyssal plain fan systems in the middle and lower Miocene (Combellas-Bigott and Galloway, 2006). Along the paleoshoreline, a foreshadow of the modern physiography of the Gulf occurs in the lower Miocene, with large wave-dominated shore zones in south Texas, deltas in the central region of Louisiana, and a broad carbonate platform in the eastern GOM. Limited published provenance work suggests a transition from volcanic rock fragment-rich Oligocene to more quartz-dominated sandstones in the central GOM (Dutton et al. 2012). By the latest early Miocene (GBDS LM2 deposode), sediment supply began to increase and the Appalachians began to contribute more to the sediment provenance of the basin. By the middle Miocene, the uplifting Cumberland Plateau began to outpace western sources in sediment volume (Poag and Sevon, 1989; Boettcher and Milliken, 1994). This is partly due to the disparity in climate recorded in the two source terranes, with arid conditions prevailing in the northern Rockies, limiting sediment transport from large alluvial fans related to tectonic uplifts.

Problem: Drainage basin and large fluvial transport paleogeographic reconstructions for the lower Miocene of the GOM (Figure 1) are currently built upon very limited provenance constraints based on proportions of quartz, feldspar and lithic fragments and consideration of likely river courses through known paleo-geomorphological elements (Galloway et al. 2011; Dutton et al. 2012). However, rigorous reconstructions of the timing and location of mountain uplift and linked sediment dispersal to outboard depositional systems requires use of the latest analytical approaches such as DZ U-Pb dating (e.g. Lee et al. 2009; Mackey et al. 2012). Advanced techniques such as DZ U-Pb-He double dating would provide the necessary foundation for reconstruction of the various fluvial systems that provide sandy input to deltas and eventually the deep water fairways that today are located below a thick canopy of salt.

Methods: Novel DZ U-Pb-He double dating provenance analysis combined with more traditional mapping approaches (from seismic and well data) will generate rigorous reconstructions of the lower Miocene depositional systems from source terrain to deep-water sink for this key transitional period in geologic history. Insights have important implications for understanding other timeframes of shifting climate, tectonics, and paleo-drainage systems (e.g., late Eocene, early Pliocene). DZ U-Pb-He analysis and regional mapping from wells and seismic would help differentiate multiple highland terranes, including potential clastic sources ranging from the Sierra Madre Oriental in Mexico (Hernandez-Mendoza et al. 2008), southern Rockies, Northern Rockies, Edwards Plateau, Arkoma region, Eastern and Western Appalachians. In addition, the techniques also provide greater resolution on time from unroofing to deep-water deposition.

