GIS Project: Study on Gulf of Mexico basin provenance in Lower Miocene

Introduction

Background: The Lower Miocene of the Gulf of Mexico (GOM) Basin is a transitional unit from many respects. 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 Middle Miocene (Galloway et al. 2011). Climatic conditions changed from the relatively arid Oligocene to the wetter climates of the Miocene and resulting increased sedimentary yield from exhumed tectonic structures. Local uplift of the Edwards Plateau probably caused diversion of rivers to the east (forming the modern Red River drainage system), and/or created local input from this small local source area. Globally, the Lower Miocene is a time of considerable tectonic, climatic, and oceanographic change (Potter and Szatmari, 2009).

Problem: Drainage basin and large fluvial transport paleogeographic reconstructions for the Lower Miocene of the GOM are currently built upon standard provenance information based on proportions of quartz, feldspar and lithic fragments and consideration of likely river courses through known paleogeomorphological 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 detrital zircon (DZ) geothermometry (e.g. Lee et al. 2009; Mackey et al. 2012). Advanced techniques such as DZ double and triple dating would provide the necessary foundation for subsequent source to sink analysis along the lines of Somme et al. (2009). A key element is the selection of representative sections where scaling relationships can be used to predict deep-water parameters, clearly needed in Lower Miocene subsalt play analysis.

The key goal is to use a combination of advanced provenance analytical techniques (DZ analysis) with the traditional mapping approaches (from seismic and well data) to generate rigorous reconstructions of the Lower Miocene depositional systems from source terrane 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 paleoflow (e.g. Late Eocene, Early Pliocene).

In the project, I will try to locate the outcrop location by use major river intersect the Lower Miocene outcrop belt in Texas and Louisiana. Also find the well which have whole core samples of Lower Miocene and map these locations on the project map. This information are very useful for us to decide where to collect samples from outcrops and wells. We try to spread the distributions of wells and outcrops so it can cover a big area and make the research more precisely and less uncertainty.

Database access and method:

1. Get geological map of Texas and Louisiana from USGS and Texas Natural Resource Information System (TNRIS). Also get Texas and Louisiana county map from USGS. Load them into ArcMap. Select the outcrop within Lower Miocene and out export them to create a new shapefile so we can get a shapefile containing Lower Miocene outcrop distribution.

2. Get the river data from Texas Water Development Board and USGS. Map the river distributions in these two states, especially the Mississippi river which is the main transportation force. The best outcrops are almost always by the valley margins of the major rivers. Through intersecting the main big rivers in Texas and Louisiana with outcrop belts, so we can locate the outcrop place where we can get samples for LM. But later it proved this method didn’t work because the Lower Miocene was absent where rivers across because these places were alluvial deposits. So we can create a new shapefile and draw an area nearby as possible outcrop location.

3. Get wells having whole cores samples from BEG core database for future zircon analysis. The samples in LM under earth surface are essential make zircon analysis and can provide important information. Map them on the project map.

Detailed Procedures

(1) Load the “StratMap_County_poly” shapefile and “State_boundary_LA” shapefile to a blank ArcMap. Save it and give it a new name “project”. The coordinate system is NAD_1983_UTM_14N (Fig. 1). Check each layer before add to this project ArcMap file to make sure the coordinate system is NAD_1983_UTM_14N. If not convert it to NAD_1983_UTM_14N by the ArcToolbox-Data Management Tools-Projections and Transformations – Feature- Project tool in the ArcMap(Fig.2).

