TWENTY SEVENTH ANNUAL HIGHWAY GEOLOGY SYMPOSIUM

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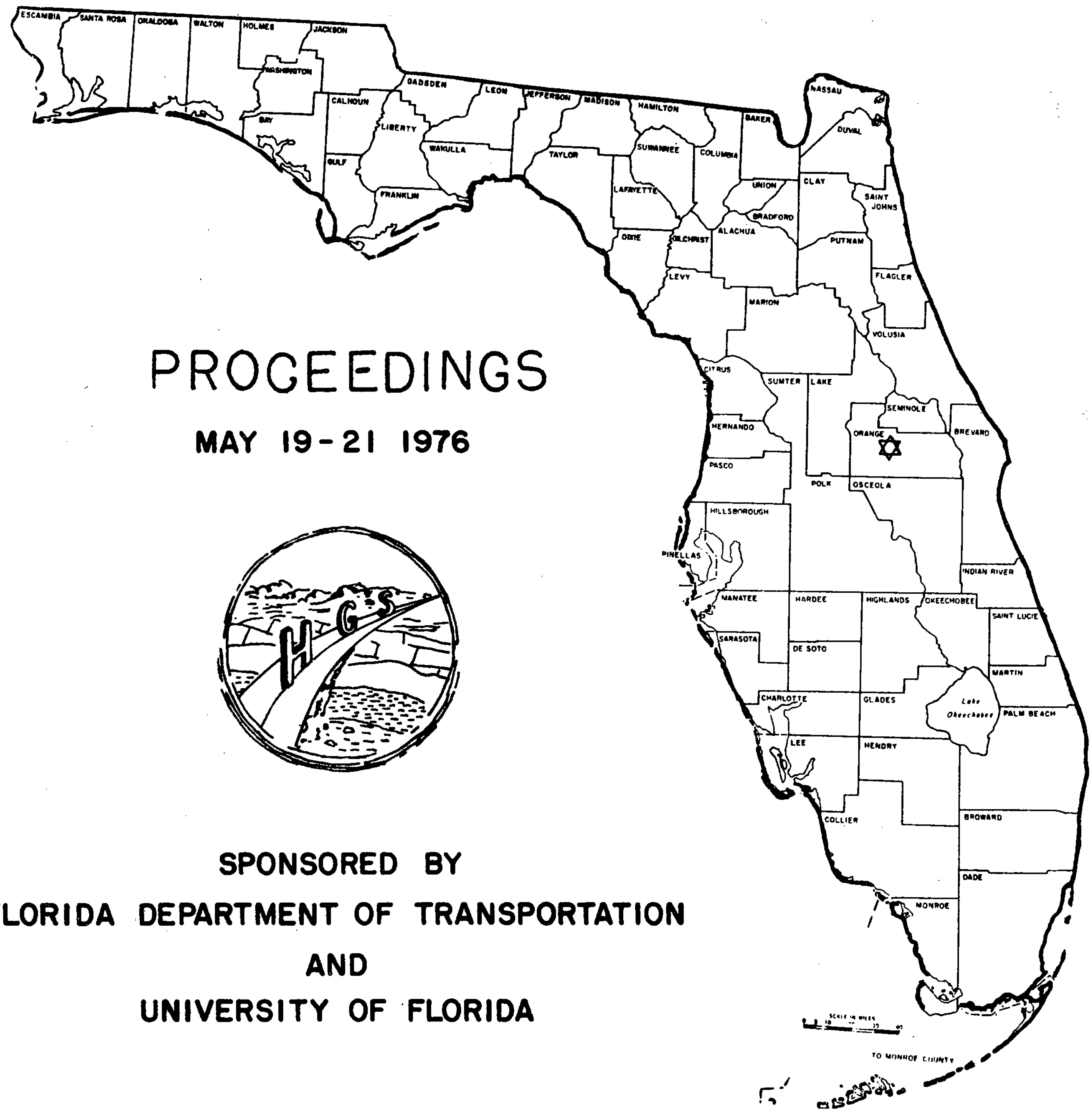

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Miami, Florida------------------------------------Flowers

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Brainard-Kilman Drill Company
Tucker, Georgia-----------------------------------Bar

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FLORIDA DEPARTMENT OF TRANSPORTATION

FLORIDA GEOLOGY & SINKHOLES

William A. Wisner, Jr.

Florida Department of Transportation

A brief slide presentation giving Symposium participants a general view of Florida Geology and solution related problems in the State.

There is no Report.

CIRRICULUM VITAE

WILLIAM A. WISNER, JR.

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1958-1960 - Construction Industry, Central Florida
1960-1962 - Construction Superintendent, Cone Brothers Contracting Co., Tampa, Florida
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Presently Head of Engineering Geology & Soils Testing Laboratories.

