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A STRATIGRAPHIC AND DEPOSITIONAL INTERPRETATION OF A SAND QUARRY IN MIDDLE GEORGIA

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A Stratigraphic and Depositional Interpretation of a Sand Quarry in Middle Georgia

by
Jessica Taylor

A Thesis Submitted in Partial Fulfillment of
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ABSTRACT

Analysis of sediments from two sand quarries in Mauk, Georgia indicate braided stream environment. Sediment samples of both Pleistocene and Cretaceous age were collected, sedimentary features such as trough cross-bedding along with laminar bedding were recorded, and photos were taken to document the scale and stratigraphic sequences of the sediments. Petrified wood was collected throughout the two sand quarries indicating a terrestrial origin. Post-depositional modifications seen at some of sites include load and flame structures. Sediment samples were examined for grain-size distributions and other sediment textures.

INTRODUCTION

In Georgia and the southeastern United States, few studies have been conducted concerning sediments of Cretaceous and Pleistocene age to determine their relevant paleoenvironmental settings. Past studies have mostly resulted in paleoenvironmental interpretations of "terrestrial" or "fluvial." More recent studies have concluded Tuscaloosa and some Pleistocene deposits of southwest Georgia in the Chattahoochee Valley region to be meandering stream in deposition; while, other recent studies have concluded late Quaternary and Cretaceous alluviation further to the east on the southeastern Atlantic Coastal Plain were of braided river origin. The deposits from the sand quarry, which are further east than the previous studies of Marsalias and Friddell (1975) and Frazier (2005), revealed patterns and fossils that indicated a braided stream deposit.

Leigh, Srivastava, and Brook (2004) point out in their study of Pleistocene braided rivers that it is important to understand these implied braided deposits "pronounced differences in sediment and water discharge compared to modern conditions." Recent work by Leigh et al. has focused on southeastern fluvial paleoenvironments of Pleistocene age in an attempt and to determine the paleoclimate of the early to middle Holocene epoch. However, the Leigh et al. studies only deal with Pleistocene braided stream deposits; there are no current studies indicating Cretaceous braided deposits. Several paleontological studies have been conducted in the area. In spite of these paleontological studies, there has not been much recent work on reconstructing past environments of the Cretaceous further to the east of the Chattahoochee Valley, thus showing a clear need for more research in the southeast involving Cretaceous depositional reconstruction.

REGIONAL SETTING

Beginning with the Tuscaloosa Formation, the Upper Cretaceous Series of Georgia formed in a continental basin that derived its sediments from the Piedmont. The Piedmont consists of moderate-to-high-grade metamorphic rocks ranging from schists, amphibolites, gneisses and migmatites to felsic and mafic igneous rocks which formed prior to and during Paleozoic Appalachian orogenesis and subsequent Mesozoic supercontinent breakup. As sea level rose, the landscape changed from a continental basin to a marine basin for most of coastal plain in Georgia. The Tuscaloosa Formation is characterized by crossbedded arkosic, fine to very coarse sands and massive, mottled kaolin clay. Coarsening upward sequences and lensoid sand bodies suggest a braided stream system depositional environment for the Tuscaloosa formation in the study area.

During the Pleistocene, the Southeast’s climate was unstable and experienced several abrupt shifts. Braided stream deposits in Georgia during the early to middle Holocene “probably reflects the response of discharge and sediment yield to generally cooler and drier paleoclimates, which may have had a pronounced runoff season” (Leigh et al, 2004). These sediment and water discharges, which were much higher compared to modern conditions, could have led to the formation of large fluvial deposits such as the Deweyville complex. Bernard first described the Deweyville beds in his 1950 Ph. D. dissertation as terraces underlying the west bank of the Sabine River in southeast Texas, which is characterized by large abandoned meanders that are considerably larger than modern meander scars (Anderson et al., 2008). Later, this unit was classified as allostratigraphic unit that consisted of two- three distinct terraces located along "the modern Trinity, San Jacinto, Nueces, and Pearl River valleys" (Anderson et al., 2008). These Deweyville terraces serve as an analog for the strata discovered in Mauk.

