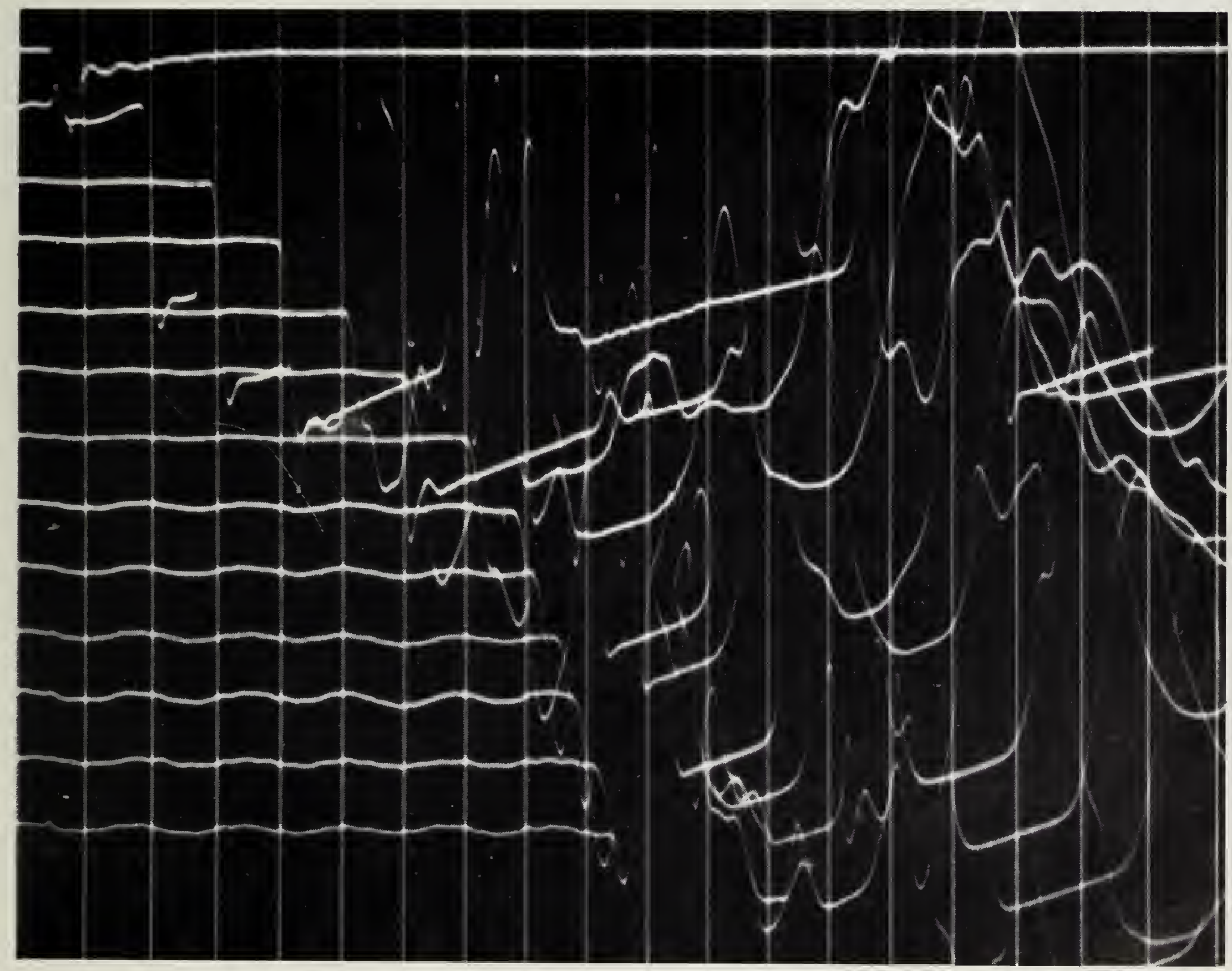
A SEISMIC REFRACTION SURVEY OF THE LOWER ILLINOIS VALLEY BOTTOMLANDS

Paul C. Heigold and Robert W. Ringler



Illinois Institute of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY DIVISION, URBANA, ILLINOIS
Jack A. Simon, Chief

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COVER PHOTO: Seismic refraction record obtained near Meppen in Calhoun County, Illinois. The parallel vertical lines are timing lines spaced at 10-millisecond intervals. The uppermost horizontal trace shows the instant at which the shot was detonated, and the other horizontal traces indicate the times at which seismic waves emanating from the shot first arrived at 12 equally spaced geophones extending in a line away from the shot. A plot of first arrival times as a function of geophone distance is subsequently used to examine the nature, depth, and attitude of geologic units below the surface.

Heigold, Paul C

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ABSTRACT

A seismic refraction survey of the lower Illinois Valley bottomlands was conducted to supplement the sparse outcrop data and borehole data available for the area. Results of the survey indicate that unconsolidated sediments up to 170 feet thick cover a bedrock surface whose configuration is determined mainly by bedrock lithology. In places where weak, easily eroded rocks have been removed downstream from overlying, erosion-resistant rocks, sizable variations in the declivity of the bedrock surface have resulted. The topography that was produced has been preserved by subsequent erosion.

The anomalous gradients on the bedrock surface may be the result of normal fluvial processes, but their youthful appearance and preservation may have been caused by more complex erosional and depositional processes associated with glaciation during the Pleistocene Epoch.

INTRODUCTION

The lower Illinois Valley between Beardstown and Grafton is a relatively undeveloped part of the Illinois Waterway, which extends from Lake Michigan to the Mississippi River (fig. 1). The need for additional information on the geology of the area has been pointed out by Willman (1973, p. 2):

> At a time when the areas bordering the Waterway anticipate a growing population, an expanding industry, and improved supervision of the environment, knowledge of the earth's materials that directly underlie the ground surface is a basic part of the perspective needed to solve problems and to plan effectively for the future.

The unconsolidated deposits and some bedrock formations in the lower Illinois Valley have great potential for municipal, industrial, and irrigational ground-water supplies. It is important for the continued economic development of the area that our knowledge of these aquifers be refined and expanded.

The term *unconsolidated deposits* is used in this report in a general sense for the overburden above the firm, lithified, layered bedrock. Some glacial till units may have become consolidated to the extent that they yield seismic velocities as high as the shale bedrock.

Outcrop and borehole data in the lower Illinois Valley are particularly sparse where unconsolidated deposits containing the most readily available and abundant source of ground water are thickest. For this reason, we conducted a seismic refraction survey of the lower Illinois Valley

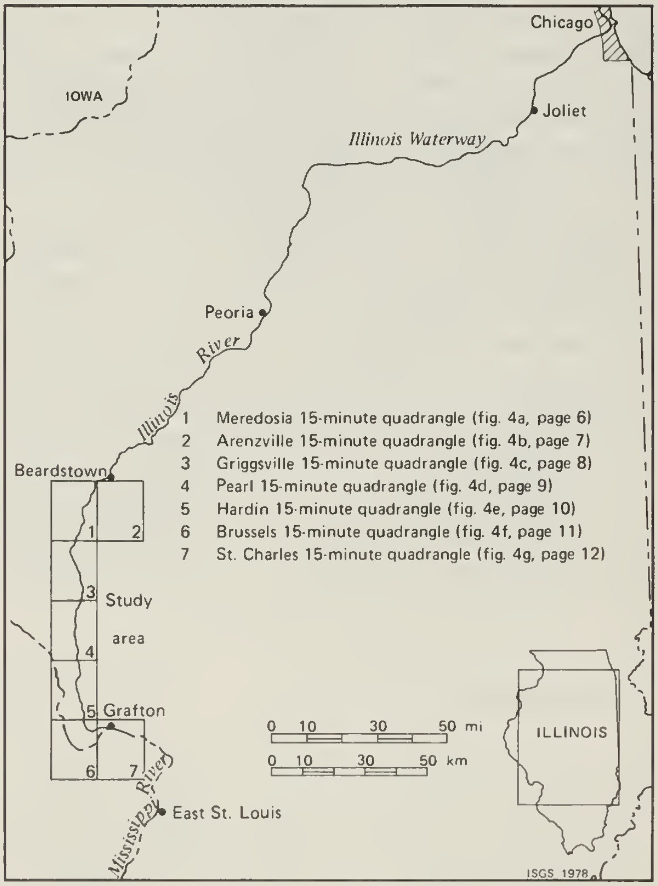

Figure 1. Area of study, including the Illinois Waterway and lower Illinois Valley.

bottomlands. We collected 106 reversed seismic refraction profiles that provided information concerning the depth, configuration, and lithology of the bedrock surface and the characteristics of the overlying unconsolidated deposits. In addition to enhancing the existing knowledge of the ground-water geology, the new data provided by the seismic refraction survey allowed further insight into the geologic history of the area.

Previous studies

Horberg constructed a bedrock surface map of Illinois which represented the status of outcrop and borehole information at the time of publication (1957). The accuracy of the map varies greatly in different areas because of unequal distribution of data, but in general the map delineates the main bedrock valleys and upland surfaces. The report accompanying the map describes the characteristics of the glacial and alluvial deposits in the valleys.

Piskin and Bergstrom (1967, 1975) described the thickness, distribution, and characteristics of the glacial drift in Illinois. They constructed maps of the thickness of the drift which are considered to be updated supplements to Horberg's map.

Bergstrom and Zeizel made a preliminary report in 1957 on the ground-water geology of western Illinois which includes the area studied for this report. They presented maps showing areal and vertical distribution, type, and water-yielding potential of the upper bedrock formations and the probability of occurrence and characteristics of sand and gravel aquifers.

