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SEISMIC REFRACTION STUDY OF A BURIED VALLEY NEAR PENINSULA, SUMMIT COUNTY[1]

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Abstract. A portion of the buried preglacial Akron River valley in northern Summit County was investigated using the seismic refraction method with a BISON 6-channel model 1580 seismograph and a mechanical shock source. From 42 traverses, we gained depth information that permitted construction of an improved structural contour map of bedrock topography. The buried Akron River valley is located in approximately the same position as described by Smith and White (1953), but we determined that it is much narrower than they had estimated with a steep V-shaped bottom portion and gently sloping shoulders. The approximate depth to bedrock over the valley axis is 500 ft. The seismic data further indicated 2 types of valley fill: a lower layer of probably Wisconsinan glacial material with P-wave velocity of 5700±1400 ft/sec and a thinner, discontinuous upper layer of uncertain nature with P-wave velocity of 2600±600 ft/sec. The weathered zone ranges in thickness from 4 ft to 32 ft and has a seismic velocity of 800±160 ft/sec. Bedrock seismic velocities were 12000±2000 ft/sec, appropriate for shale or sandstone.

OHIO J. SCI. 81(2): 69, 1981

One of the legacies left by the ice age in Ohio are buried valleys. These valleys and their sand and gravel deposits provide important aquifers for much of Ohio. Because the exact shape and location of most deeper buried valleys is still not well known, it is of considerable economic as well as scientific interest to gather additional data about these important features.

In Summit County, the present state of knowledge of bedrock topography is represented by the bedrock map published by Smith and White (1953). To date no additional bedrock survey in Summit County has been published. Smith and White (1953) compiled their map from water well data, but since water wells do not reach bedrock in the deeper portions of buried valleys, bedrock contours in these regions were rough estimates. The work presented here is an effort to improve these estimates through the use of the seismic refraction technique.

[1]Manuscript received 1 October 1979 and in revised form 3 October 1980 (#79-50).

MATERIALS AND METHODS

The study area, approximately 3 by 5.5 miles in size, is located in north central Summit

County near Peninsula (Boston and Northampton townships) and contains a portion of the Cuyahoga Valley (fig. 1). The area is underlain by the buried preglacial valley cut by the ancient Akron River (Smith and White 1953). We conducted our investigation with the seismic refraction technique utilizing field equipment consisting of a BISON Model 1580 6-channel portable seismograph mounted on a modified boat trailer with a custom built 440 lbs weight-drop shock generator. Because equipment limitations prohibited the use of continuous profiles across the entire area, 42 strategically placed short (up to 1850 ft) seismic traverses were carried out with each starting and ending at a road or path (see slanted numbers, fig. 1) to provide seismic depth soundings to bedrock.

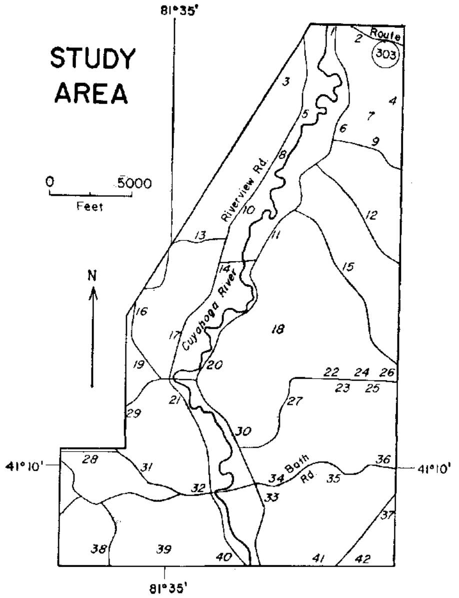

FIGURE 1. Study area map indicating major roads and seismic traverse locations marked by slanted numbers.

Wherever possible, we ran both forward and reverse profiles to obtain depths for both ends of a given traverse. In a few places where terrain prohibited transport of the weight drop rig to the far end of the traverse, we obtained only single ended traverses (traverses 6, 13, 30, 39 and 42). Similarly, traverses 7, 28, 33 and 34 were not completed due to terrain problems. The resulting travel time curves indicate up to 4 distinct interfaces. We calculated corresponding layer depths and seismic velocities on the University of Akron IBM 370–158 computer using the equations for the dipping n-layer case as developed by Motta (1953). The weathered layer was treated as the top layer to eliminate the need for a weathering correction. The scatter in the raw time distance data was analyzed statistically and used to calculate standard errors for depth and seismic velocity. The necessary error propagation equations are based on the ideal horizontal layer case since most dip angles are small. Further details of this work are discussed more fully by Mangun (1980).