METHODS

Sampling

Figure 1 shows the general location of Mauk, Georgia. A total of five sampling sites were established within two sand quarries that were approximately 1.4 miles apart as seen in figure 2 which shows a closeup of sand quarry locations. Sites one through three were separated by approximately twenty meters and collected in sand quarry 1 as seen in figure 3. Sites four and five were also separated by about twenty meters each and collected in the sand quarry 2, as seen in figure 4. Site four was revisited in August and re-sampled since the area had been hydrologically mined approximately fifteen further back into the outcrop wall. Also, when this site was revisited, the Pleistocene surficials were discovered on top of the Cretaceous sediments. All of the samples were collected and later dried in an oven for grain size analysis.

Grain Size and Microscopic Analysis

Samples were sieved through screens at one-φ intervals between -5.0 to below 4.0 φ in a CSC Scientific Sieve Shaker at a setting of three for fifteen minutes. These sieve results were than used to generate grain-size distribution graphs using Microsoft's Excel™ for analysis of mean sediment load and transportation modes. A microscope was used to characterize average roundness and sphericity of the samples.

RESULTS

Grain Size and Texture Data

Figures 2, 5, and 9 are measured sections, along with their generated grain-size distribution graphs. Grain-size distribution graphs suggest that coarser, sandy sediments tend to be unimodal. Whereas the clayey-sand sediments tend to be bimodal. Both Pleistocene and Cretaceous sand deposits are unimodal. Tuscaloosa sands average a 2.0 ϕ size, whereas the clayey sands have an mean of 2.5 to 3.0 ϕ. Site four's grain-size distribution graphs revealed a coarsening upward sequence; while, sites one, two, and three, which are also Cretaceous, exhibit a trend of no significant chance in the grain size throughout the deposit. Furthermore, the Pleistocene surficials revealed a similar tendency in sorting as sites one, two, and three; even though, the Pleistocene sands have a slightly lower mean phi size of about 1.0.

Microscopic analysis revealed all Cretaceous sediments to be angular to subangular with low sphericity and poor to moderate sorting. Pleistocene deposits also revealed their quartz grains to be angular to subangular in texture with a low sphericity and poor to moderate sorting. The basal conglomerates which consisted of clayey-sand balls were subrounded to rounded in appearance with a low sphericity .Mica was observed in Cretaceous sediments ranging up to five percent and in Pleistocene ones ranging up to two percent samples. No microfossils were seen in either deposits. The average mineral composition of the Upper Cretaceous is 85% quartz, 10% clay, and 5% mica for the sandy deposits; whereas, the clayey sand deposits consist of 75% quartz, 20% clay, and 5% mica. Taking the clayey sand balls into account for the mineral composition, Pleistocene sediments average 88 % quartz, 9% clay, 2 % mica, and 1 % heavy minerals.

STRATIGRAPHIC DESCRIPTIONS

The first three sites were located in sand quarry 1 while site four and five were located approximately 1.4 miles down the road in sand quarry 2 as seen in figure 2. The site locations can be seen in figure 3. Sites one through three's general cross-sections along with observed sedimentary features can be seen in figure 5. Site one consisted of a white sand layer with purple clay lenses below a purple clay layer. Fifteen meters down the cliff wall, site two consisted three layers. Located at the bottom of the deposit was layer one, a thick layer of trough cross-bedding white and pink arkosic sand. Above layer one, layer two is a solid hematite-cemented bed with laminar bedding. Layer three was white sand with no visible layering. Five meters away to the left from the second site is site three, which consisted of trough cross-bedded white and pink arkosic sand. None of these sites showed any difference in grain size.