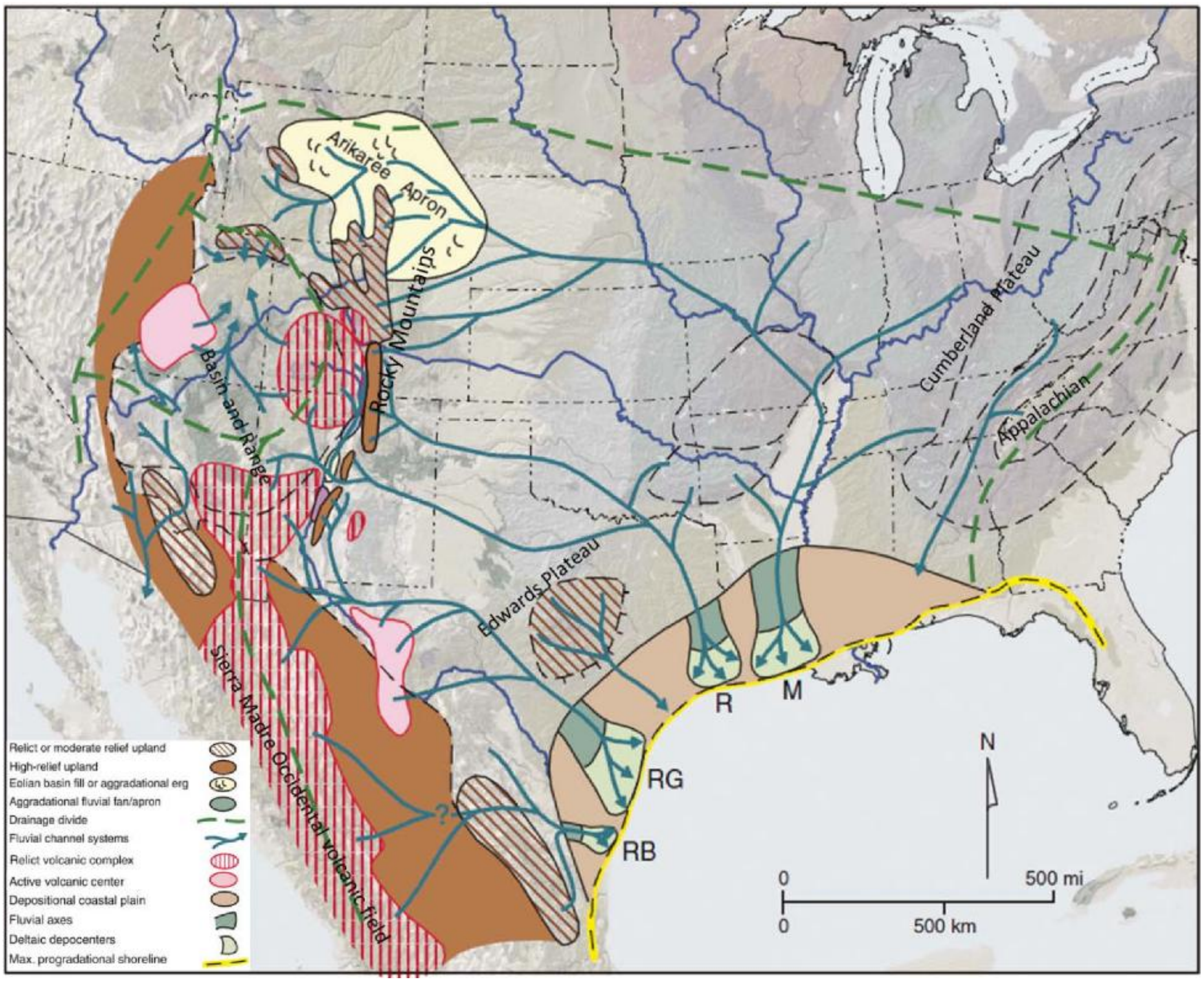

Figure 1 Early Miocene paleogeography (from Galloway et. al., 2011).

Databases and Sample Study Sites: The large sample sizes of sediment required for detrital zircon analysis means that outcrop localities must be accessed, as well as whole core in onshore and shelf wells and a smaller subset of deep-water wells (where restrictions are likely to be greater). Mineral exploration efforts by Galloway in the 1970's were largely centered upon abundant the Lower Miocene outcrop belt in Texas (Figure 2). 19 outcrop samples from 13 outcrops in six counties in Texas are already sampled. There are still some good outcrops in De Witt and Fayette counties haven't get sample yet. Besides outcrop sample in Louisiana will also be sampled with help of Dr. Gary L. Kinsland from University of Louisiana. The samples we finally get will cover most part of fluvial system of Lower Miocene in GOM and provide adequate source terranes information. Besides whole-core samples can be obtained from the BEG core repository (http://igor.beg.utexas.edu/crc2). Table 1 shows part of potential lower Miocene whole-core wells in BEG core database. These cores are allowed to sample with low cost. Two samples from Hidalgo and Liberty are already sampled (see figure 1). Other wells samples, particularly on present deep-water acreage, would have to be negotiated with operating companies that maintain large core databases (e.g. ExxonMobil, Chevron, BP, etc.). Samples from Mexico may prove to be the most difficult to obtain, given current security and safety issues. Potential academic connections (e.g. UNAM through Stockli) will be explored. While the lower Miocene (LM1 and LM2) has not achieved hydrocarbon discovery/production of the middle and upper Miocene, it has considerable upward potential as large portions of prospective fairways are below the thick salt canopy in the western and central GOM. The sub-salt location also means that traditional seismic facies analysis and mapping are more restricted, given image quality and frequency resolution. New reverse time migration and wide-azimuth data collected across the sub-salt fairways is meant to enhance structural imaging, not stratigraphy. Thus regional and basin-scale reconstructions are even more important for reducing reservoir risk to acceptable levels for prospecting the lower Miocene hydrocarbon systems.