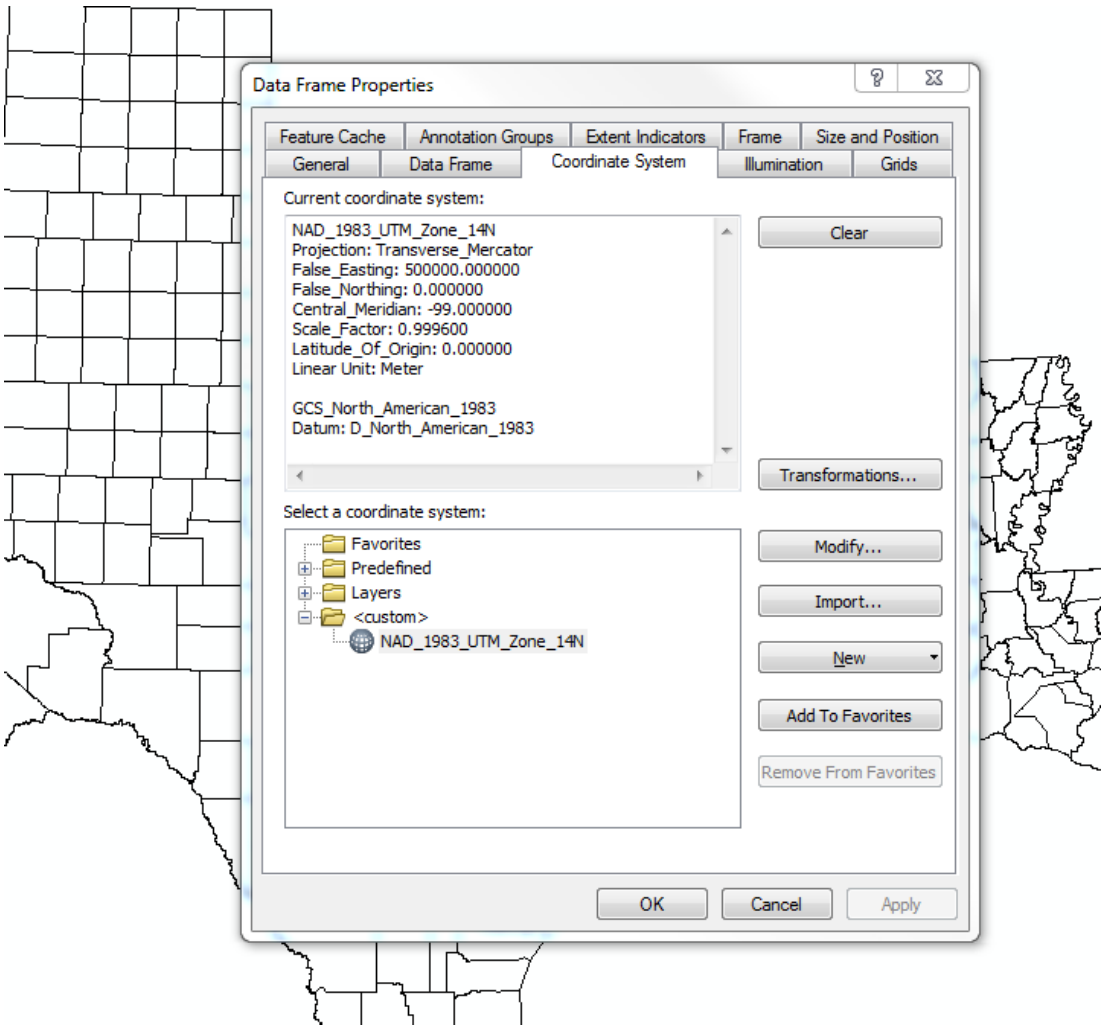

Fig. 1 Spatial reference for this project

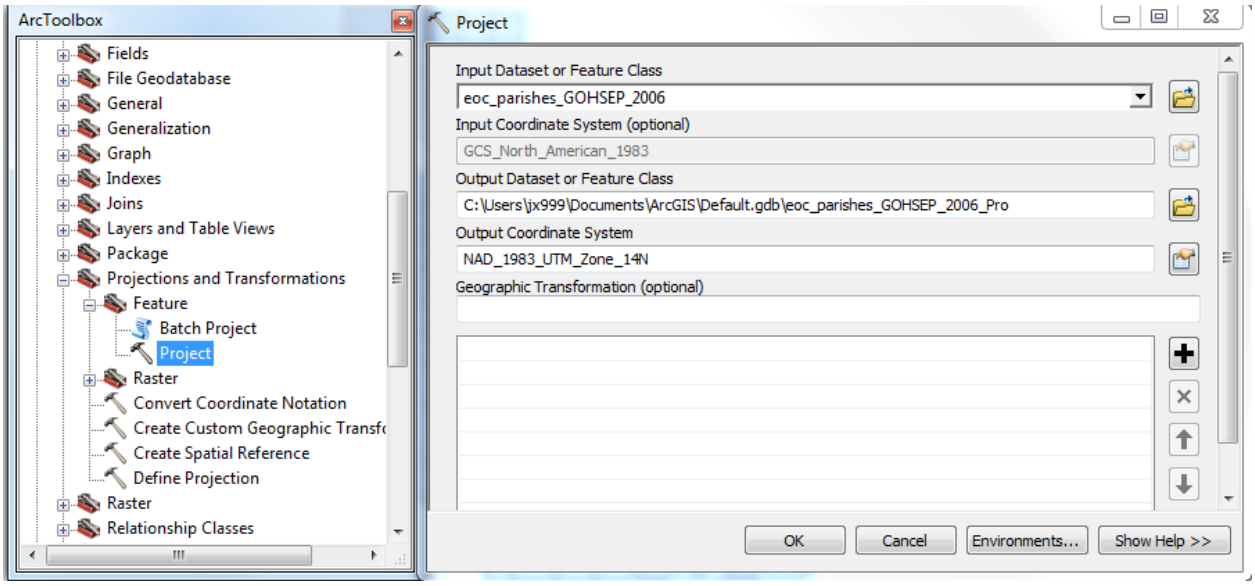

Fig.2 Convert the spatial reference of shapefile to NAD_1983_UTM_14N

(2) Add the downloaded shapefile "geological map of Texas" to this ArcMap. Open the attribute table to find what kinds of information are included in this table. The Unit_Age reveals the information of outcrop age (Table 1). Right click the column of Unit_Age and use "Sort Ascending" to rearrange the data. Then select the data which contains Miocene and will find the outcrop of Miocene age is showed as blue color in the map (Fig. 3).

(3) Export the selected feature in "geological map of Texas" shapefile. Give it a new name, like "Outcrop_belt" and store it in the project file. So we will get a new shapefile contains Miocene outcrop in Texas.

Table 1 Attribute table of geological map of Texas

Table

txgeo_polygon

FID	Shape	AREA	PERIMETER	TXGEOL_DD_	TXGEOL_DD1	ORIG_LABEL	SGMC_LABEL	UNIT_LINK	SOURCE	UNIT_AGE	ROCKTYPE1	ROCKTYPE2
1785	Polygon	0.062993	9.899518	17855	11707	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1912	Polygon	0.001564	0.371029	19122	11084	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1924	Polygon	0.08869	14.09754	19250	9202	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1925	Polygon	0.002291	0.603596	19260	10974	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1927	Polygon	0.000284	0.13636	19273	10196	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1940	Polygon	0.000023	0.022527	19402	10045	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1963	Polygon	0.000109	0.067047	19639	11712	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1970	Polygon	0.014927	1.503728	19703	9216	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1977	Polygon	0.00043	0.261904	19773	11781	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1977	Polygon	0.003776	0.493819	19779	9096	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1987	Polygon	0.007446	1.977172	19880	11102	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1997	Polygon	0.000773	0.387486	19980	11715	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
1999	Polygon	0.00112	0.417911	19993	11684	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
2001	Polygon	0.080612	9.728732	20012	8426	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
2005	Polygon	0.000871	0.337631	20055	11683	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
2010	Polygon	0.007585	2.413002	20105	10079	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone
2019	Polygon	0.003317	0.872624	20197	10201	Mf	Mlf;0	TXMlf;0	TX001	Miocene	clay or mud	sandstone

0 (471 out of 35195 Selected)

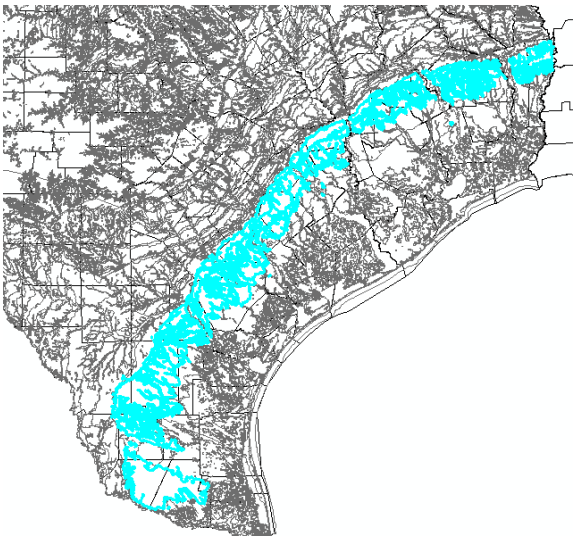

Fig. 3 Outcrop in Texas.