Site four can be seen in figure 4. Site four consists of six main layers. Figure 6 shows the overall sedimentary features seen at the site along with the general cross-section. Figure 7 shows the exposed unit of site four that consisted of a coarsening upward sequence. The bottommost layer was a repeat of the top most observed layer of white and pink arkosic laminar sand which grade into layer two. Layer two consists of mottled red (10R 4/6) and gray (5BG 7/2) clayey sand. At the mottled clayey sand and arkosic sand boundary, there are more deformation structures including a flame structure. Figure 8 shows the deformation features. Layer three is above the soft sediment deformation and consists of 5BG 7/2 clayey sand layer with weathered orange (10YR 6/6) balls. If you scratch away the weathered surface, you see purple (5RP 4/2) clayey sand. Layer four is a 5RP 4/2 clayey sand layer interbedded with 5BG 7/2 clayey sand balls. Layer five is a trough cross-bedded 5Y 8/1 arkosic sand. The top most deposit (layer six) consists of laminar bedded white and pink arkosic sand which was about 6.2 feet thick. This sequence of sediments shows a coursing upward.

Figure 9 marks the contact between the Cretaceous deposits and the Pleistocene surficials. The overlying Pleistocene and underlying Cretaceous deposit is denoted by a sharp and erosional boundary which is unconformable. This unconformity shows a well-developed basal conglomerate which is composed of clayey sand clasts similar in texture and color to the underlying Cretaceous clayey sand deposits. There is also an abrupt change from trough cross-bedded, lite arkosic, medium sand to coarser, darker stained arkosic, laminar bedded sand.

The site location can be seen in figure 4. Site five includes these Pleistocene surficials sediments perched on top of Cretaceous trough cross-bedded sands. Figure 10 shows a close-up of the collection site six. Figure 11 shows the general cross-section with generated grain-size distribution charts. The Pleistocene deposit also shows a non-fining sequence similar to the Cretaceous sediments; however, they consist of coarser sand deposits (gravelly sands) with clay balls ranging from a few centimeters up to about fifteen cm in size. One single clay ball with one of sieving samples which was measured at eight cm. The overall pattern of the sediment is laminar beneath slight trough cross-bedding below more laminar bedding. This exposed unit shows no difference in grain size throughout its generated grain-size distribution charts.

FOSSILS

Through the years at the sand quarry, the miners have mined several pieces of petrified wood that they let collect at the front door of their main office as seen in figure twelve. This fossilized wood was preserved by silicification. Many of these fossils are very heavy and hard to move. Miners once ran across a solid 20 foot log of petrified wood which much to their dismay they had to break up to move it out of the way to continue hydrologically mining. There were no other macrofossils observed.

DISCUSSION

Based on the fossils and the mottled green and red to purplish-red clayey sand layers, often a sign of plant rooting, I interpret these exposed units to have formed in a terrestrial environment. The results revealed many features of a braided stream environment. Braided stream deposits tend to be unimodal. Grain-size distribution analysis indicates sandy units to be unimodal; whereas, the clayey sands were bimodal likely indicating a in-situ chemical weathering of feldspar sand grains to clay. These sands may have been askosic in origin because of their high percent of feldspar, varying range of quartz which is higher than 75 percent, and reddish or gray hue. When coupled with evidence of the deformation structures, it is highly probable that the feldspar sand grains present along with quartz and other detrital minerals were derived from the weathering of a granitic or gneissic source terrain from the north. This results in a quartz wacke with a kaolinitic clay matrix. Microscope analysis revealed the grains to be angular to subangular with moderate to poor sorting which is commonly a feature of braided rivers. However, it could be a textural attributes resulting from the source-terrain geology and distance of transportation. A coarsing upward sequence along with non-fining sequences, trough cross-bedding, and laminar bedding are all features indicative of a braided stream deposit. Figure 13 shows more of the observed trough crossing-bedding seen throughout the two quarry sites. There were no fining upward sequences recorded during the study, which is one of the main indications of a meandering stream deposit.

These Cretaceous units show many similarities to the Tuscaloosa Formation. Eargle (1955) documented the Tuscaloosa throughout Georgia from Muscogee County to Geneva, Georgia, approximately eight miles from the study area. Eargle (1955) documented the site at Geneva as having: "sand, coarse, crossbedded; contains small clay balls or pebbles" on top of a ferruginous sand (p. 18). Farther down the site he describes "clay and clayey sand, gray mottled with drab red and purplish red" (p. 19). Overall, the Tuscaloosa Formation is known for its trough and planar crossbedding in arkosic sands overlain by thick layers of mottled clay and silt which were seen throughout the sites.