Willman (1973) constructed geologic maps that show the extent of various types of materials that are exposed at or directly underlie the land surface in the Illinois Valley bottomlands, bluffs, and uplands up to about one mile back from the bluffs. The area mapped includes portions of the study area from the northern boundaries of the Meredosia and Arenzville 15-minute quadrangles to the southern boundary of the Pearl 15-minute quadrangle (fig. 1). The geology of the lower end of the waterway in the Hardin and Brussels 15-minute quadrangles (fig. 1) has been mapped and described in detail by Rubey (1952). These maps include the complex geology associated with the Cap au Grès Faulted Flexure (figs. 2 and 3).

Structural setting

The lower Illinois Valley lies along the northwestern boundary of the Illinois Basin. About 2,000 to 3,000 feet of consolidated sedimentary bedrock, topped by a thin veneer of unconsolidated sediments, covers the study area. The unconsolidated sediments consist of glacial deposits of the Pleistocene Epoch and stream and lake deposits of the Holocene Stage. The bedrock formations were deposited during the Cambrian, Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian Periods. The most pronounced structural feature of the region is a large anticlinal fold extending from Grafton in Jersey County, Illinois, westward across southern Calhoun County, Illinois, thence across the Mississippi River and westward and northwestward across Lincoln, Pike, Ralls, and southern Marion Counties, Missouri. It is called the Lincoln Anticline (fig. 2) because it attains its greatest development in Lincoln County, Missouri (Krey, 1924).

Associated with the Lincoln Anticline is the Cap au Grès Faulted Flexure (fig. 2), which parallels the anticline and breaks it just south of its crest. Several authors (Grohskopf, 1933; Mateker, 1956; and Douthit, 1959) have concluded from magnetic and gravity studies that the Cap au Grès Faulted Flexure is a long, continuous structure upthrown on the north at least 1,000 feet. Faulting extends deep into the basement.

South of and parallel to the Cap au Grès Faulted Flexure is the pronounced east-west-trending Troy-Brussels Syncline, which extends from Troy in Lincoln County, Missouri, to Brussels in Calhoun County, Illinois (fig. 2). Another important structure in this region is the Pittsfield-Hadley Anticline, which attains its greatest development near Pittsfield in Pike County, Illinois. This structure, which can be traced from Bedford on the Illinois River in Pike County, Illinois, to La Grange in Lewis County, Missouri, roughly parallels the Lincoln Anticline and lies over a Precambrian bedrock high (Workman and Bell, 1949).

Bedrock geology

The oldest rocks that make up the bedrock surface in the study area belong to the Galena and Platteville Groups (Ordovician) (fig. 3). These rocks are in a narrow band under the Illinois River just north of the Cap au Grès Faulted Flexure. Northward, along the thalweg, or line drawn through the lowest points, of the Illinois bedrock valley, the bedrock surface in the study area is made up of progressively younger rocks of the Ordovician, Silurian, Devonian, and Mississippian Systems. Along the extreme northern edge of the study area, the oldest rocks forming the bedrock surface are the Lower Valmeyeran Keokuk and Burlington Limestones (Mississippian). Northward from the Cap au Grès Faulted Flexure, away from the lower Illinois Valley bottomlands, the bedrock surface consists of progressively younger rocks. South of the Cap au Grès Faulted Flexure, in the vicinity of the Troy-Brussels Syncline, the bedrock surface is generally much younger than it is just north of the flexure. The rocks that constitute the bedrock surface there range in age from middle Valmeyeran (Mississippian) to the Carbondale Formation of the Desmoinesian Series (Pennsylvanian) (Willman and others, 1967).

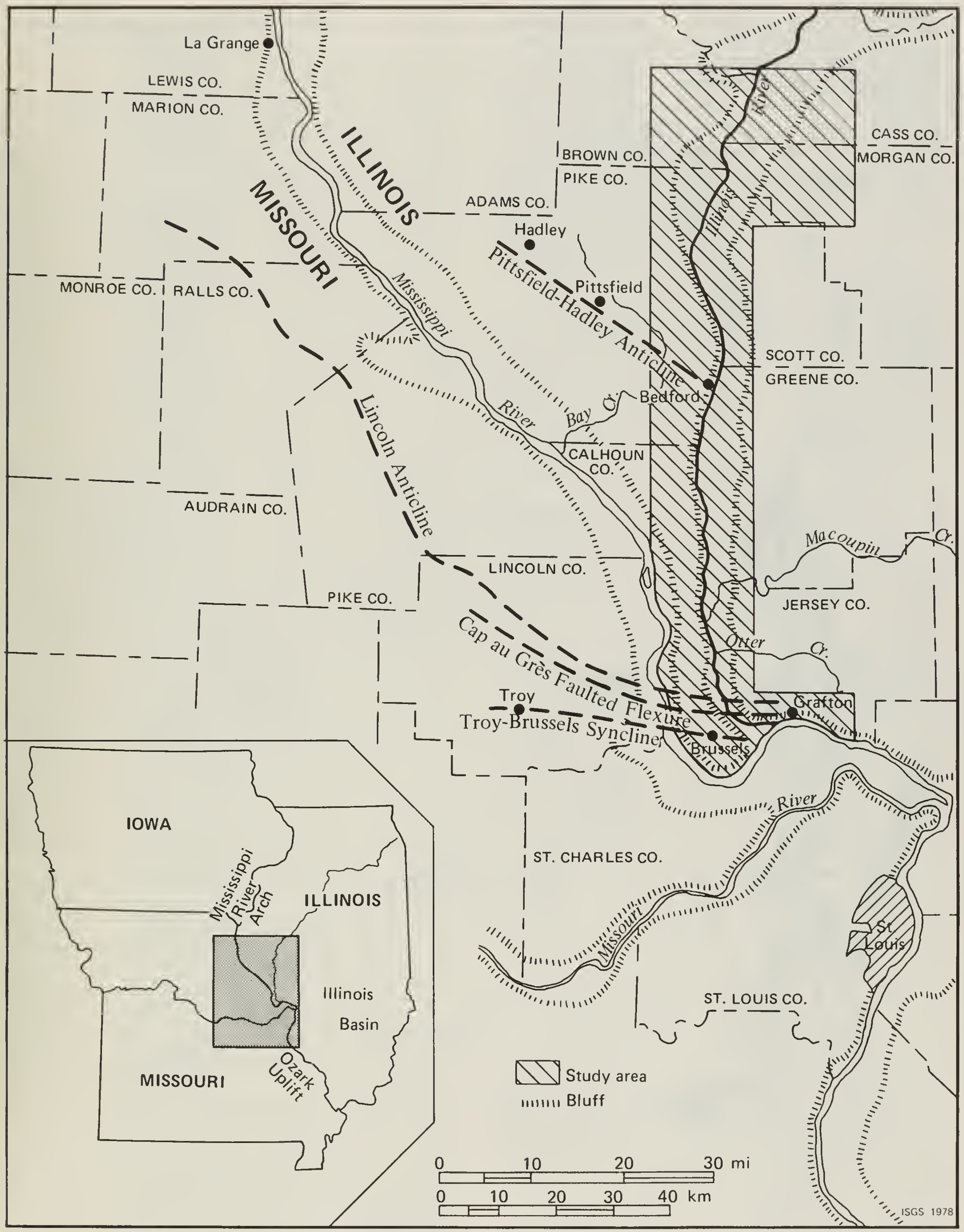

Figure 2. Principal geologic structures in and around the lower Illinois Valley.