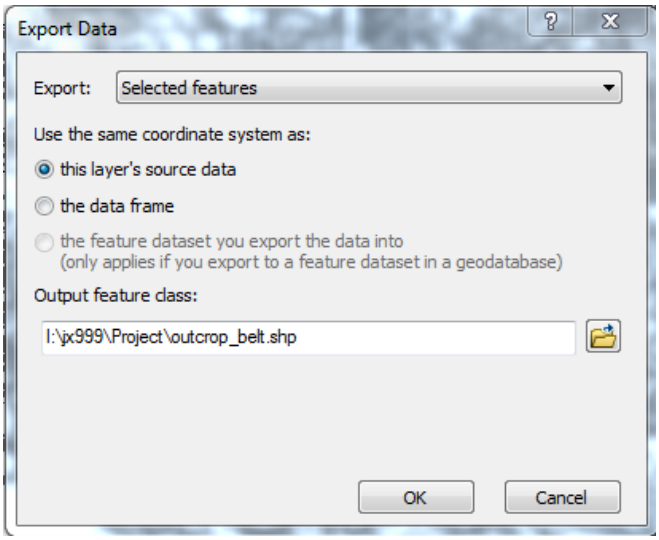

Fig. 4 Export the selected featyre.

(4) Make the layerfile “geological map of Texas” invisible, we only need Miocene outcrop belt. Add the exported file “Outcrop_belt” to this project and highlight it. Do the same process to Louisiana and we finally get the Lower Miocene outcrop belt across Texas and Louisiana (Fig. 5).

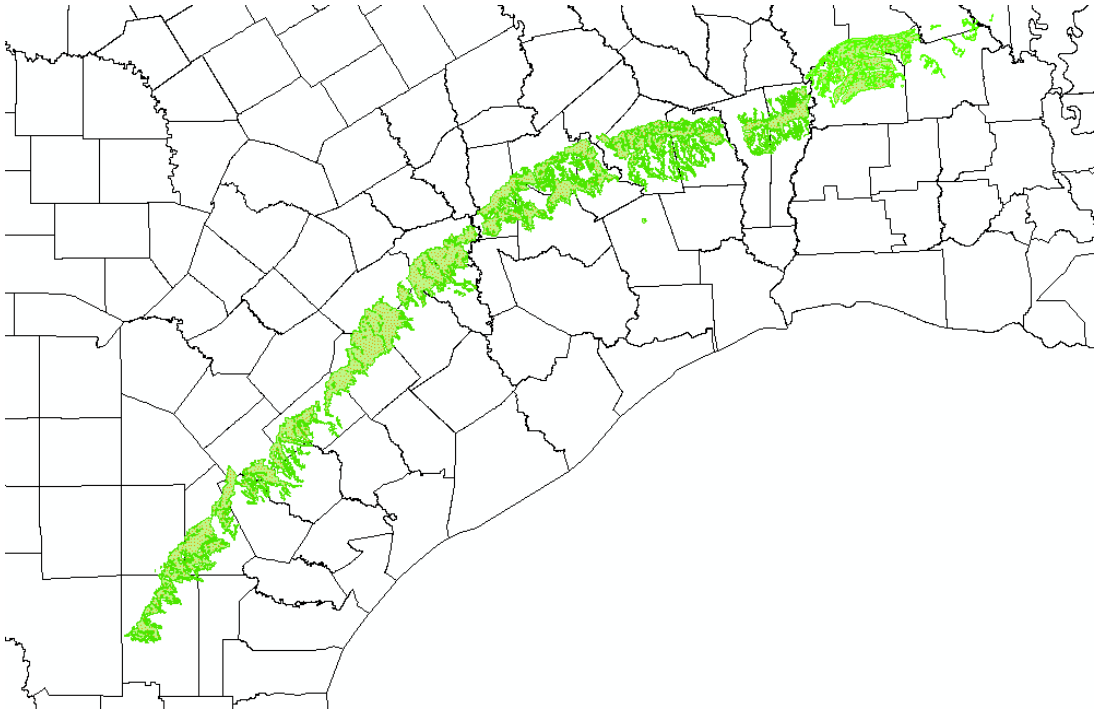

Fig. 5 Outcrop belt distribution in Texas and Louisiana

(5) Add the “Major_Rivers” shapefile to this project and change the river color to blue. So we will get outcrop belt in Texas and Louisiana and major river distribution map in Texas and Louisiana (Fig. 6). The best outcrops are almost always by the valley margins of the major rivers. Through intersecting the major large rivers in TX with outcrop belts, we can locate the outcrop place where we can get samples for Lower Miocene (Fig. 7). Use “select by location” and choose “Target layer(s) features intersect the Source layer feature” so we will get the outcrop locations (Fig. 7). Unfortunately, the polygon for outcrop is big and we can see from fig. 6 that nearly all the outcrops are selected. And actually the river and outcrop nearly didn’t contact each other because the place where they contact is filled by alluvial deposits. So we add the outcrop location where large rive run across this lower Miocene outcrop belt by ourselves.