Pleistocene surficials found in the study site are similar to those studied by Leigh and others (2004), who indicate that Oconee and Altamahama River sediments "are unequivocal examples of braided channel patterns" and "closely resemble late Pleistocene braided terraces described in the lower Mississippi River valley." Sediment at their site tended to be "medium to coarse sand; whereas, paleochannels contain[ed] 1.0-1.5 thick clayey soils unconformably overlying sands and fine gravelly sand" indicating a bar-sequence. Pleistocene surficials at site five consisted of gravelly sands interbedded with clayey sand balls that were probably eroded from a previous deposit as the braid bar migrates which is a common feature in braided stream deposits.

The deposits of braided rivers depend highly on their flow conditions and sediment load. Usually braided systems have highly variable flow condition with high discharges during one season leading to gravel- or sand-dominated sedimentation with significantly lower discharges during another season leading to subordinate muds. Braided stream deposits tend to display little or no pattern to their vertical facies change in grain-size unless the braid is migrating which can led to a coarsening or fining upward sequences based on the direction of the migration in relation to the floodplain. Overall, samples did not show vertical changes in grain size, except for site four which shows coarsening upward, suggestive of a braided stream toward the center of the stream and away for the overbank muds.

CONCLUSIONS

My sediment samples had a strong similarlies to local work on Pleistocene and Cretaceous sediments, specifically the Tuscaloosa formation. The macrofossils found on site indicate a terrestrial environment. Their sediment source was Piedmont crystalline rocks which traveled downstream then lost momentum as the slope of the land became more gradual thus most likely changing the river into a braided stream based on sediment analysis, abundant sediment found within the sand quarries, and structural features of the strata. Post-depositional modifications caused in-situ weathering of weatherable minerals, an increase in clay-sized particles, deformation of boundaries between layers, and secondary sedimentary features such as the flame structure which were seen clearly at site four.

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Figure 1: Location Map showing Junction City, GA. Map generated with mapquest.

Figure 2: Location Map showing quarry sites 1 and 2 labeled within a black box by white arrows and text. Map generated with mapquest.

Figure 3: Location Map of quarry 1with sites 1, 2, and 3 labeled within a black box by white arrows and text. Map generated with mapquest.

Figure 4: Location Map of quarry 2 with sites 4 and 5 labeled within a black box by white arrows and text. Map generated with mapquest .