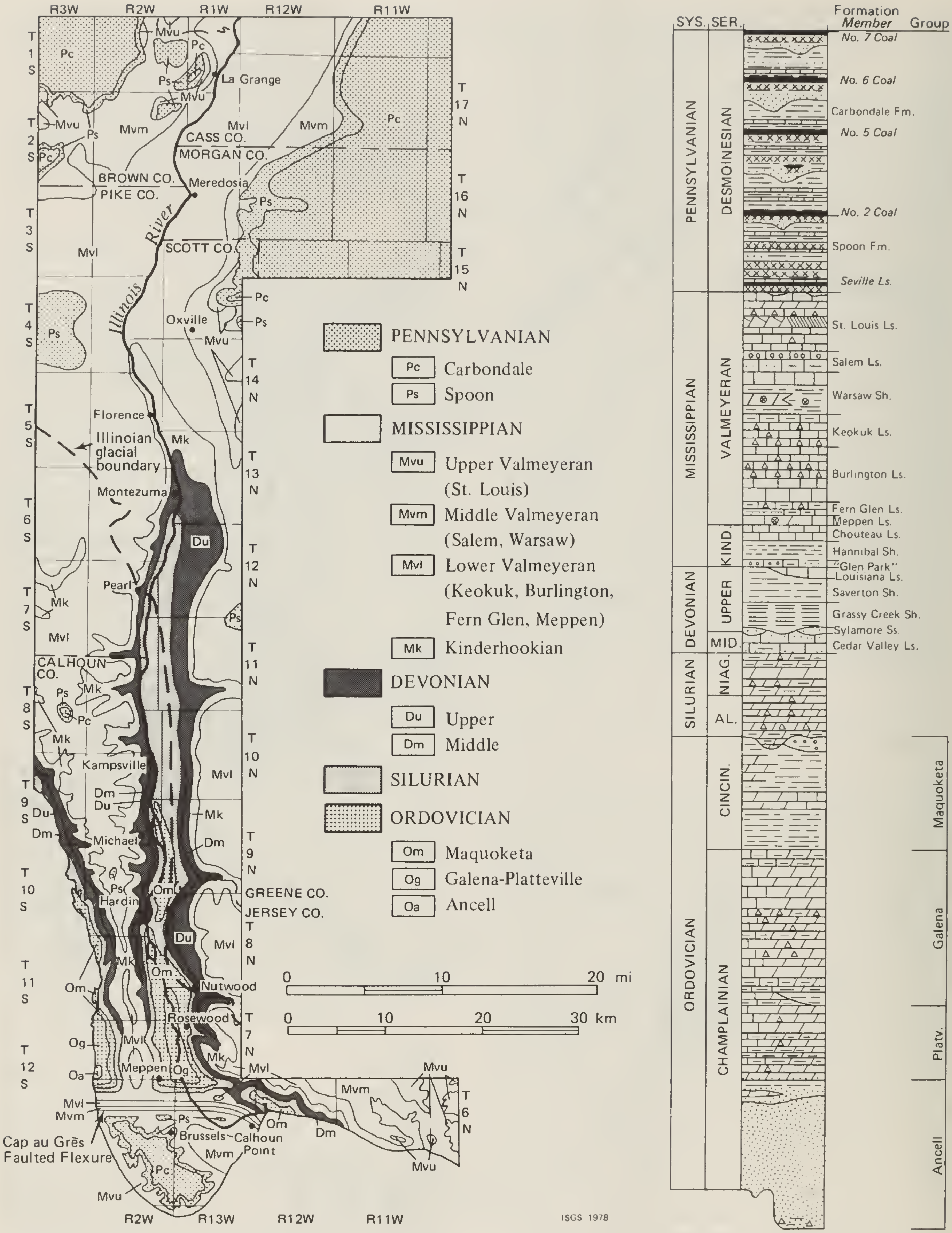

Figure 3. Bedrock geology in the lower Illinois Valley bottomlands.

GEOPHYSICAL INSTRUMENTATION AND FIELD PROCEDURES

A 12-channel Geospace GT-2B seismic refraction system, owned by the Illinois State Geological Survey, was employed in the seismic refraction survey. One hundred six reversed seismic refraction profiles, arranged in 14 lines, were run in and near the lower Illinois Valley bottomlands from La Grange in Brown County (about ten miles south of Beardstown) to Grafton in Jersey County (fig. 4 and table 1). Twelve of these lines were perpendicular to the axis of the valley and two were parallel to the axis of the valley. One of the north-south lines parallel to the valley was run to confirm an abrupt drop in the elevation of bedrock in the center of the bottomlands near Florence in Pike County. The other north-south line was run across the Cap au Grès Faulted Flexure on the west side of the Illinois River between Meppen and Brussels in Calhoun County.

Locations for the seismic profiles were selected on the bases of proximity to cultural features, consistency of spacing along lines (usually at half-mile intervals), and surface topography.

At the beginning of the survey, individual seismic profiles were 1,200 feet long with 100-foot geophone spacings. It immediately became apparent, however, that 600-foot profiles with 50-foot geophone spacings were adequate to obtain depth to the bedrock and seismic velocities of the unconsolidated materials and bedrock. The source of energy was a one-pound Du Pont Nitramon S Primer detonated in a hand-augered hole 5 feet deep at each end of the profile. In some cases where the surficial materials were loose and capable of attenuating much of the energy, two-pound charges were employed.

INTERPRETATION OF SEISMIC REFRACTION DATA

Interpretation of seismic refraction data in and around the lower Illinois Valley bottomlands was generally a problem involving three layers (fig. 5). Proceeding from the earth's surface downward were (1) a thin weathering layer, (2) a layer of unconsolidated deposits, usually sands, gravels, and glacial tills, and (3) bedrock.

From the data provided by the 600- and 1,200-foot seismic refraction profiles alone, it was not always possible to calculate the velocity, and therefore the thickness, of the thin surficial weathering layer. Periodically throughout the survey, however, short seismic refraction profiles utilizing short geophone spacings were run to determine the velocity and thickness of this thin layer. The layer was found to have a consistent velocity of approximately 1,250 ft/sec. The same value for this layer has been found in other surveys run elswhere in Illinois. Thus, a velocity of 1,250 ft/sec was assumed throughout the survey for the surficial weathering layer. Establishment of that value as a constant allowed the thickness of the layer to be calculated for each seismic refraction profile.

The second layer corresponded to unconsolidated sediments resting on the bedrock surface. This layer consisted of alluvium, colluvium, till, or loess. Where seismic refraction profiles were run, the velocities of the layer ranged from 3,378 to 5,884 ft/sec.

The third, or bottom, layer was bedrock. In the study area, the bedrock surface was composed of many lithologic types, including dolomites, limestones, sandstones, and shales. Bedrock seismic velocities ranged from 7,369 to 21,811 ft/sec.

The interpretation of the seismic refraction data was generally straightforward, especially where there was a large seismic velocity contrast between the unconsolidated deposits and bedrock. Areas were encountered, however, where well-compacted but unconsolidated sedimentary deposits overlay a bedrock surface composed of relatively soft, clastic rocks, making interpretation more difficult.

IMPLICATIONS OF THE SURVEY

The characteristics of the bedrock surface and the unconsolidated sediments resting on it in Illinois have been examined extensively from time to time by using available outcrop data and borehole data. This means of upgrading existing data is a useful and necessary procedure; however, in addition to being a rather slow process, collection of additional information of this sort, particularly borehole data, often adds to data only in areas where existing data are already plentiful and not where data are sparse, such as in the lower Illinois Valley bottomlands. The problem was remedied to a great extent in this study by a seismic refraction survey in and around the bottomlands during the summer of 1975. Most of the new data gathered in this study were from the bottomlands (fig. 4 and table 1).

The borehole and seismic refraction data in the bottomlands indicates that the configuration of the bedrock topography there has been largely determined by lithology of the uppermost bedrock. From La Grange in Brown County to Florence in Pike County the bedrock surface appears to be relatively smooth and has only a few irregularities. Figure 3 indicates that the bedrock surface there is predominantly carbonate rock of lower and middle Valmeyeran (Mississippian) age.

South of Florence, between the east-west Florence and the east-west Montezuma seismic refraction lines, the elevation of the bedrock decreases sharply. Along the Florence line, the lowest calculated bedrock elevation is 330 feet above mean sea level, whereas along the Montezuma line, five miles to the south, the lowest calculated bedrock elevation is 265 feet above mean sea level. Figure 3 indicates a bedrock surface of predominantly Kinderhookian (Mississippian) and Upper Devonian rocks along the Montezuma line. This portion of the sedimentary rock column is composed mainly of soft, shaly rocks and is much more

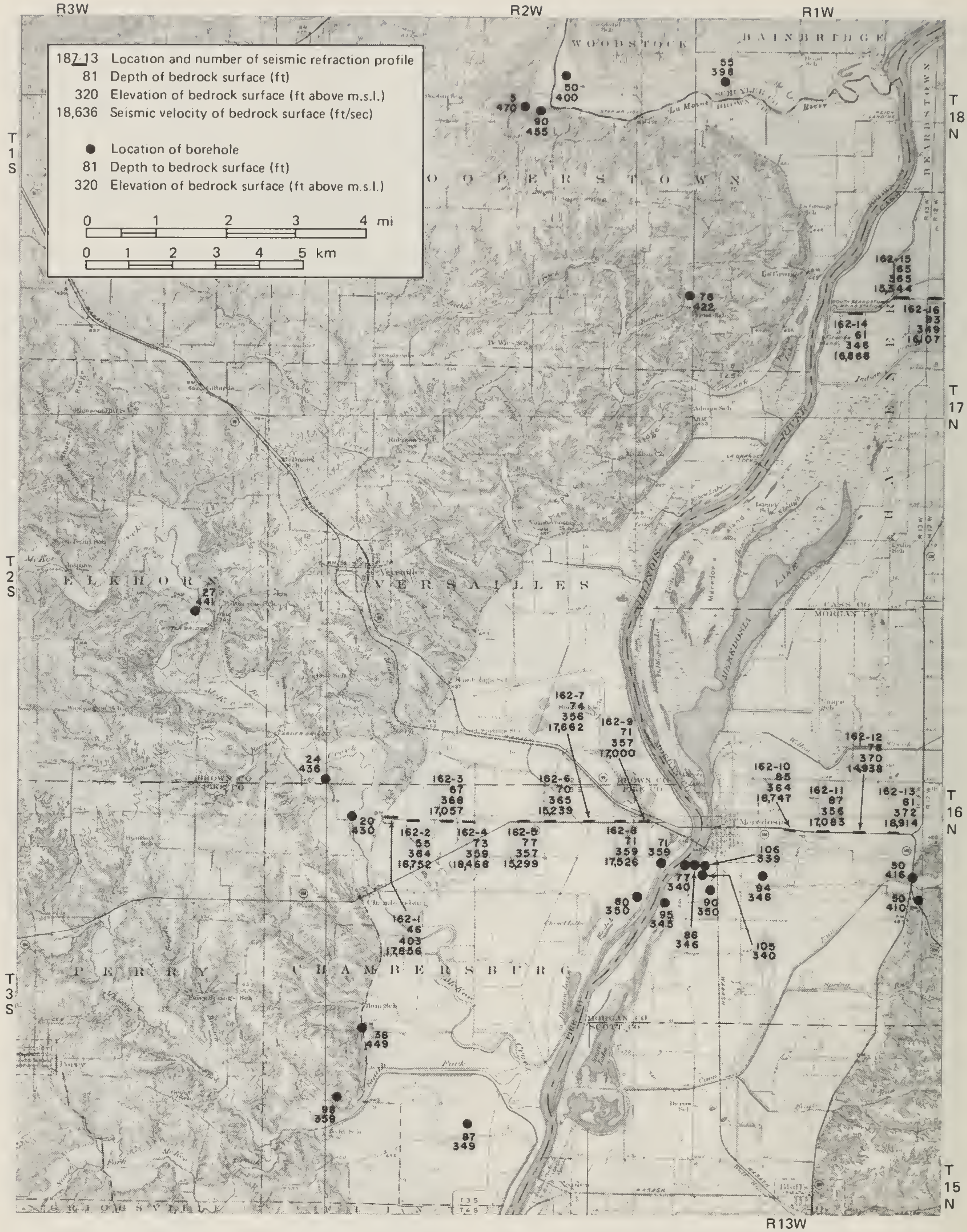

Figure 4a. Seismic refraction data and borehole data for the Meredosia 15-minute quadrangle.