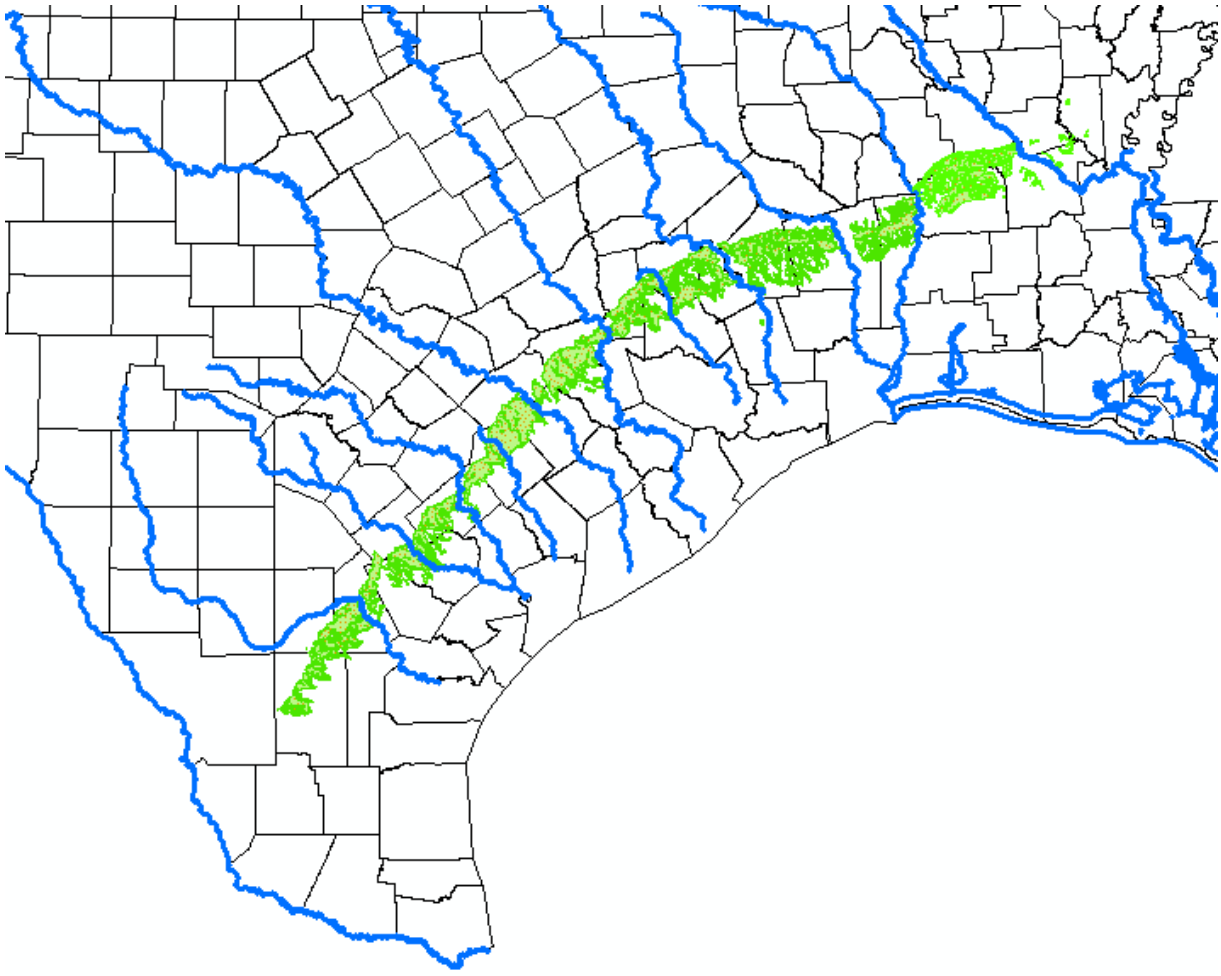

Fig. 6 Distribution map Major rivers and Miocene outcrop belt in Texas.

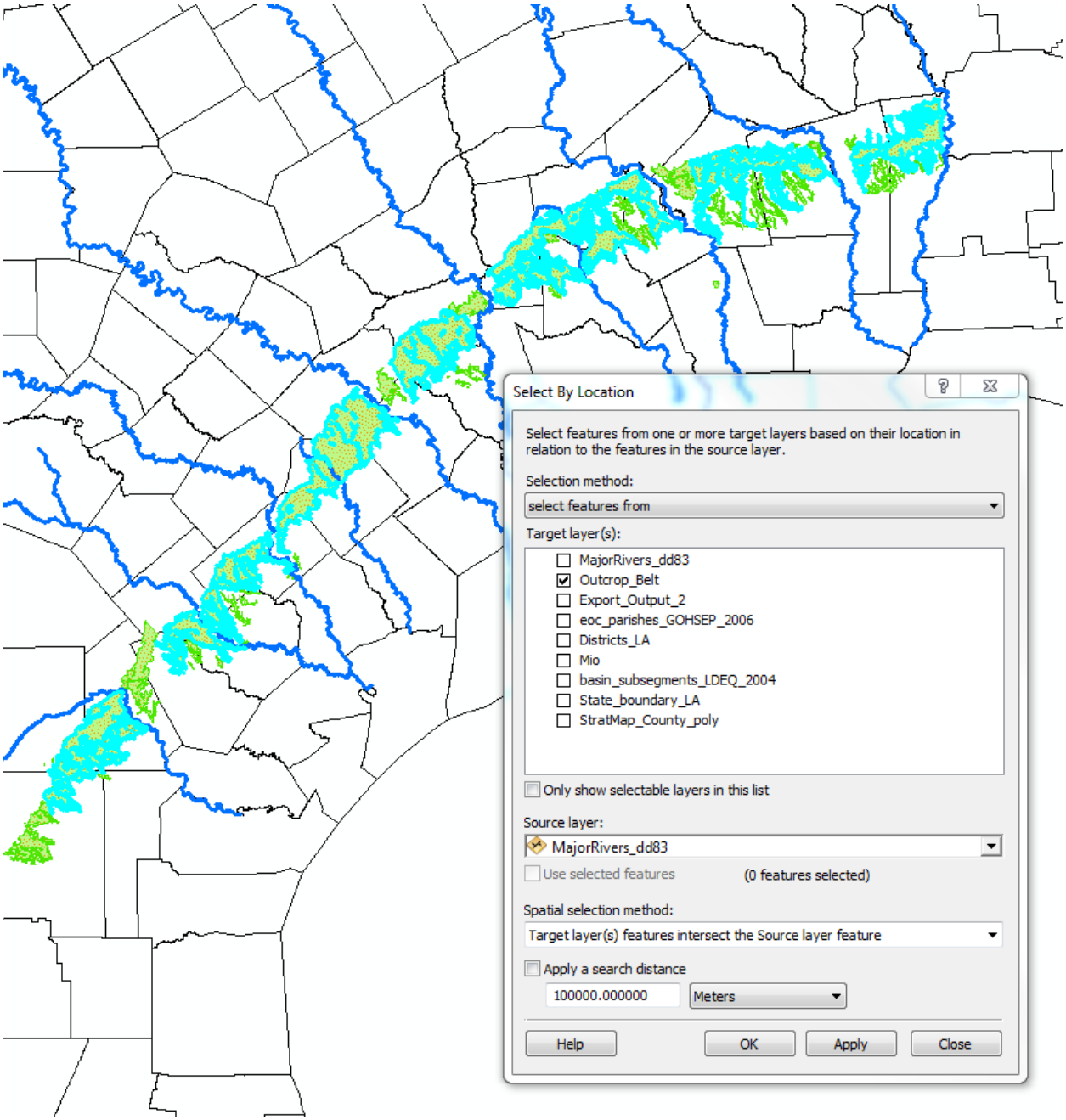

Fig. 7 Map of outcrop intersect with major river in Texas

(6) Create a new shapefile (Fig. 9) and edit it. Before we edit this shapfile, we should make sure all the shapefile in the data frame have the same spatial reference. Then we use polygon tools to draw the outcrop location. After doing this process we finally get the outcrop distribution in Texas and Louisiana (Fig. 10).