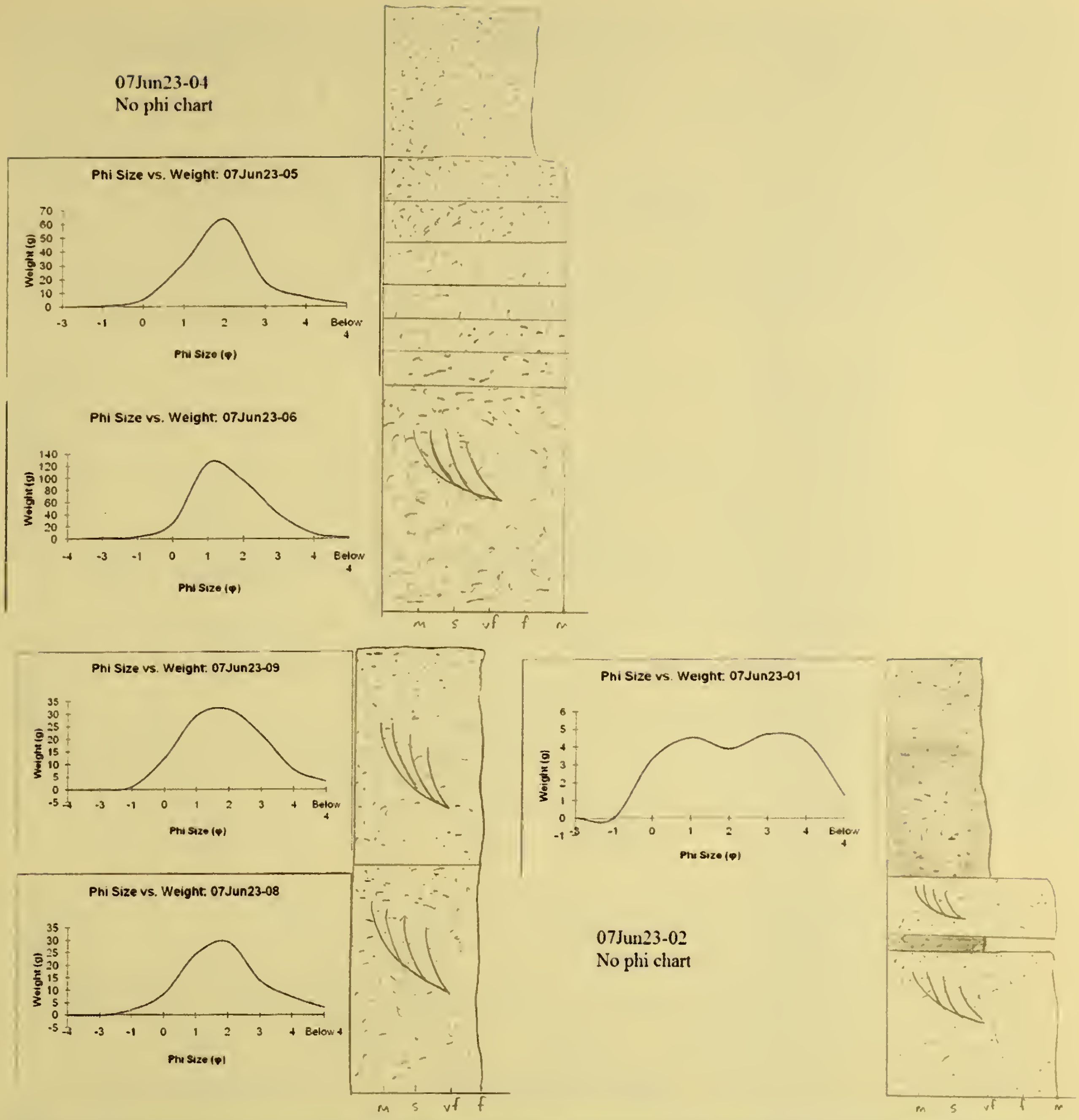

Figure 5: Generalized cross-sections for sites one through three with their grain-size distribution graphs