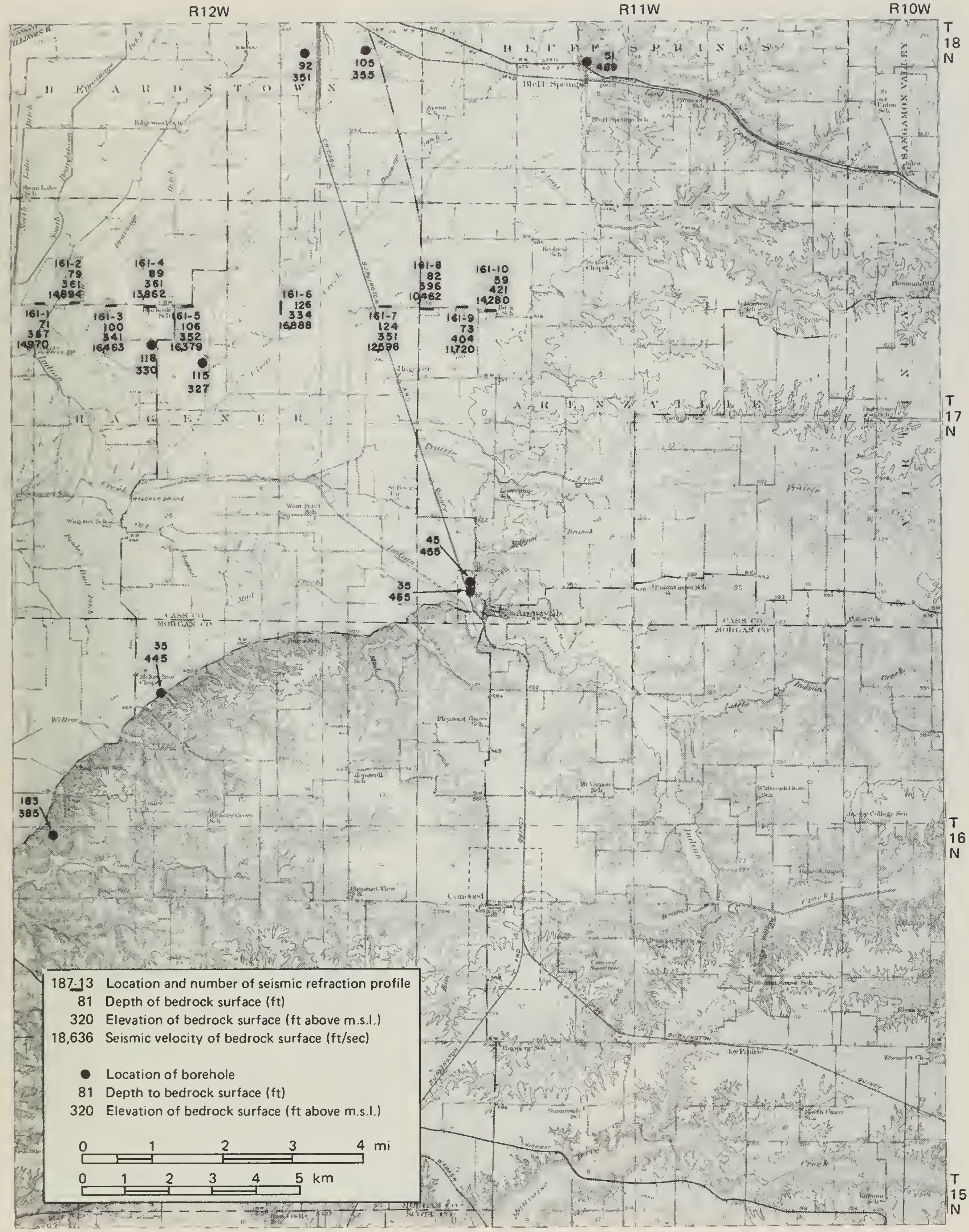

Figure 4b. Seismic refraction data and borehole data for the Arenzville 15-minute quadrangle.

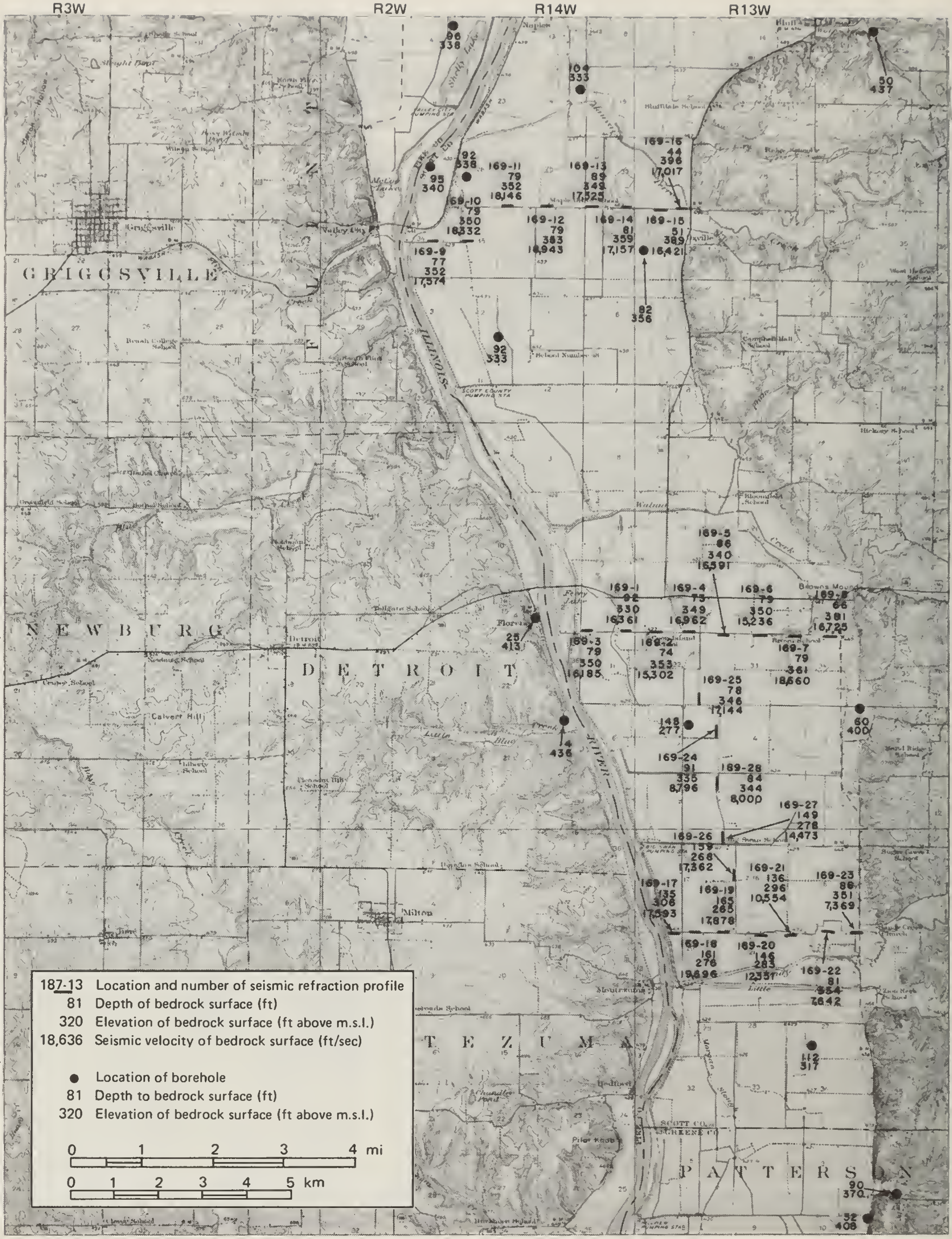

Figure 4c. Seismic refraction data and borehole data for the Griggsville 15-minute quadrangle.