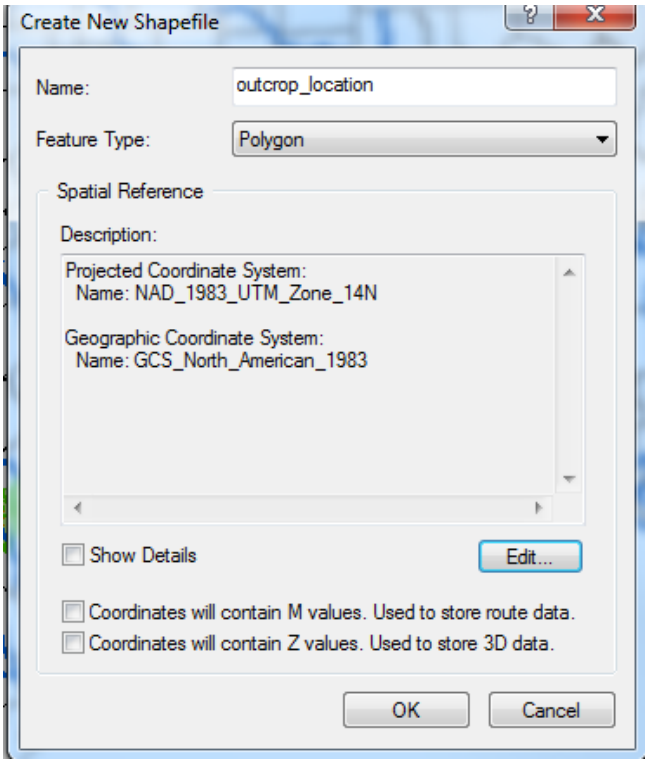

Fig. 9 create a new shapefile

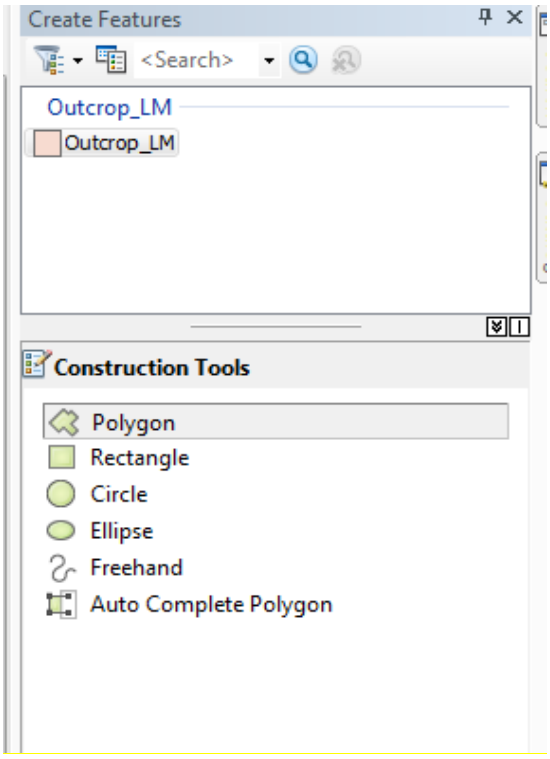

Fig. 10 Draw the outcrop location using polygon tool.

(7) Map the wells having Lower Miocene samples to the project. The wells with longitude and latitude location information are all from BEG core database. Create a point shapefile and edit it and we finally get a well location map (Fig. 10).

(8) Load the Faults shapefile in Texas and Texas, Louisiana and Gulf of Mexico Hillshade into project (Fig. 11). But there are backgrounds (Fig. 12) of no data needed to remove. In this case we change the symbology to make the background of no data invisible (Fig. 13) and then we can get a more concise map (Fig. 14).

(9) Create a new shapefile to make a box to confine the map area (Fig. 15). Use the Analysis tools – Extract- Clip tool to extract data (Fig. 15). This method is effective to extract feature classes but doesn't work for raster file. But we can use "Spatial analyst tools-Extraction-Extract by Mask" tool to extract raster data in a certain range (Fig. 16).

(10)Change to layout view, add scale bar, legend and title for this final project (Fig. 17).

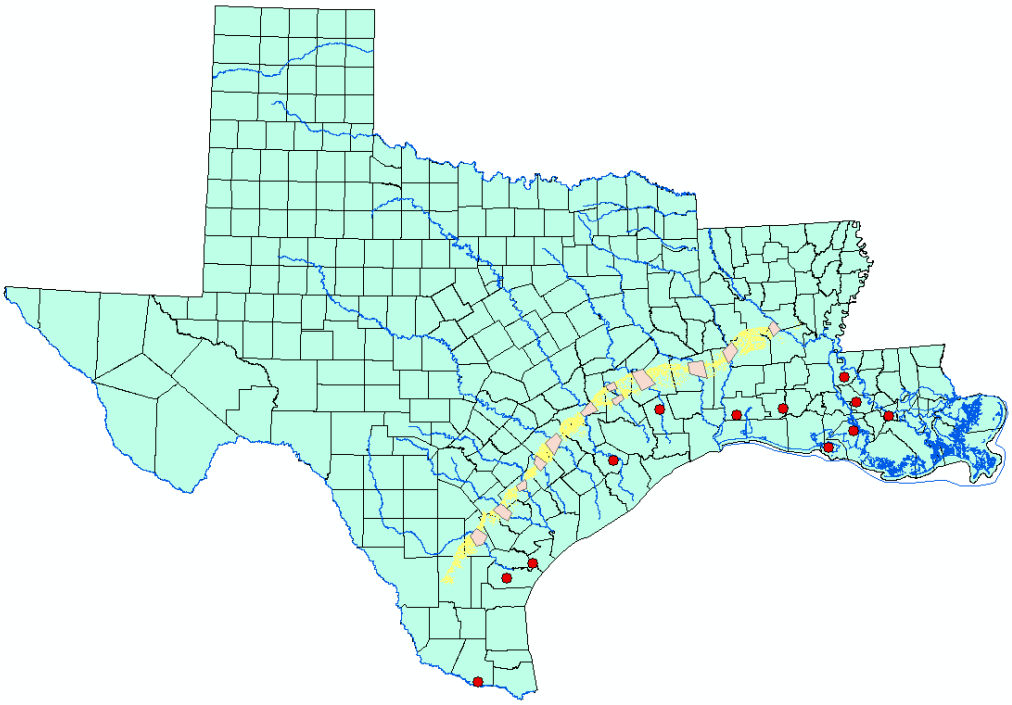

Fig. 11 Outcrops and wells distribution across Texas and Louisiana.