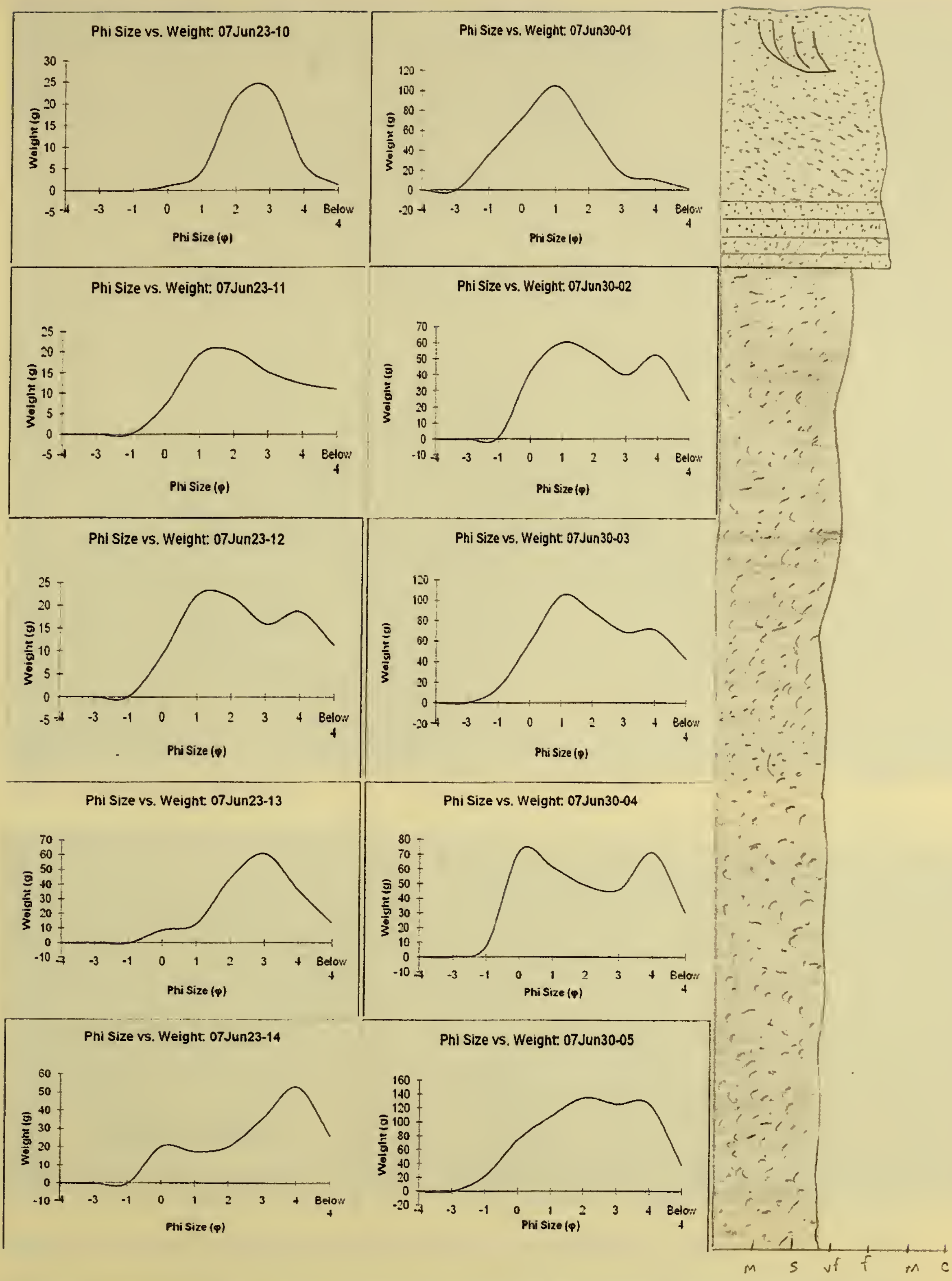

Figure 6: Generalized cross-section for collection site four with grain-size distribution graphs