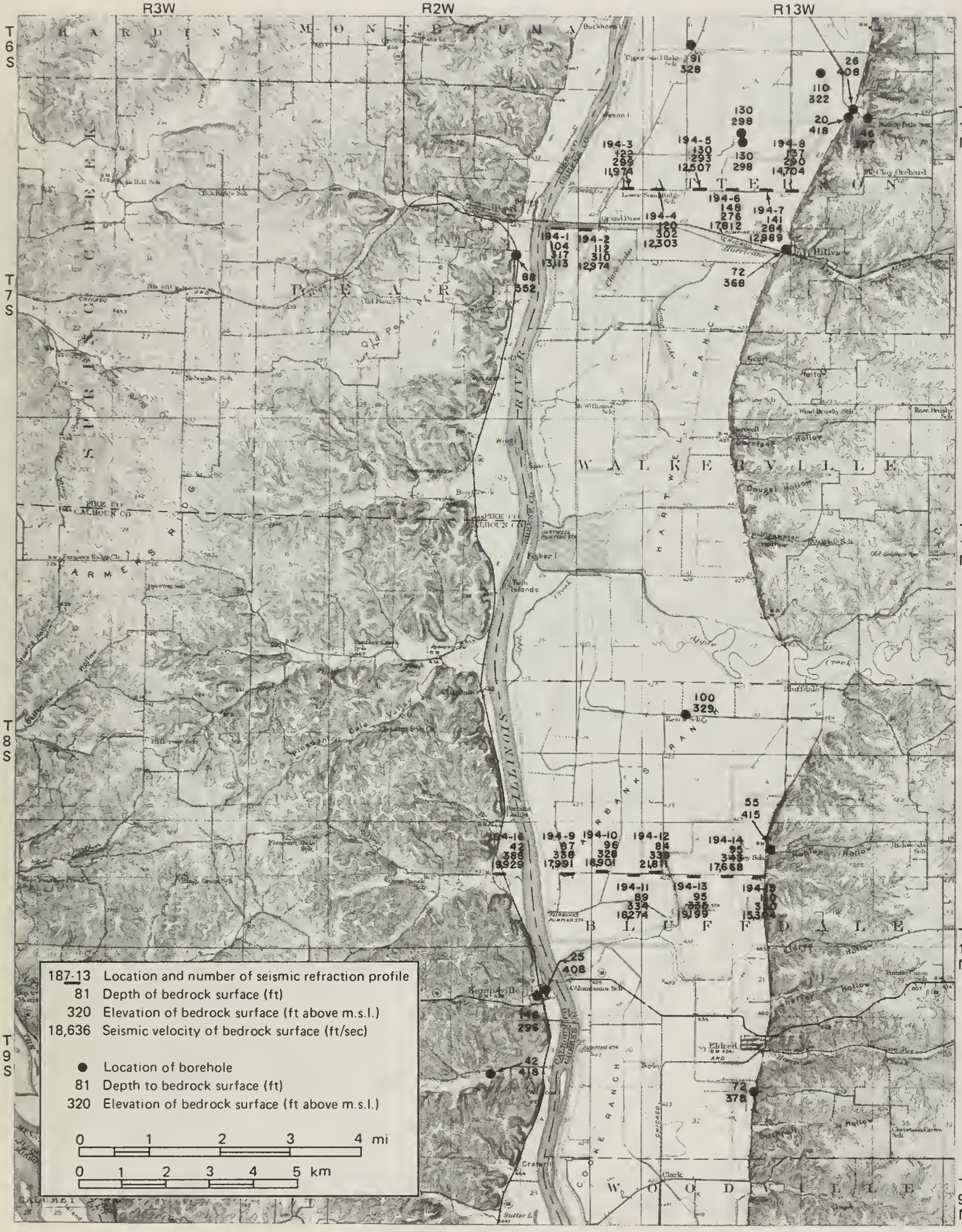

Figure 4d. Seismic refraction data and borehole data for the Pearl 15-minute quadrangle.

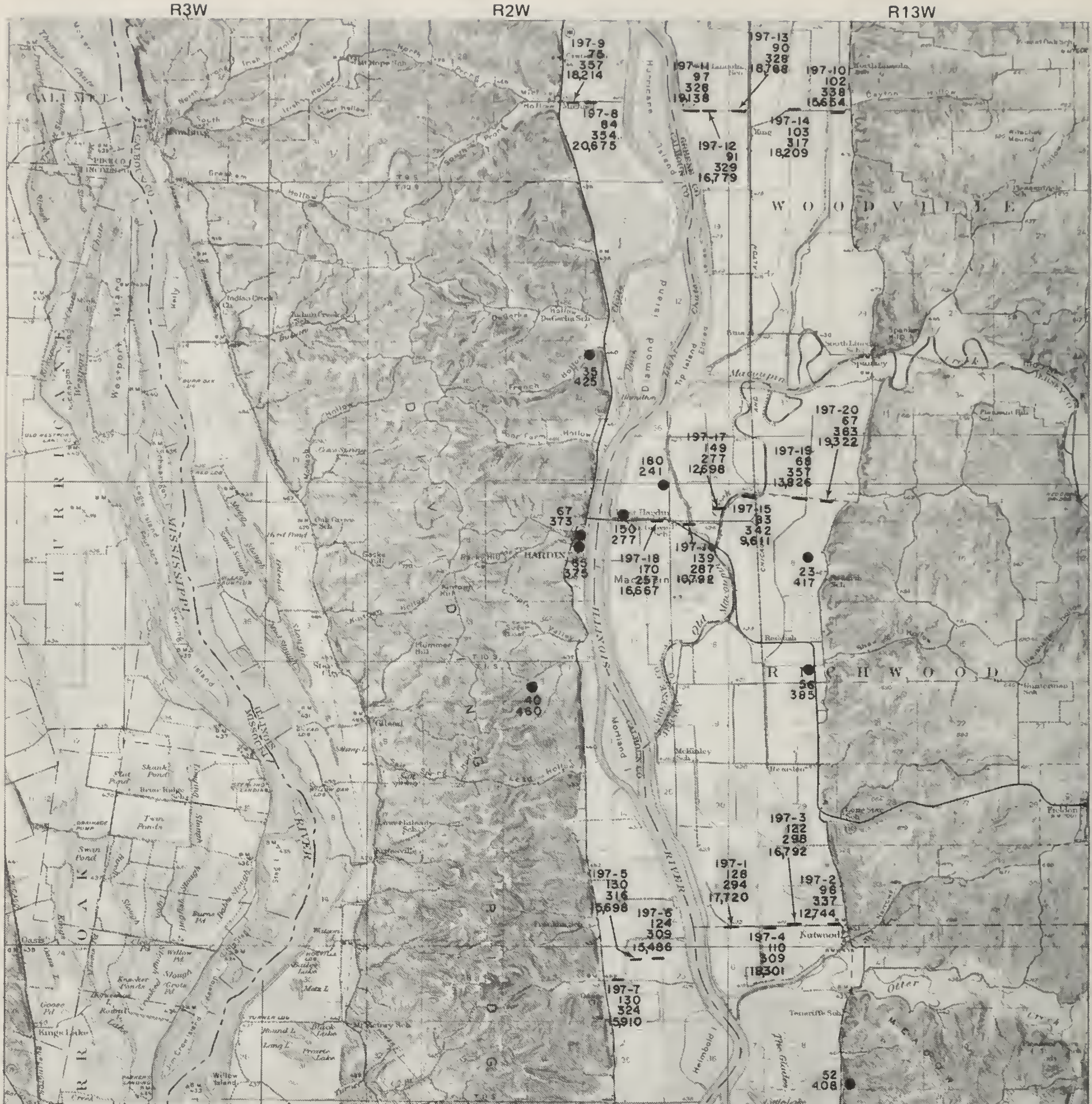

Figure 4e. Seismic refraction data and borehole data for the Hardin 15-minute quadrangle.

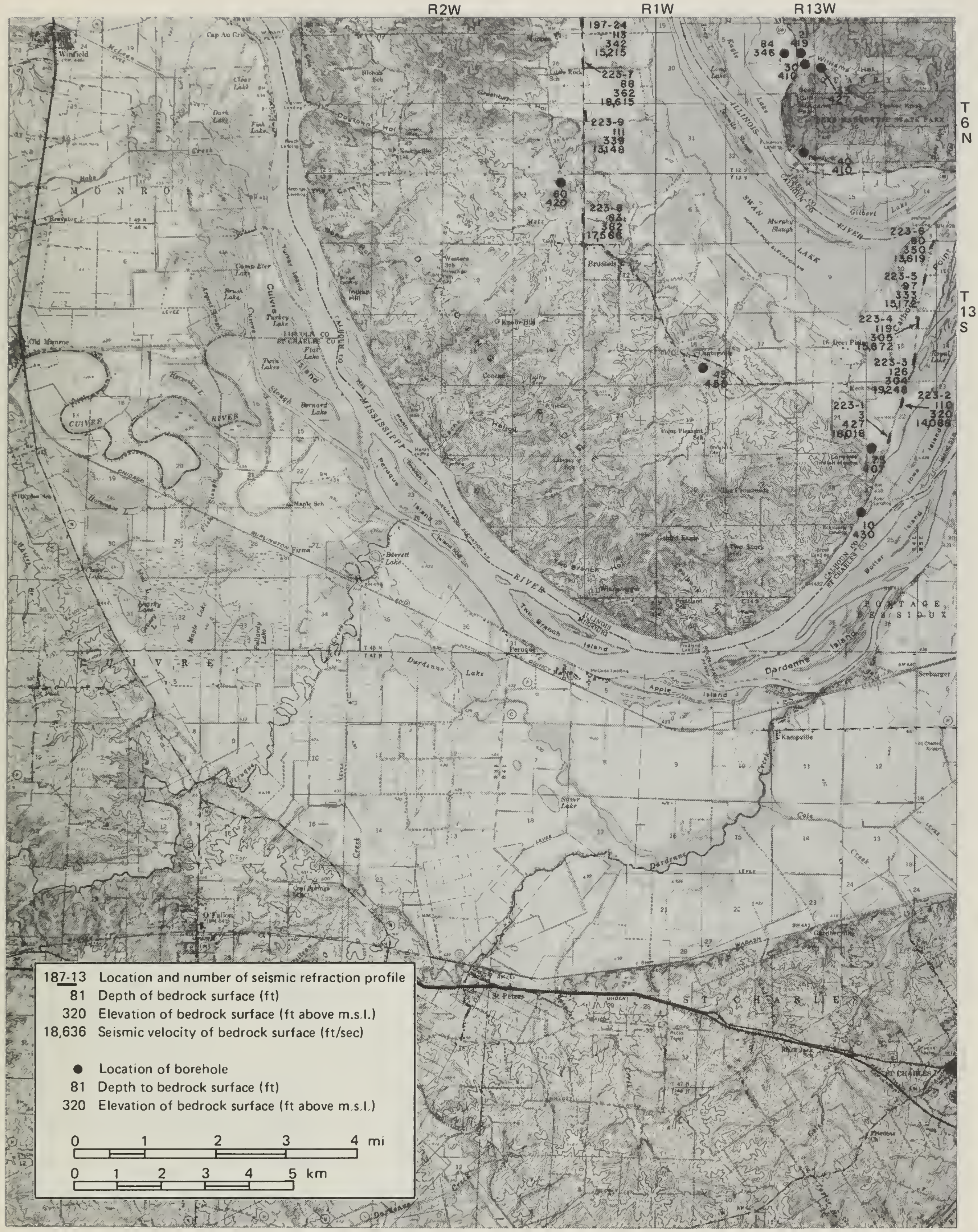

Figure 4f. Seismic refraction data and borehole data for the Brussels 15-minute quadrangle.