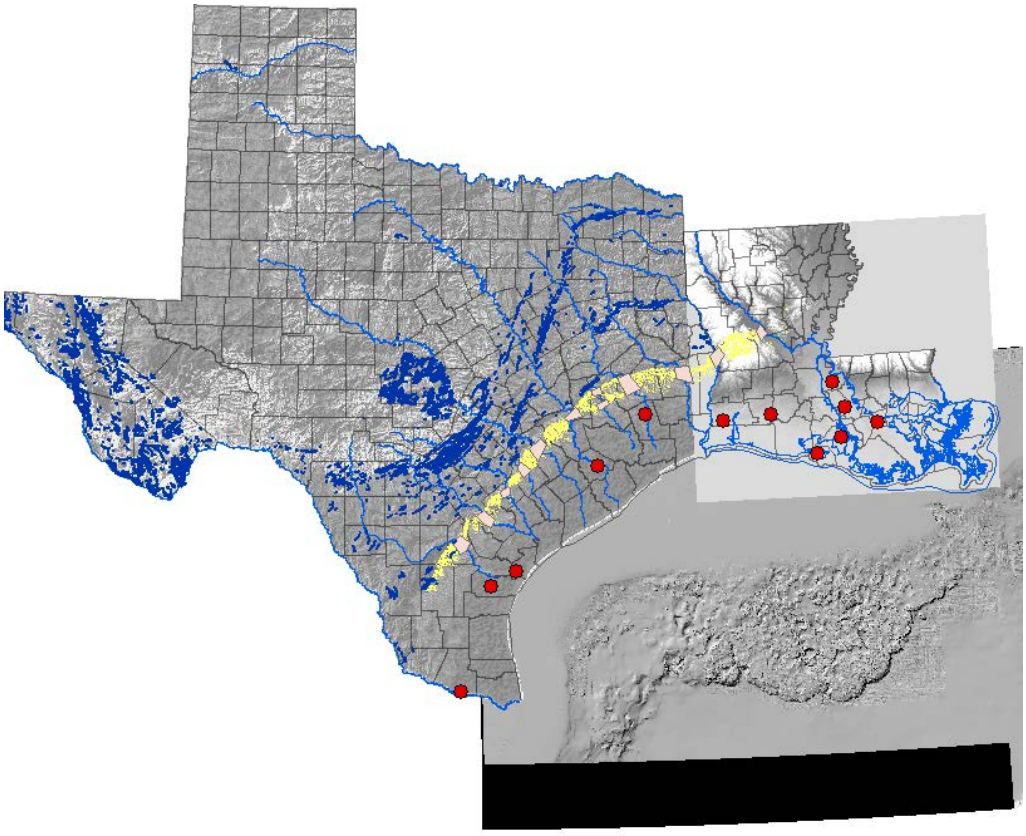

Fig. 12 Outcrops and wells distribution across Texas and Louisiana.