RESULTS AND DISCUSSION

Depths to bedrock for 38 successful seismic traverses as well as 4 incomplete traverses are presented in table 1. (Data for opposite ends of a given traverse are designated A and B). We estimated the standard error of the depth data to be less than 10%. Seismically derived bedrock depths were confirmed by well depths wherever there were nearby water wells. The maximum depths to bedrock are 555 ft (traverse 30) and possibly in excess of 600 ft (incomplete traverse 7). Table 1 presents the data on topographic surface elevation and corresponding bedrock elevations. The bedrock elevation data were used to construct a plausible bedrock structural contour map (fig. 2).

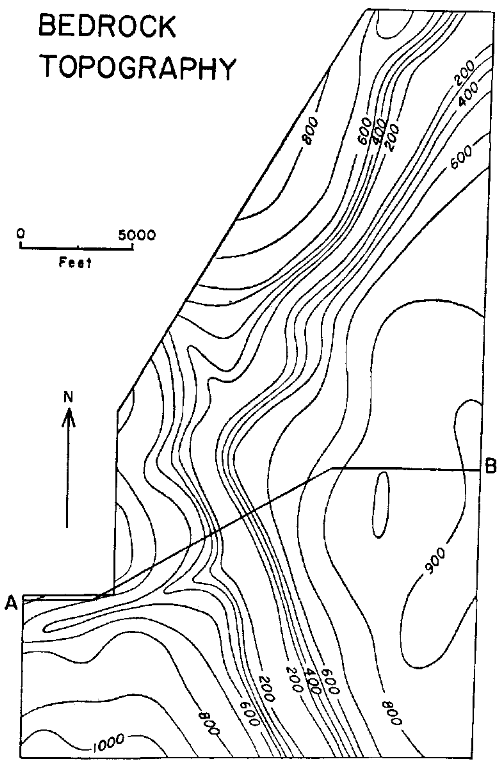

FIGURE 2. Structural contour map of bedrock surface. Elevations are given in feet above sea level.

This map shows a main valley corresponding to the ancient Akron River (Smith and White 1953), and two tributary valleys entering from the west (near present day Yellow Creek and Furnace Run). The main valley is located in approximately the same position as mapped by Smith and White (1953) but appears to be much narrower than they estimated with a very steep sided and distinctly V-shaped lower portion, and a more gently sloping upper portion. The width of the valley floor appears to be 1000 ft or less. A cross section of the buried main valley along the same line as the cross section published by Smith and White (1953) (near line A–B; figure 2) is shown in figure 3.

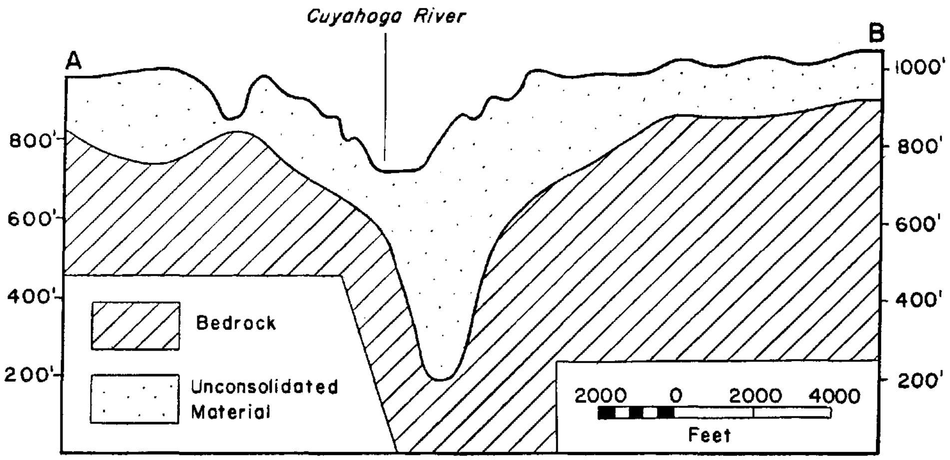

FIGURE 3. East-west profile of the buried valley in the southern portion of the study area.

This buried valley configuration is in agreement with the model advanced by Ver Steeg (1933) in which the lower portion of the valley was filled with material before active glaciation affected the area. The valley floor presumably slopes to the north, but the seismic data were insufficient to permit reliable determination of this slope. It is therefore not represented on the contour map.

The valley fill appears to consist of the following distinct types of material:

1. A lower layer with seismic P-wave velocity of 5700±1400 ft/sec (fps) (fig. 4, layer A). This layer is probably continuous throughout the buried valley—the dashed lines indicate uncertain boundaries because of lacking data in these areas. Outside the buried valley, this layer is discontinuous and appears to coincide with material identified as "end moraine" by Smith and White (1953). Most of this material probably corresponds to glacial drift of Wisconsin age whose seismic velocity is given as 6000±500 fps by Knox (1967). Considering the V-shape of the valley, however, at least the lower part of the valley fill may be older alluvium or outwash. Unfortunately, this cannot be verified with the seismic refraction technique.