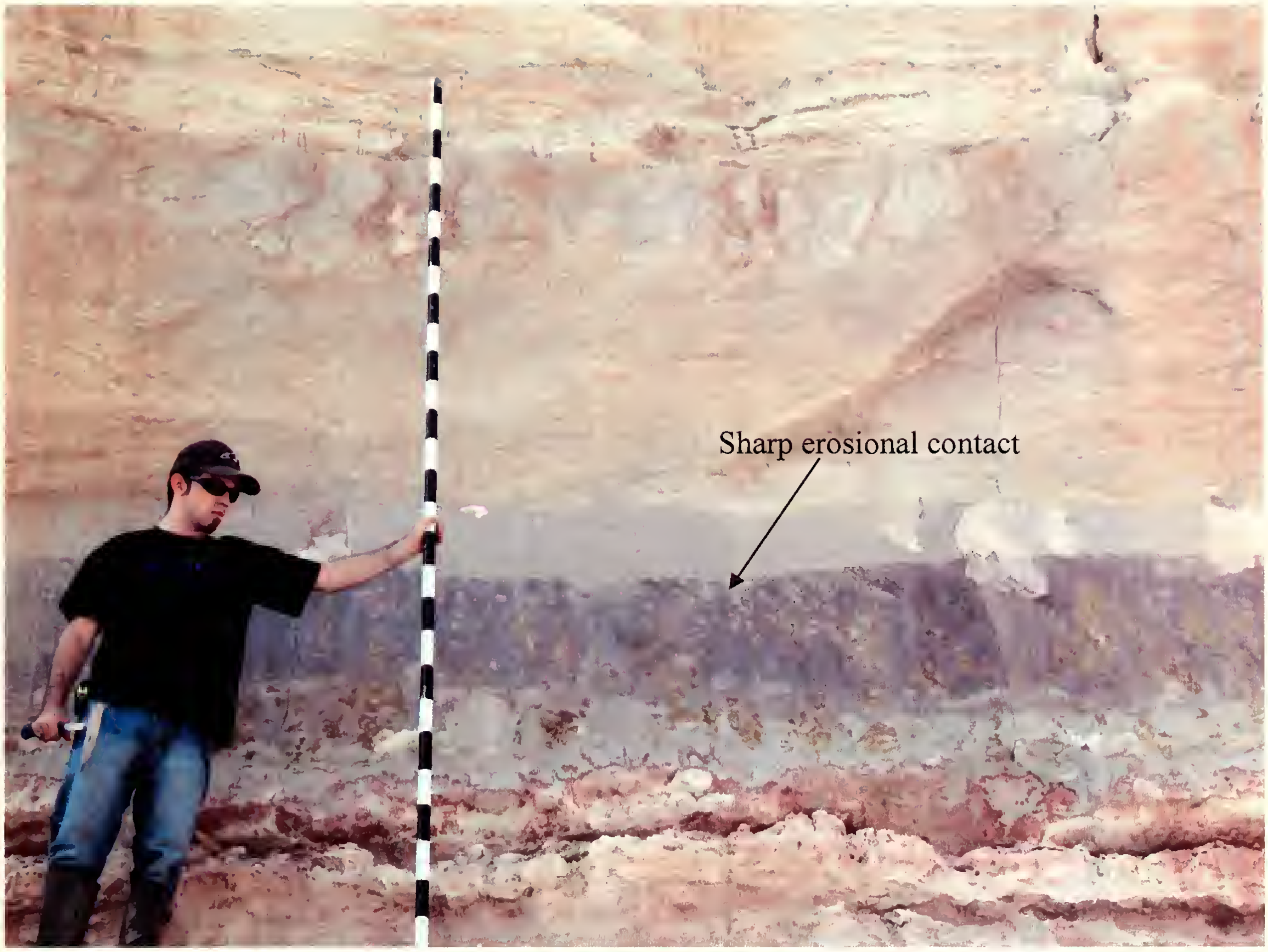

Figure 7: Location of site four.

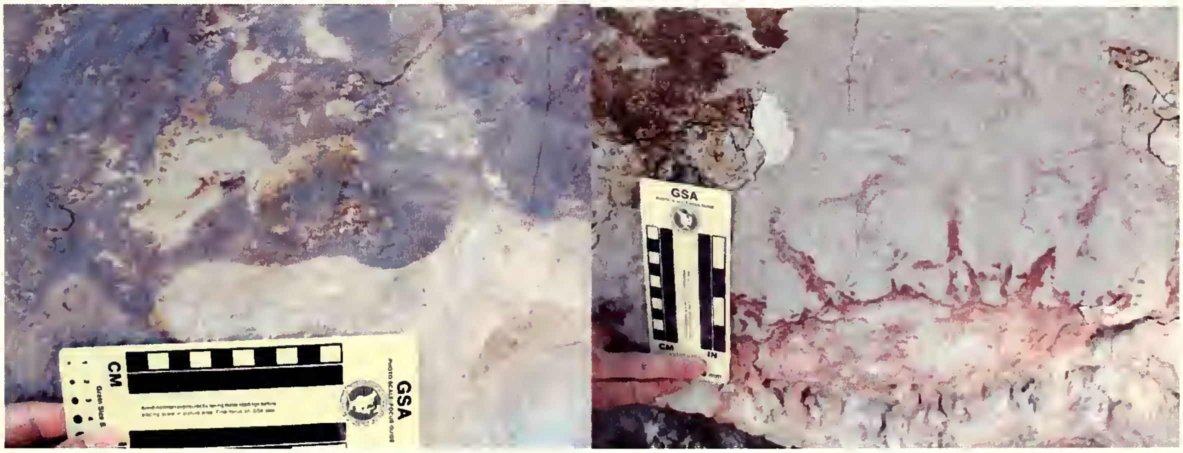

Figure 8: Close-up of deformation structures observed at collection site four.

Figure 9: Pleistocene surficials on top of Cretaceous trough cross-bedding marked by basal conglomerate

Figure 10: Close-up of Pleistocene Deposits found August 25, 2007.