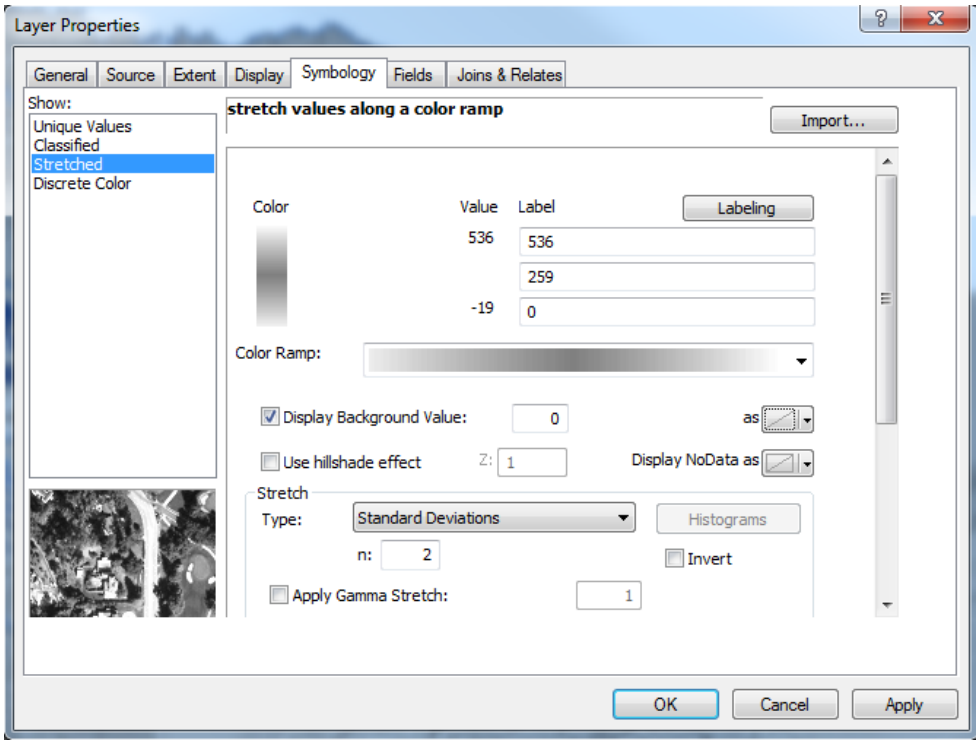

Fig. 13 Make Display background value 0 as no value

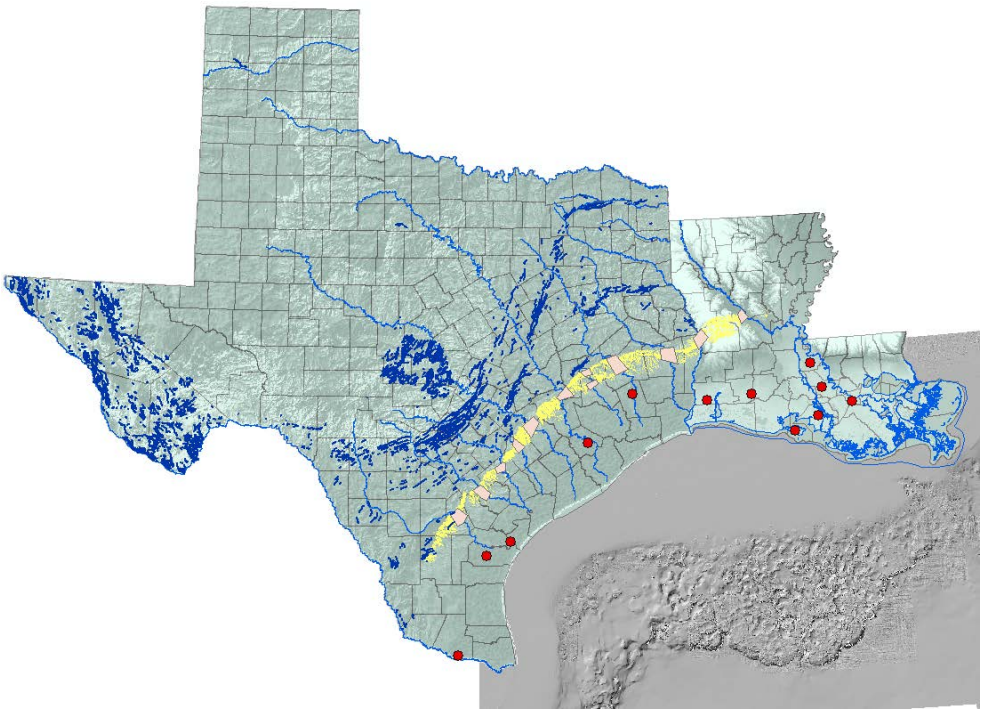

Fig. 14 Make Display background value 0 as no value. Also the county shapefile is made 60 transparent.

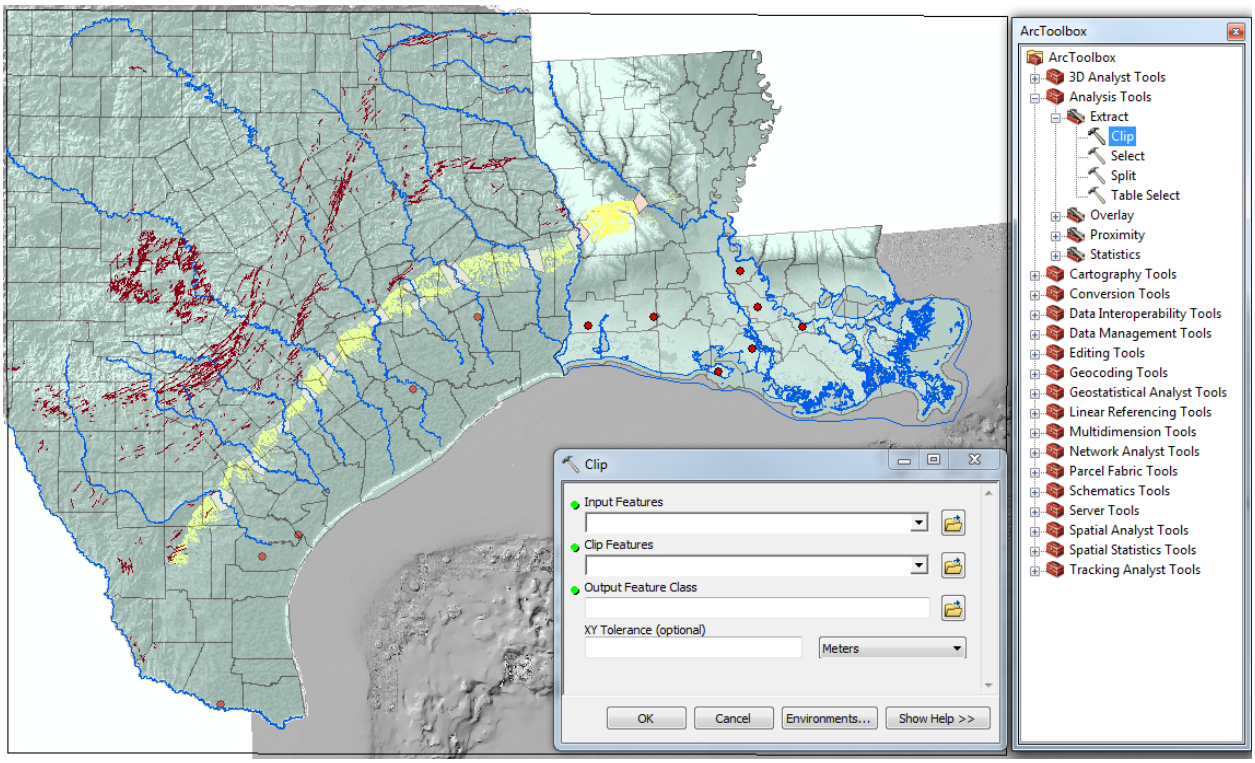

Fig. 15 Create a box for map area and use clip tool and extract map area from project.