2. An intermediate layer with seismic of velocity of 2600±600 fps (fig. 4, layer B). The distribution of this layer is patchy and mostly outside the main buried valley. In the northern part of the study area, it occurs in regions identified as "ground moraine" by Smith and White (1953). Its average thickness is approximately 130 ft, and its seismic velocity falls in the range of those for alluvium or similar unconsolidated material, including clay (Clark 1966). At least parts of layer B consist of multiple tills, outwash, and lacustrine silts and clays (Szabo 1979).

TABLE 1
Seismic depths and related data.

Traverse	Depth A	(Ft) B	Surface A	Elevation B	Bedrock A	Elevation B
1	90	120	703	703	610	580
2	180	90	737	778	560	690
3	110	80	863	871	750	790
4	340	340	842	862	500	520
5	10	10	718	718	710	710
6	—	490*	—	678*	—	190*
8	10	10	733	733	720	720
9	180	200	878	862	700	660
10	110	100	722	720	610	620
11	460	360	719	722	260	360
12	140	140	898	898	760	760
13	—	260*	—	740*	—	480*
14	360	410	728	728	370	320
15	70	70	940	951	870	881
16	70	60	787	798	720	740
17	480	530	738	729	260	200
18	310	260	945	906	640	650
19	120	170	740	748	620	580
20	190	210	721	721	530	510
21	110	100	730	729	620	630
22	100	110	1002	1008	900	900
23	240	140	1022	1022	780	880
24	130	120	1009	1022	880	880
25	150	190	1002	1009	850	820
26	90	100	1002	1002	910	900
27	100	170	938	928	840	760
29	120	90	972	972	850	880
30	—	555*	—	740*	—	190*
31	10	10	885	898	880	890
32	10	10	765	755	760	750
35	60	40	968	962	910	920
36	130	110	989	846	860	740
37	130	140	970	970	840	830
38	10	10	1008	1009	1000	1000
39	—	10*	—	1010*	—	1000*
40	20	10	751	751	730	740
41	250	190	923	922	670	730
42	—	120*	—	930*	—	810*
7	—	>600*	—	710*	—	<110*
28	—	>130*	—	993*	—	<860*
33	—	>280*	—	749*	—	<470*
34	—	>200*	—	909*	—	<710*

*Value at midpoint of traverse (depth calculated using horizontal interface equations).

3. A continuous surface layer ranging in thickness from 4 ft to 32 ft with seismic velocities of 800±160 fps. This layer represents largely the weathered zone and, occasionally, artificial fill. In several places, most notably in the southwestern part of the study area, this layer rests directly on bedrock. Smith and White (1953) identified the material in this area as end moraine, but this interpretation must be regarded as erroneous in view of our seismic data (which are also supported by water well data in the area in question).

Warrick and Winslow (1960) found seismic velocities of 5,700 fps for glacial material and 11,300 fps for bedrock in neighboring Portage County; Watkins and Spieker (1971) determined 5,700 fps for glacial material and 13,000 fps for bedrock in western Ohio. The bedrock seismic velocities we found were mostly in the range of 12,000±2000 fps. These velocities correspond to those of

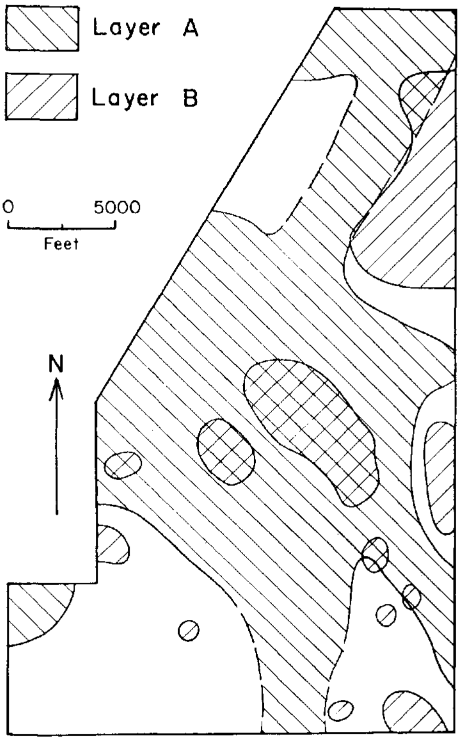

FIGURE 4. Distribution of unconsolidated material: Lower layer (A) with high seismic velocity, upper layer (B) with low seismic velocity.

shale (6562–14108 fps) or sandstone (6890–14436 fps) as listed in Clark (1966). The expected bedrock types are Ohio and Chagrin shales in the deepest portion of the buried valley, and the sandstones and shales of the Cuyahoga group on the valley flanks.

Acknowledgements. We wish to express our gratitude to Mr. William Birdsell, Park Superintendent, CVNRA, for granting permission to conduct our study in the Cuyahoga Valley National Recreation Area, and to Dr. Jim Jackson, Director of the Oak Hill Environmental Center, CVNRA, for his valuable assistance. We also thank the University of Akron Computer Center for providing the necessary computer time, and Mr. Richard Wiggins for the use of his seismic analysis program SAP and other programming assistance.

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