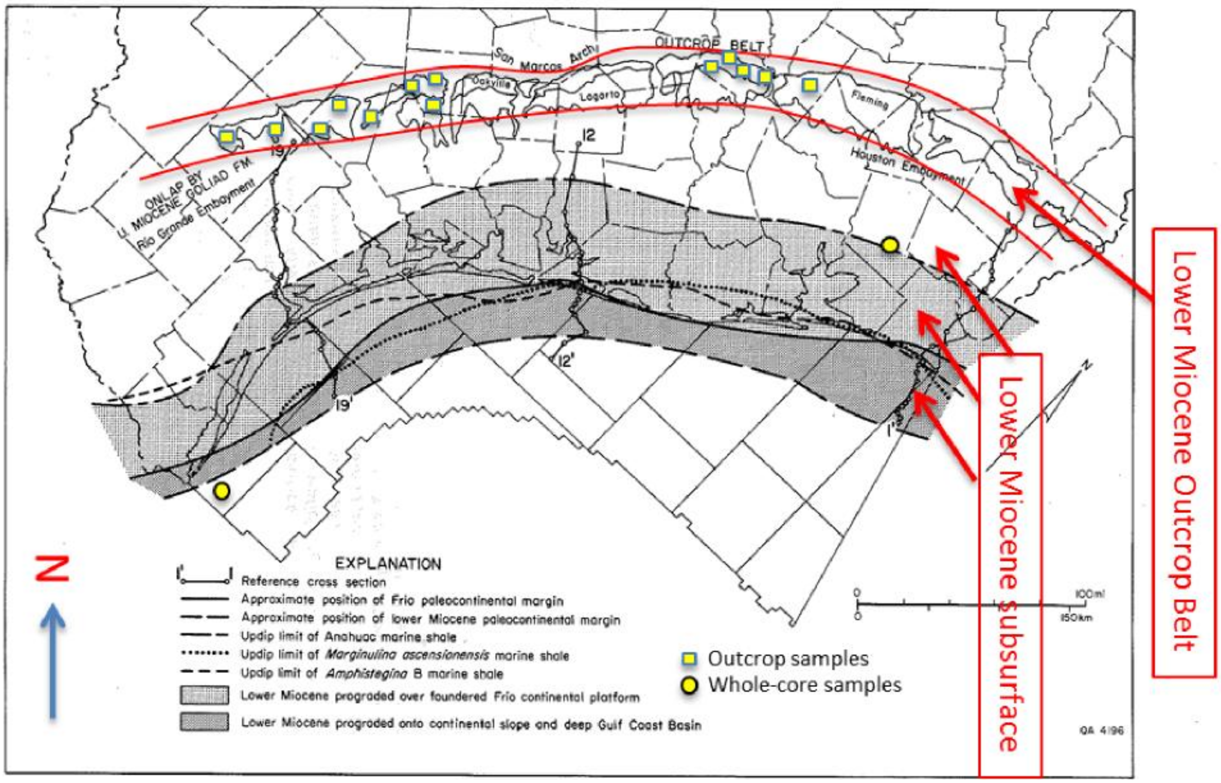

Figure 2 Outcrop and whole samples location map

Table 1 Parts of potential whole-core wells from BEG core database

County	Operator name	Lease name	facility	Top depth	Bot depth
Live Oak	U.S. STEEL URANIUM OPERATIONS	BOOTS 165-2C	Austin	270	325
Live Oak	U.S. STEEL URANIUM OPERATIONS	BURNS 60-1511IC	Austin	353	430
Live Oak	EVEREST MINERALS	MOUNT LUCAS #337-304C	Austin	415.5	440
Live Oak	EVEREST MINERALS	MOUNT LUCAS #335-305C	Austin	422.5	445
Hidalgo	ARCO OIL & GAS CO	SORENSON GU #2	Houston	3877	3916
Liberty	CARDINAL CREEK CORP	FLOWERS, FORT H. FOUNDATION #2	Houston	1680.8	2102.7
West Cameron	Unknown	OCS 00299	Houston	10305	10338
Matagord a island	Sun Oil Company	OCS G 5169	Houston	13583.5	13589

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