Figure 4g. Seismic refraction data and borehole data for the St. Charles 15-minute quadrangle.

TABLE 1. Summary of results of a seismic refraction survey of the lower Illinois valley bottomlands

Line	Profile number	Location Sec.	T.	R.	Velocities $\bar{v}_1$ (ft/sec)	$\bar{v}_2$ (ft/sec)	$\bar{v}_3$ (ft/sec)	Thicknesses z_1 (ft)	z_2 (ft)	z_{total} (ft)	Surface elevation (ft above m.s.l.)	Bedrock elevation (ft above m.s.l.)
La Grange	162-14	11	17N	13W	1,250	5,146	16,868	12	69	81	427	346
	162-15	12	17N	13W	1,250	5,012	15,344	6	59	65	430	365
	162-16	7	17N	12W	1,250	5,298	16,107	7	76	83	432	349
	161-1	7	17N	12W	1,250	5,441	14,970	6	65	71	438	367
	161-2	8	17N	12W	1,250	5,291	14,894	8	71	79	440	361
	161-3	8	17N	12W	1,250	4,748	16,463	10	90	100	441	341
	161-4	9	17N	12W	1,250	5,052	13,862	9	80	89	450	361
	161-5	9	17N	12W	1,250	5,265	16,379	8	98	106	458	352
	161-6	11	17N	12W	1,250	5,208	16,888	9	117	126	460	334
	161-7	12	17N	12W	1,250	5,628	12,596	23	101	124	475	351
	161-8	7	17N	11W	1,250	5,628	10,462	18	64	82	478	396
	161-9	7	17N	11W	1,250	4,554	11,720	9	64	73	477	404
	161-10	7	17N	11W	1,250	4,464	14,280	11	48	59	480	421
Meredosia	162-1	5	16N	2W	1,250	5,555	17,856	11	35	46	449	403
	162-2	4	16N	2W	1,250	4,773	16,752	6	49	55	439	384
	162-3	4	16N	2W	1,250	4,761	17,057	5	62	67	435	368
	162-4	4	16N	2W	1,250	5,000	18,468	6	67	73	432	359
	162-5	3	16N	2W	1,250	5,756	15,299	13	64	77	434	357
	162-6	2	16N	2W	1,250	4,554	15,239	9	61	70	435	365
	162-7	2	16N	2W	1,250	5,012	17,662	7	67	74	432	358
	162-8	1	16N	2W	1,250	5,000	17,526	4	67	71	430	359
	162-9	1	16N	2W	1,250	5,132	17,000	6	65	71	428	357
	162-10	23	16N	13W	1,250	4,761	16,747	14	71	85	449	364
	162-11	23	16N	13W	1,250	4,871	17,083	11	76	87	443	356
	162-12	24	16N	13W	1,250	5,012	14,938	13	65	78	448	370
	162-13	24	16N	13W	1,250	4,583	18,914	12	69	81	453	372
Oxville	169-9	34	15N	14W	1,250	4,975	17,574	3	74	77	429	352
	169-10	35	15N	14W	1,250	5,012	18,332	4	75	79	429	350
	169-11	26	15N	14W	1,250	5,132	18,146	5	74	79	431	352
	169-12	25	15N	14W	1,250	4,554	18,943	4	75	79	432	353
	169-13	30	15N	13W	1,250	5,292	17,325	8	81	89	438	349
	169-14	30	15N	13W	1,250	5,278	17,157	13	68	81	440	359
	169-15	32	15N	13W	1,250	5,000	16,421	13	38	51	440	389
	169-16	29	15N	13W	1,250	5,000	17,017	14	30	44	440	396
Florence	169-3	30	14N	13W	1,250	5,000	16,185	8	71	79	429	350
	169-1	30	14N	13W	1,250	5,077	16,361	9	83	92	422	330
	169-2	29	14N	13W	1,250	4,715	15,302	8	66	74	427	353
	169-4	29	14N	13W	1,250	5,000	16,962	6	67	73	422	349
	169-5	33	14N	13W	1,250	5,319	16,591	12	74	86	426	340
	169-6	33	14N	13W	1,250	4,674	15,236	13	66	79	429	350
	169-7	34	14N	13W	1,250	4,881	18,660	18	61	79	440	361
	169-8	34	14N	13W	1,2504	4,563	16,725	16	50	66	447	381
Montezuma	169-17	20	13N	13W	1,250	4,260	17,593	7	128	135	441	306
	169-18	20	13N	13W	1,250	5,185	19,696	4	157	161	437	276
	169-19	21	13N	13W	1,250	5,405	17,878	6	159	165	430	265
	169-20	21	13N	13W	1,250	5,522	12,351	13	133	146	429	283
	169-21	22	13N	13W	1,250	5,225	10,554	13	123	136	432	296
	169-22	22	13N	13W	1,250	5,267	7,642	9	72	81	435	354
	169-23	22	13N	13W	1,250	5,576	7,369	12	74	86	437	351
Pearl	194-1	25	12N	14W	1,250	5,255	13,113	6	98	104	421	317
	194-2	30	12N	13W	1,250	5,479	12,974	9	103	112	422	310
	194-3	19	12N	13W	1,250	5,356	11,974	16	106	122	421	299
	194-4	20	12N	13W	1,250	5,327	12,303	14	106	120	422	302
	194-5	20	12N	13W	1,250	5,454	12,507	13	117	130	423	293
	194-6	21	12N	13W	1,250	5,452	17,812	9	139	148	424	276

TABLE 1. *(continued)*

Line	Profile number	Location Sec.	T.	R.	Velocities $\bar{v}_1$ (ft/sec)	$\bar{v}_2$ (ft/sec)	$\bar{v}_3$ (ft/sec)	Thicknesses z_1 (ft)	z_2 (ft)	z_{total} (ft)	Surface elevation (ft above m.s.l.)	Bedrock elevation (ft above m.s.l.)
Pearl (cont.)	194-7	21	12N	13W	1,250	5,559	12,989	10	131	141	425	284
	194-8	21	12N	13W	1,250	4,605	14,704	4	133	137	427	290
Kampsville	194-16	27	8S	2W	1,250	5,000	19,929	9	33	42	430	388
	194-9	13	10N	14W	1,250	4,773	17,991	3	84	87	425	338
	194-10	7	10N	13W	1,250	5,000	18,901	3	93	96	424	328
	194-11	18	10N	13W	1,250	5,237	18,274	2	87	89	423	334
	194-12	7	10N	13W	1,250	5,247	21,811	4	80	84	422	338
	194-13	17	10N	13W	1,250	5,264	19,199	8	87	95	430	335
	194-14	17	10N	13W	1,250	5,008	17,668	12	83	95	438	343
	194-15	16	10N	13W	1,250	4,693	15,304	14	96	110	460	350
Michael	197-9	34	9S	2W	1,250	5,128	20,675	7	77	84	438	354
	197-8	35	9S	2W	1,250	5,132	18,214	10	65	75	432	357
	197-11	18	9N	13W	1,250	4,854	19,138	8	89	97	425	328
	197-12	18	9N	13W	1,250	5,562	16,779	6	85	91	420	329
	197-13	18	9N	13W	1,250	5,376	18,768	5	85	90	418	328
	197-14	8	9N	13W	1,250	5,525	18,209	5	98	103	420	317
	197-10	16	9N	13W	1,250	4,879	15,654	20	82	102	440	338
Hardin	197-18	12	8N	14W	1,250	5,426	16,667	4	166	170	427	257
	197-16	7	8N	13W	1,250	5,416	10,792	8	131	139	426	287
	197-17	6	8N	13W	1,250	4,912	12,698	8	141	149	426	277
	197-15	6	8N	13W	1,250	4,499	9,611	9	74	83	425	342
	197-19	5	8N	13W	1,250	4,777	13,826	6	62	68	425	357
	197-20	5	8N	13W	1,250	5,000	19,322	7	60	67	430	363
Nutwood	197-7	26	11S	2W	1,250	5,001	15,910	11	119	130	454	324
	195-5	26	11S	2W	1,250	4,766	15,698	7	123	130	446	316
	197-6	26	11S	2W	1,250	4,834	15,486	5	119	124	433	309
	197-1	31	8N	13W	1,250	4,715	17,720	2	126	128	422	294
	197-4	5	7N	13W	1,250	4,045	18,301	2	108	110	419	309
	197-3	32	8N	13W	1,250	5,201	16,792	3	119	122	420	298
	197-2	32	8N	13W	1,250	5,437	12,744	8	88	96	433	337
Rosedale	197-22	13	12S	2W	1,250	4,360	16,777	5	124	129	450	321
	197-21	13	12S	2W	1,250	5,216	16,467	9	116	125	440	315
	197-25	29	7N	13W	1,250	5,379	18,424	4	105	109	434	325
	197-26	28	7N	13W	1,250	5,000	17,604	4	91	95	434	339
	197-27	28	7N	13W	1,250	4,881	18,754	6	61	67	434	367
Calhoun Point	223-1	22	13S	1W	1,250		18,018	3	0	3	430	427
	223-2	22	13S	1W	1,250	4,202	14,088	11	99	110	430	320
	223-3	15	13S	1W	1,250	5,058	19,248	13	113	126	430	304
	223-4	15	13S	1W	1,250	5,240	15,872	12	107	119	424	305
	223-5	10	13S	1W	1,250	5,644	15,172	15	82	97	430	333
	223-6	10	13S	1W	1,250	5,881	13,619	13	67	80	430	350
North-south	169-25	32	14N	13W	1,250	5,441	17,144	8	70	78	424	346
line between	169-24	5	13N	13W	1,250	5,884	8,796	6	85	91	426	335
Florence and	169-28	8	13N	13W	1,250	5,502	8,000	9	75	84	428	344
Montezuma	169-27	9	13N	13W	1,250	5,781	14,472	8	141	149	427	278
lines	169-26	16	13N	13W	1,250	5,789	17,362	8	151	159	427	268
North-south	197-23	23	12S	2W	1,250	3,735	14,936	11	102	113	472	359
line between	197-24	23	12S	2W	1,250	4,759	15,251	4	109	113	455	342
Meppen and	223-7	26	12S	2W	1,250	3,378	18,615	11	77	88	450	362
Brussels across	223-9	36	12S	2W	1,250	5,000	13,148	8	103	111	450	339
Cap au Grès	223-8	2	13S	2W	1,250	4,861	17,568	7	56	63	445	382
Faulted Flexure												