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SUBSURFACE CAVITY DETECTION:
FIELD EVALUATION OF RADAR, GRAVITY AND
EARTH RESISTIVITY METHODS

BY

Lewis S. Fountain
Senior Research Engineer
Southwest Research Institute

San Antonio, Texas

SUBSURFACE CAVITY DETECTION: FIELD EVALUATION OF RADAR, GRAVITY, AND EARTH RESISTIVITY METHODS

By

Lewis S. Fountain
Senior Research Engineer
Southwest Research Institute
San Antonio, Texas

ABSTRACT

Gravity, ground-penetrating radar, and earth resistivity profiling were experimentally evaluated and compared as subsurface cavity detection methods. Tests were conducted in three different geological environments.

Verification tests showed that gravity measurements located large cavernous areas but did not detect mud-filled troughs; radar detected air-filled cavities at maximum depths of 4.6 metres (15 ft.) at one site, only penetrated three (3) metres (10 ft.) with inconclusive results at a second site, and could not resolve 0.6-metre (2-ft.) diameter vertical cylindrical cavities at another. Earth resistivity measurements using a pole-dipole electrode arrangement located cavities at all sites, indicating targets at depths of 24.4 metres (80 ft.). Both air-filled cavities, including vertical cylinders, and mud-filled troughs were detected using the resistivity technique, giving accurate depth and size resolution. A large mud-filled trough was detected at a 9.1-metre (30-ft.) depth that extended below 30.5 metres (100 ft.).

The earth resistivity technique was judged to be the most successful and practical underground cavity detection method in the environments tested. It was also found to be capable of delineating the irregularities of the bedrock at the soil-rock interface.

1. INTRODUCTION

Sudden collapse or subsidence above unknown cavities, results in extensive damage and property loss; and corrective action costs are very high and not always positive cures. This is a very serious problem in the construction and maintenance of highways and railroads. The public costs for damages, property losses and accidents would be greatly reduced if subsurface earth structural conditions along transportation routes and at building construction sites were known prior to final planning and construction.

Presently, the only reliable method for locating underground cavities of concern in highway planning and construction stages is by direct drilling. The time and cost of this method, however, is generally restrictive because of the close spacings required between borings in order to reliably detect and delineate possible underground cavities.

The subsurface cavities of concern in most highway stability and construction are those located within 15 metres (50 ft.) of the surface. They may of various sizes and shapes and may contain various amounts of air, water, or soil. Broadly speaking, conventional geophysical exploration techniques have been of only limited success in detecting subsurface cavities of this type because of size resolution difficulties and because of low contrast between the various observable cavity manifestations and the typical background conditions.

The presence of possible underground cavities may be noted from subtle indirect surface anomalies under ideal conditions using airborne sensing techniques. According to Warren and Wiechowsky (1) who used infrared photography, thermography, and side-looking airborne radar to study subsidence and collapse problems in several carbonate terrains, the results of aerial surveys can be a good beginning point for further geologic and hydrologic studies. Newton (2) also found remote sensing (multispectral photography andinfrared imagery) useful in delineating features such as water loss in streams, geologic structures, and vegetative stress related to sinkhole formation.

Surface-operated geophysical exploration methods are more intimately responsive to specific subsurface conditions related to underground cavities and offer the best potential promise for cavity detection success. Of these methods, improved versions of electrical resistivity survey techniques, a newly emerging electromagnetic technique utilizing a ground-penetrating radar concept and microgravity surveys appear to offer the most effective and practical approaches to underground cavity detection for highway survey applications.

Lakshmanan (3) and Colley (4) both reported successful cavity detection using gravity measurements in 1963. Neumann (5) also successfully demonstrated in 1972 that detection of solution cavities was possible by gravity measurements if extreme care was taken in making the measurements on a very tight grid and topographic features were carefully accounty for.

Ground penetrating impulse radar is one of the most recent instruments to show promise for subsurface cavity detection. (6, 7, 8, 9). Work done by Morey (9) for the Federal Highway Administration was probably the latest attempt to use this method. His results showed the detection capability but only to depths of about 2.4 metres (8 ft.) in moist clay-rich soils. Possibilities appeared to be good if instrumentation was improved.

A third detection method found worth evaluating was earth resistivity measurements. In 1966 Bristow (10) described a search method using a pole-dipole electrode array that could resolve small underground cavities. He used a graphical data display technique that allowed a bearing to be obtained on the location of the cavity as well as a prediction of the size and shape. Bates (11) in 1973 reported successfully detecting cavities using Bristow's method and modified the search procedure to allow more redundant data to be collected. The author in 1972 was successful in detecting shallow voids using a mobile equatorial dipole electrode array (12). Results from these studies were encouraging enough to warrant further evaluation.

The Federal Highway Administration still has work in progress evaluating subsurface cavity detection methods (13). Their earlier work led to the research reported in this paper and also to the search methods used (14).

The three (3) search methods selected for evaluation (gravity surveys, ground penetrating radar mapping, and earth resistivity surveys) were tested at sites in Alabama and Florida. All sites were sinkhole prone areas where sinkhole formation was known to be active. At each site all surveys were made over a common base grid pattern comprised of a rectilinear array of traverse lines equally spaced at a distance of 3 metres (10 ft.). The grid points were identified in matrix fashion by row and column number. In this manner a direct comparison of test results could be made.