

Drone Imaging of Active Sand and Gravel Quarries to Optimize Exploration and Mining

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Introduction

Sand and gravel mining is a major industry in southwestern Tennessee, northwestern Mississippi, and eastern Arkansas (Fig. 1). The principal sand and gravel target in this tri-state region is the ancestral Mississippi River sediments that underlies the higher elevations (uplands), that is, those areas exclusive of the low lying Mississippi River floodplain and its tributaries' (e.g. Wolf River) floodplains (Fig. 2) (Van Arsdale et al., 2007; Cupples and Van Arsdale, 2014; Cox et al., 2014). Approximately 3.1 million years ago (Van Arsdale et al., 2014) the Mississippi River system flowed at an elevation 70 meters higher than today (Fig. 3) and deposited its river floodplain sand and gravel over a huge area of the ancient Mississippi River valley (Lumsden et al., 2016). During the multiple ice ages of the past 3 million years, sea level declined as much as 140 m and the Mississippi River and its tributaries entrenched, thereby eroding away much of its former floodplain sediment (Fig. 3) (Van Arsdale et al., 2007; Cupples and Van Arsdale, 2014). The study of the ancestral Mississippi River is of great geologic importance to understanding the transitional period from pre-glacial (Pliocene) time to glacial (Pleistocene) time; one of the major climatic changes in Earth history. A second scientific reason to better understand the geometry and distribution of the erosional remnant of the Upland

Complex (name given to this ancient Mississippi River floodplain sand and gravel unit) is to determine whether or not the Upland Complex strata has been displaced by faulting. If it has been displaced by fault movement then the faulting is considered young enough to be a seismic threat. The connection here is that sudden movement on faults causes earthquakes. We bring this geologic history to your attention to point out that there are basic Earth science and earthquake hazards reasons to conduct further studies on these ancient sediments. However, the principal objective of this proposal is economic.

In this research we will focus on the very important economic reasons to study these ancient floodplain sediments. The Upland Complex is the principal source of sand and gravel (aggregate) in the tri-state region and these materials are essential ingredients in road base, fill material, Portland cement concrete, and hot mix asphalt (Van Arsdale et al., 2012). The Memphis metropolitan area demands over 12 million tons of aggregate each year. Construction aggregate is a high-unit-weight, high-volume commodity that trades at a low unit cost. Its proximity to market is critical as a result of high costs of transportation. This is why most of the nation's counties have some type of local aggregate operation (Fig. 4). A local source of high quality aggregate results in lower costs for construction and also reduces air pollution, fuel consumption, degradation of roads, and vehicular accident rates (Van Arsdale et al., 2012).

Most sand and gravel mined for the Memphis aggregate market are conducted as open pit surface quarries. Sand and gravel mined for construction aggregate is approximately 40% gravel, 55% sand, and 5% silt and clay. The sand is predominantly red (iron oxide) stained quartz grains with minor amounts of red stained chert grains. The gravel is predominantly red stained chert with minor amounts of clear or milky quartz and quartzite (Lumsden et al., 2016).

The average gravel particle size is less than 2.5 cm and individual clasts are up to 30 cm in diameter. Principal operations during the life span of a quarry include; 1) stripping of surface wind-blown silt called loess that is typically 4.5 to 7.6 meters thick, 2) mining of underlying sand and gravel that is usually 4.5 to 9.1 meters thick, 3) separating sand and gravel into size fractions for markets, 4) market distribution of sand and gravel, and 5) reclaiming the quarry site by backfilling and landscaping for sale and subsequent residential, commercial, and industrial development. Most of the site reclamation occurs during mining with waste from an active portion of the quarry placed in the previously mined portion of the quarry. Sand and gravel deposits are thin in the Shelby County area and are mined within a relatively short period of time. For example, a 10-ha (25 acre) deposit may be depleted in one year. This creates extraordinary pressure to locate, permit, and develop projects ahead of demand (Van Arsdale et al., 2012).