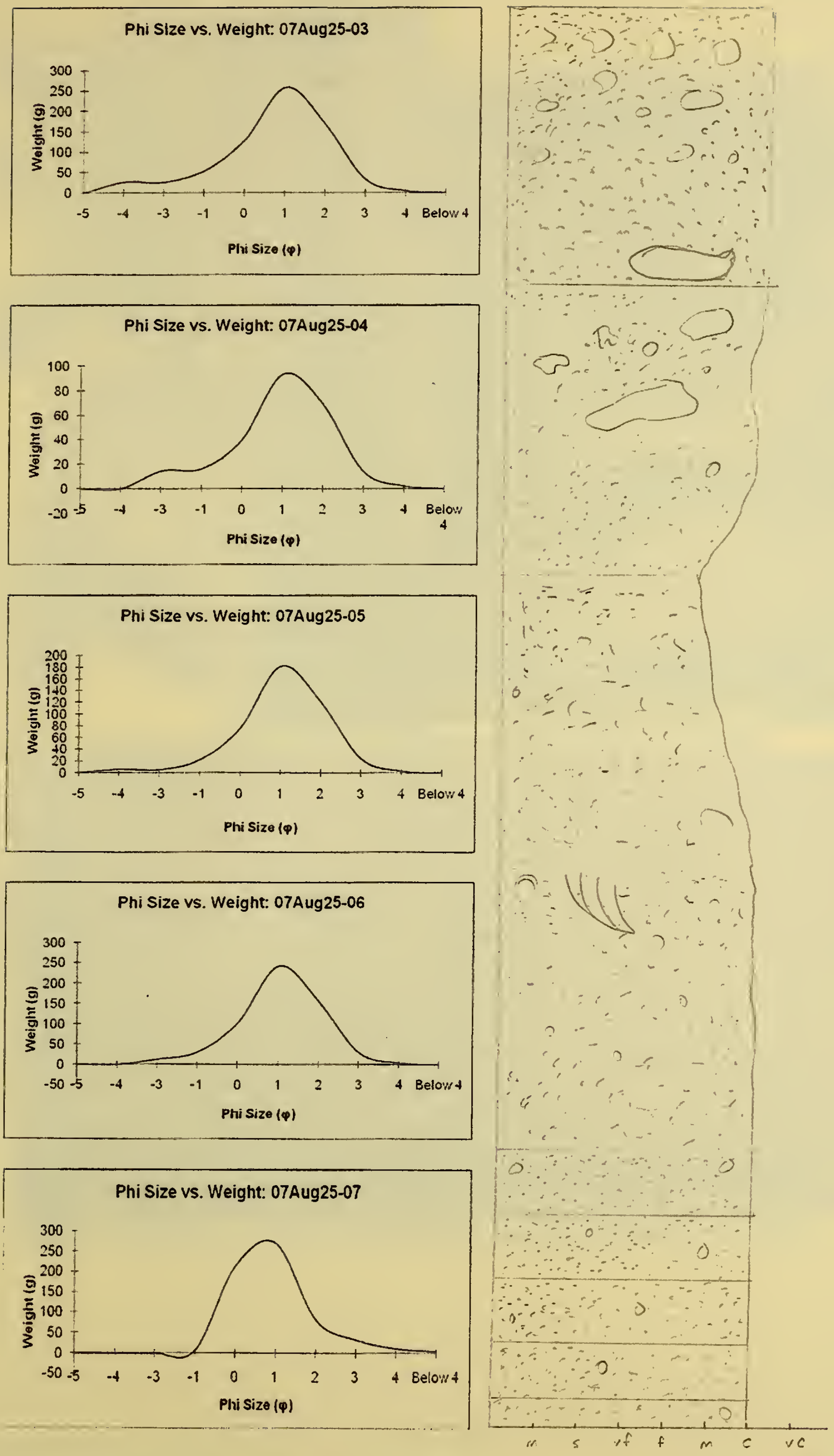

Figure 11: Generalized cross-section for site 5 with grain-size distribution graphs.

Figure 12: Pictures of the collected petrified wood provided by Dr. Frazier.

Figure 13: Common trough cross-bedding seen throughout both sand quarries.