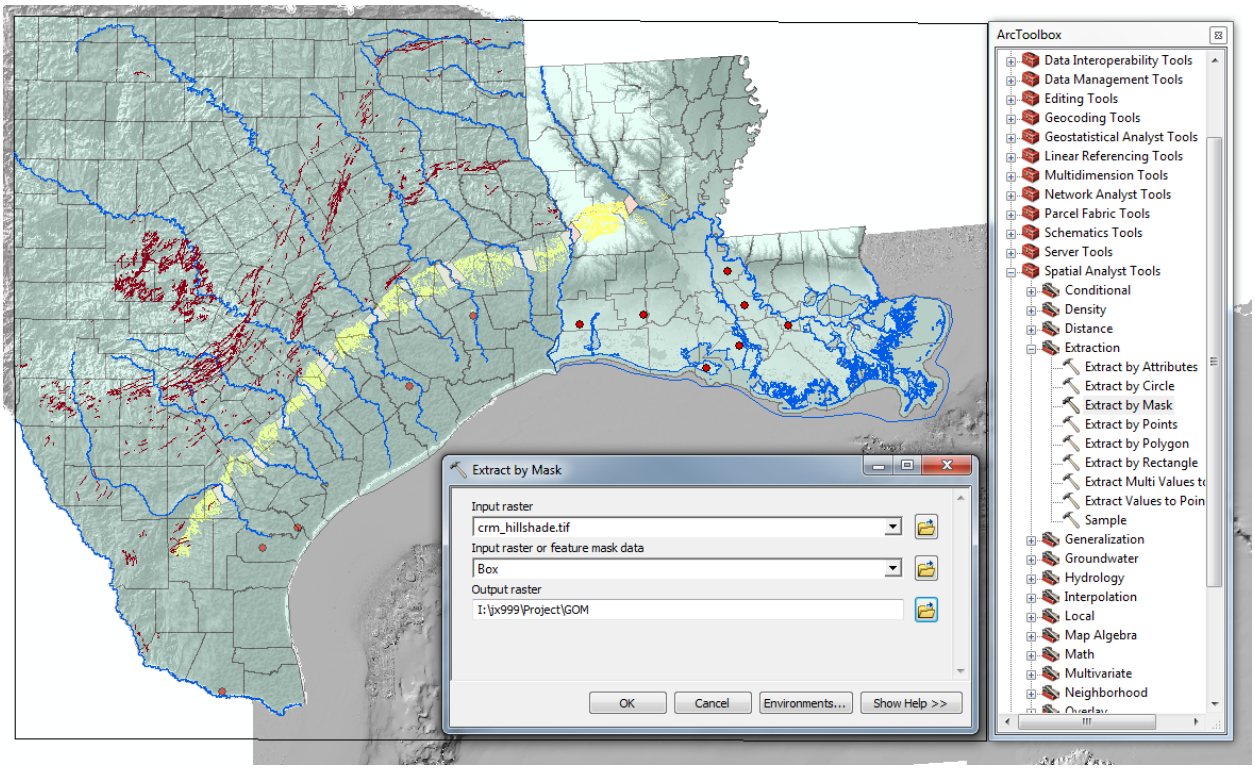

Fig. 16 Use Extract by Mask method

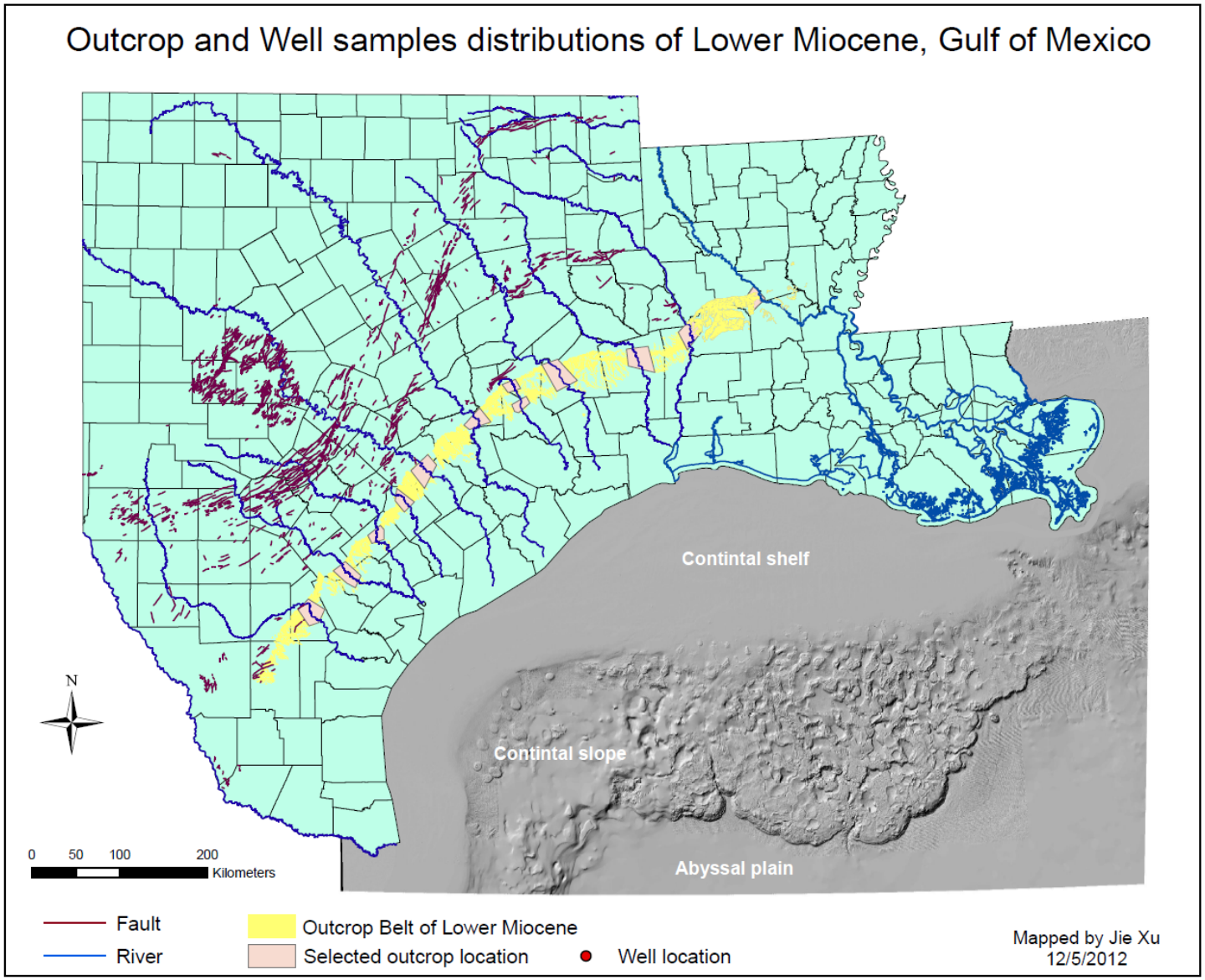

Fig. 17 Outcrop and Well samples distribution of Lower Miocene, Gulf of Mexico