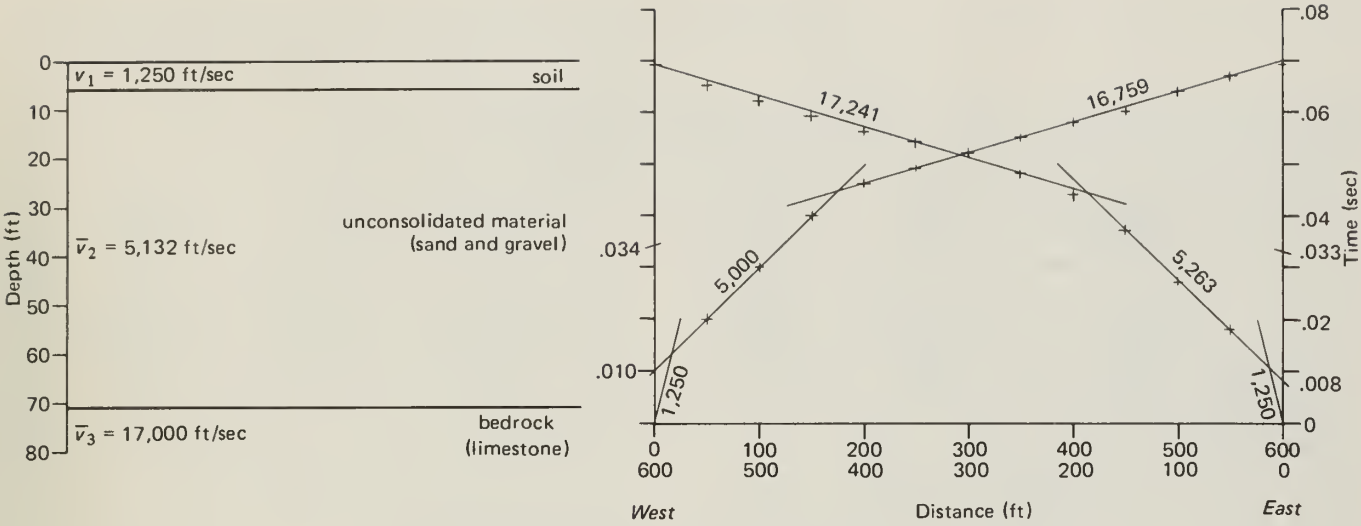

Figure 5. Typical graph of travel time as a factor of distance and interpretation for the seismic refraction profile of the lower Illinois Valley bottomlands.

susceptible to erosion than the bedrock surface immediately to the north. Bedrock seismic velocities along the Montezuma line show considerable variation, from 7,396 to 19,696 ft/sec. The lower velocities probably correspond to the shaly rocks forming the bedrock surface along the line. The higher velocities are indicative of carbonates.

A north-south line consisting of five seismic refraction profiles between the Florence and the Montezuma lines more accurately defines the decrease in elevation of the bedrock surface to the south and shows a variation in seismic velocities in the bedrock indicative of lithologic change on the bedrock surface. Still further to the south, along the Pearl line, bedrock elevation is as low as 276 feet. Again, bedrock velocities indicate variation in bedrock lithology. It appears that along the Pearl line, just as along the Montezuma line, erosion has removed much of the soft, clastic rock (on the order of 50 to 60 feet).

The next line to the south, near Kampsville in Calhoun County, shows bedrock elevations similar to those at Florence. Moreover, bedrock velocites are extremely high all along the Kampsville line. According to figure 3, the oldest rocks at the bedrock surface there are Silurian dolomites. Velocities of these rocks are the highest encountered anywhere in the seismic refraction survey. These rocks are also resistant to erosion, perhaps more so than the lower Valmeyeran rocks north of Florence. At Michael in Calhoun County, bedrock elevations and bedrock velocities are similar to those along the Kampsville line, indicative of the similarity in lithology between the two lines.

At Hardin, bedrock elevation at station 197-18 is 257 feet above mean sea level, the lowest bedrock elevation observed in the survey. Figure 3 shows that the oldest rocks at the bedrock surface belong to the Maquoketa Shale Group (Ordovician). Bedrock velocities along this line vary through a range similar to that along lines to the north where bedrock elevations are anomalously low. The soft Maquoketa rocks have apparently been eroded in much the same manner as younger clastics (Kinderhookian and Upper Devonian) to the north.

South of the Hardin line, bedrock elevations are similar to those immediately north of Hardin. From there to the junction of the Illinois and Mississippi Rivers at Grafton, Illinois, bedrock elevations are typical of those in a smoothly graded bedrock valley. No significant irregularities in bedrock elevation are apparent across the Cap au Grès Faulted Flexure, which traverses the valley in an east-west direction between the Rosedale and Calhoun Point lines (figs. 2 and 4; table 1).

In an attempt to portray graphically the variations in declivity along the thalweg of the bedrock valley from La Grange on the north to Calhoun Point on the south, we selected the profile showing the lowest bedrock elevation along each east-west seismic refraction line traversing the bottomlands. The straight-line distances between these profiles on successive lines were measured, and each profile was assigned a distance relative to the profile that had the lowest bedrock elevation on the La Grange line by summing the increments. The graph of the lowest bedrock elevations plotted against distance from the La Grange profile represents an approximate profile of the bedrock valley thalweg (fig. 6).

Along the thalweg profile, the extremely low elevations at Montezuma, Pearl, and Hardin are apparent. If these low points are disregarded and a least-square line is fit to the remaining points, the average slope is .62 ft/mi (7.4 in./mi). This value seems reasonable for a major pre-Pleistocene drainage line. The present-day Illinois River, which flows on unconsolidated sediments from Kampsville to its mouth, has a gradient of 1 in./mi there (Rubey, 1952). All of the low bedrock elevation points along the thalweg have bedrock velocities ranging from 16,467 to 19,248 ft/sec. This range indicates that relatively hard, erosion-resistant rocks

