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# Engineering geologic and geotechnical analysis of paleoseismic shaking using liquefaction effects: field examples

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**Abstract**

The greatest impediments to the widespread acceptance of back-calculated ground motion characteristics from paleoliquefaction studies typically stem from three uncertainties: (1) the significance of changes in the geotechnical properties of post-liquefied sediments (e.g., "aging" and density changes), (2) the selection of appropriate geotechnical soil indices from individual paleoliquefaction sites, and (3) the methodology for integration of back-calculated results of strength of shaking from individual paleoliquefaction sites into a regional assessment of paleoseismic strength of shaking. Presented herein are two case studies that illustrate the methods outlined by Olson et al. [Engineering Geology, this issue] for addressing these uncertainties.

The first case study is for a site near Memphis, Tennessee, wherein cone penetration test data from side-by-side locations, one of liquefaction and the other of no liquefaction, are used to readily discern that the influence of post-liquefaction ã agingã and density changes on the measured in situ soil indices is minimal. In the second case study, 12 sites that are at scattered locations in the Wabash Valley and that exhibit paleoliquefaction features are analyzed. The features are first provisionally attributed to the Vincennes Earthquake, which occurred around 6100 years BP, and are used to illustrate our proposed approach for selecting representative soil indices of the liquefied sediments. These indices are used in back-calculating the strength of shaking at the individual sites, the results from which are then incorporated into a regional assessment of the moment magnitude, **M**, of the Vincennes Earthquake. The regional assessment validated the provisional assumption that the paleoliquefaction features at the scattered sites were induced by the Vincennes Earthquake, in the main, which was determined to have **M** ~ 7.5. The uncertainties and assumptions used in the assessment are discussed in detail.


*Keywords:* Paleoliquefaction; Paleoseismic; Liquefaction; Earthquake; Wabash Valley; New Madrid

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**Contents**



## 1. Introduction

The study of paleoliquefaction effects to assess the characteristics of prehistoric earthquakes is gaining an increasingly prominent role in evaluating seismic hazard, especially in regions that experience infrequent earthquakes. However, questions remain regarding the use of geotechnical data for paleoearthquake investigations because of the uncertain influence of changes in the geotechnical properties after the sediments have liquefied (e.g., aging and density changes), and additionally, questions remain regarding uncertainties in how to implement existing analytical procedures for performing the back-calculations and how to interpret the results. In a companion paper (Olson et al., 2004), the authors propose new methods for analyzing and interpreting paleoliquefaction manifestations, which should reduce the uncertainties in the back-calculated earthquake parameters. The focus of the present paper is to detail two case studies that illustrate those proposed methods. The case studies are associated with paleoearthquakes in the New Madrid and Wabash Valley Seismic Zones (Fig. 1).

The first case study in this paper illustrates the authors' recommended approach (Olson et al., 2004)