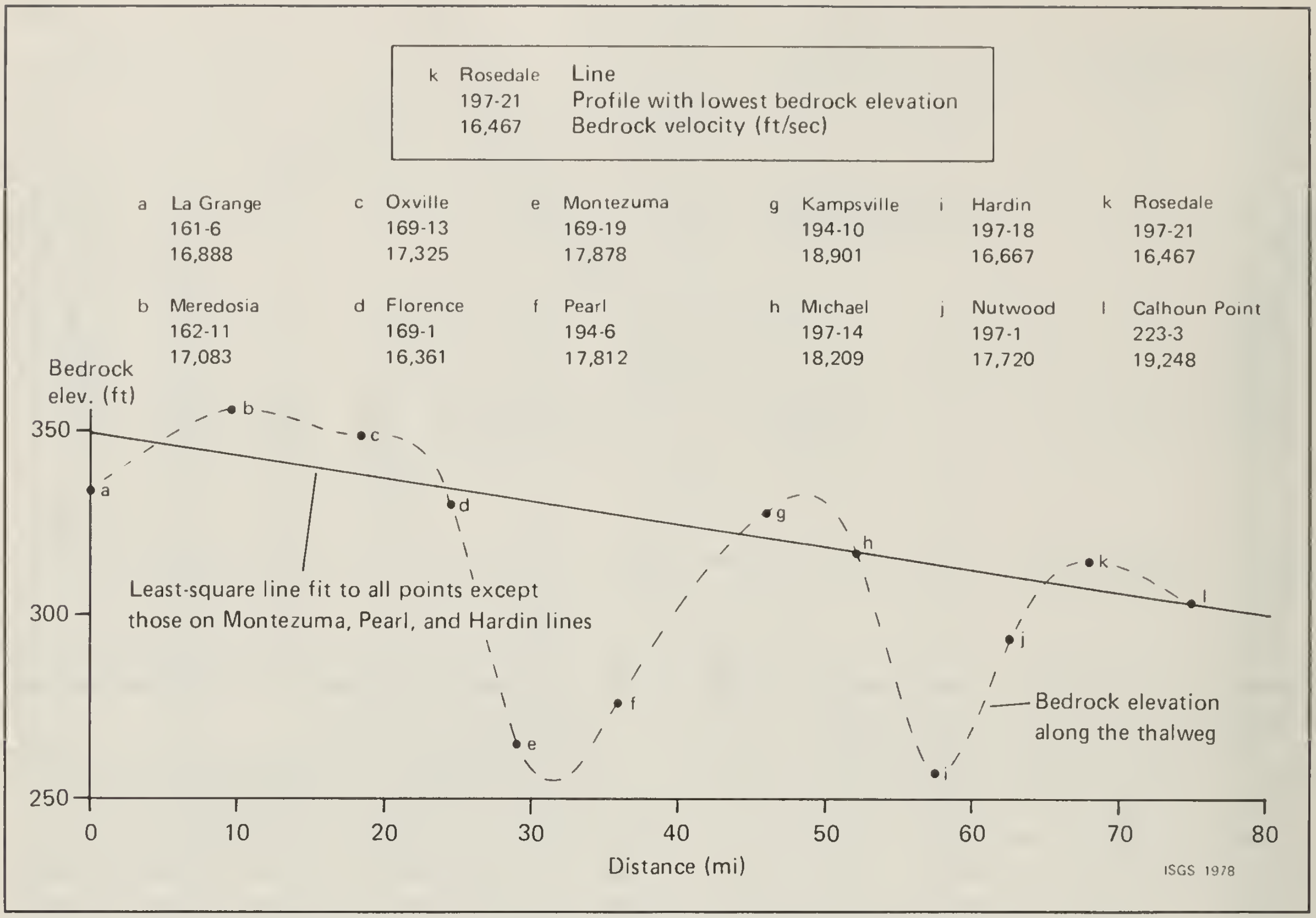

Figure 6. Thalweg profile of the lower Illinois bedrock valley based on seismic refraction data (elevation datum: m.s.l.).

form the bedrock surface at most points along the thalweg. Where bedrock elevations are anomalously low, weak, predominantly clastic rocks have apparently been eroded through their entire thickness and removed.

The variations in declivity along the thalweg of the lower Illinois bedrock valley raise several questions about their origin and preservation. Large localized irregularities in declivity are usually associated with the youthful and early maturity stages of the fluvial geomorphic cycle (Davis, 1930). Where resistant rocks overlie weak rocks, waterfalls, rapids, and related phenomena are likely to occur. During the old-age stage, these features would normally be greatly reduced and the land surface would again be close to grade. The observed phenomena may be youthful products of an early stage in the geomorphic cycle which have been preserved by subsequent fluvial deposition. A possible explanation is that at one point in the history of the valley a large volume of water of great velocity and short duration traversed this portion of the valley. Ekblaw and Athy (1925) called this the Kankakee Torrent. Traction and corrasion reached a maximum along the narrower stretches of the valley. Waterfalls, rapids, cascades, and plunge-pools were formed. When the flood subsided, much of the load was dropped, covering and preserving bedrock features below.

It is likely during the short duration of the flood that some tributary valleys did not possess the erosive power of the main stream. They were probably backed up with water from the main stream, and, as a result, their junctions with the main stream could have become discordant. When the water subsided and aggradation began, the mouths of these tributaries were filled as well. Subsequent down-cutting in the tributaries proceeded until new base levels accordant with those of the main stream were reached.

Another explanation of the erosion of the bedrock surface in the bottomlands involves glacial ice as the erosional agent. McGinnis and Heigold (1974), in a seismic refraction survey of the Meredosia channel area of north-eastern Illinois, have found evidence of sizable grooves cut in Silurian dolomite bedrock by pre-Illinoian glaciers. Figure 3 shows the Illinoian ice sheet advanced as far south as Pearl in Pike County on the west side of the valley. The map further shows the ice front traversed the bottomlands to Nutwood in Jersey County on the east side of the valley and then passed southeastward into Jersey County. Pre-Illinoian glaciers also could have entered the bottomlands. Ice moving down the valley in Illinoian time would have been thicker over the bottomlands, and its erosive powers would have been greater there. Scouring and plucking action could have lowered the bedrock surface everywhere, and in areas where weak rocks were encountered, erosion and downcutting would have been enhanced. In the middle of the valley, soft, clastic rocks could have been ground down. Hard, resistant rocks would have presented more durable barriers to the erosional action of the glacier. Only on the sides of the valley or in more protected areas would soft, clastic bedrock be expected to survive. Seismic refraction data show this to be the case (Montezuma line profiles 169-22 and 169-23). Drift from the melting ice would have covered these bedrock anomalies. Undoubtedly the junctions of many tributary valleys with the main valley would have been left in a discordant state. Another factor to be considered in the erosion and deposition associated with glacial ice is forebulge or crustal upwarping beyond the limit of a glacier (Frye, 1963). This phenomenon could have been responsible for anomalous rates of erosion and gradients on the bedrock surface, especially along those stretches of the valley where soft, clastic rocks originally formed the bedrock surface.

Perhaps the observed bedrock surface in the lower Illinois Valley bottomlands does not require such powerful erosional agents to account for its present configuration. Given a regional slope such as shown in figure 6 for the lower Illinois bedrock valley thalweg, it may have been normal for soft, clastic rocks forming the bedrock surface between hard, resistant carbonates to have been eroded to depths of 50 to 70 feet over distances of several miles. The bedrock surface in Illinois represents a considerable erosional unconformity. There would have been ample time for such downcutting to take place. Still, there can be little doubt that the bedrock surface in the bottomlands was modified somewhat by additional, complex Pleistocene glacio-fluvial processes.

SUMMARY

Seismic refraction profiling in the lower Illinois Valley bottomlands revealed that the configuration of the bedrock topography is largely controlled by bedrock lithology. Rocks having high seismic velocities, such as the Burlington and Keokuk Formations (Mississippian) and Silurian dolomites, have, in general, retained a uniform gradient along the thalweg of the bedrock valley typical of pre-Pleistocene drainage lines of the Midcontinent region. Predominantly clastic rock sections, such as the Kinderhookian Series (Mississippian), the Upper Devonian Series, and the Maquoketa Group of the Cincinnatian Series (Ordovician), have been deeply eroded, causing sizable variations in declivity on the bedrock surface. In those areas, anomalously large thicknesses of unconsolidated sediments, the primary aquifers of the region, rest on the bedrock surface.

In addition to ordinary fluvial erosion and deposition, the formation and preservation of the present bedrock configuration in the lower Illinois Valley bottomlands may have resulted from unique geologic events such as the Kankakee Torrent or possibly the advance and retreat of large ice caps. Perhaps Illinoian or pre-Illinoian glaciers could have traversed portions of the lower Illinois Valley bottomlands.

Seismic refraction data were insufficient to ascertain unequivocally the presence of glacial till in the unconsolidated bottomland sediments, and existing borehole data have not provided such information. Perhaps future drilling will encounter glacial till and clarify the role ice played in the geologic history of the area.

BIBLIOGRAPHY

Bergstrom, Robert, and Arthur J. Zeizel, 1957, Groundwater geology in western Illinois, south part: Illinois State Geological Survey Circular 232, 28 p.

Davis, W. M., 1930, Rock floors in arid and humid climates: Journal of Geology, v. 38, p. 1-27 and 136-158.

Douthit, T. D. N., 1959, Magnetic survey of the Cap au Grès Faulted Flexure, unpublished master's thesis (research): Saint Louis University, St. Louis, Missouri.

Ekblaw, George E., and L. F. Athy, 1925, Glacial Kankakee Torrent in northeastern Illinois: Geological Society of America Bulletin, v. 36, no. 2, p. 417-427.

Engeln, Oscar Diedrich von, 1942, Geomorphology: Macmillan Company, New York, 655 p.

Frye, J. C., 1963, Problems of interpreting the bedrock surface of Illinois, Illinois Academy of Science Transactions, v. 56, no. 1, p. 3-11.

Grohskopf, J. G., 1933, Magnetic surveys: Missouri Bureau of Geology and Mines, 57th biennial report, app. 4, 20 p.

Horberg, Leland, 1957, Bedrock surface of Illinois (1:250,000): Illinois State Geological Survey, 2nd ed.

Krey, Frank, 1924, Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Illinois State Geological Survey Bulletin 45, 86 p.

Mateker, E. J., Jr., 1956, Gravity survey of the Cap au Grès Structure in the Hardin-Brussels quadrangles, Illinois: Unpublished bachelor's thesis, Saint Louis University, St. Louis, Missouri.

McGinnis, L. D., and P. C. Heigold, 1974, A seismic refraction survey of the Meredosia channel area of northwestern Illinois: Illinois State Geological Survey Circular 488, 19 p.

Piskin, Kemal, and R. E. Bergstrom, 1967, Glacial drift in Illinois: Thickness and character: Illinois State Geological Survey Circular 416, 33 p.

Piskin, Kemal, and R. E. Bergstrom, 1975, Glacial drift in Illinois: Thickness and character: Illinois State Geological Survey Circular 490, 35 p.

Rubey, William W., 1952, Geology and mineral resources of the Hardin and Brussels quadrangles (in Illinois): U.S.G.S. Professional Paper 218, 179 p.

Willman, H. B., 1973, Geology along the Illinois Waterway—A basis for environmental planning: Illinois State Geological Survey Circular 478, 48 p.

Willman, H. B., and J. C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey Bulletin 94, 204 p.

Willman, H. B., and others, 1967, Geologic map of Illinois (1:500,000): Illinois State Geological Survey.

Workman, L. E., and A. H. Bell, 1949, Deep drilling and deeper oil possibilities in Illinois: Illinois State Geological Survey Report of Investigations 139, p. 2043.

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