PRINTED BY AUTHORITY OF THE STATE OF INDIANA
EVAN BAYH, GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
PATRICK R. RALSTON, DIRECTOR

GEOLOGICAL SURVEY
NORMAN C. HESTER, STATE GEOLOGIST

MISCELLANEOUS MAP 52

Table 1. Locations, types, and ages of measured outcrops and averages, means, standard deviations, and numbers of measurements of joints and fractures

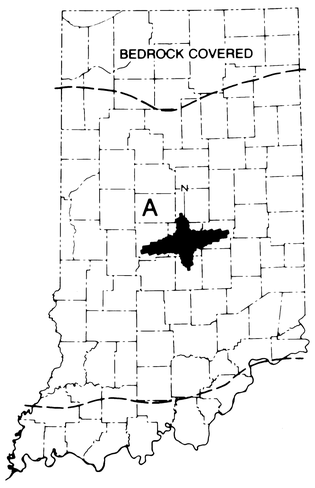
County	Location	Outcrop type	Gross lithology	Period	Measurements	Selected degree ranges	Average	Median	Std. dev.
Adams	SW SW 31-25N-15E	Qry-reef	dol	Sil	48	50-110	82.4	81.0	13.0
Adams	SE SE 33-26N-13E	Qry	dol	Sil	32	60-90	76.8	76.0	6.6
Adams	C sec. 4-26N-15E	Qry-reef	dol	Sil	31	50-85	69.0	69.0	10.6
Allen	SE SW 28-29N-13E	Qry-reef	dol	Sil	22	45-100	74.7	78.0	13.4
Allen	NE 29-30N-12E	Qry-reef	dol	Sil-Dev	28	50-75	62.1	62.5	6.0
						50-120	77.1	68.0	21.2
Allen	NW NE 23-31N-14E	Qry	dol	Sil-Dev	30	75-100	82.3	81.0	7.6
Bartholomew	NW SW 5- 8N- 7E	Qry	ls-dol	Sil-Dev	50	60-95	76.7	76.5	7.4
Blackford	SW NW 3-24N-11E	Qry-reef	dol	Sil	33	50-120	89.8	91.0	18.4
Brown	SW NE 26- 9N- 2E	Rdct	sh-ss	Miss	53	75-115	92.9	92.5	8.2
Brown	NE NW 28- 9N- 4E	Rdct	sh-ss	Miss	52	50-85	64.8	62.0	9.3
Carroll	N1/2SW 19-25N-2W	Qry-reef	dol	Sil-Dev	30	40-80	63.1	65.0	10.7
Cass	NW SE 28-27N- 1E	Qry	ls-dol	Sil	31	55-100	73.4	72.0	7.4
Cass	NE 27-27N- 2E	Qry	ls-dol	Sil-Dev	31	50-80	67.6	68.0	5.9
Clark	S1/4 CMG 121	Otc	ls-dol	Sil-Dev	41	80-155	114.8	111.0	16.8
Clark	C'EL.C MG 252	Otc	sh-ls	Dev	53	70-90	79.3	78.0	3.0
Clay	SE SE 2-13N- 7W	Rdct	ss	Penn	43	55-85	66.2	68.0	6.2
						35-55	41.5	41.0	4.8
Crawford	NW SE 24- 3S- 1W	Rdct-otc	ls	Miss	64	65-90	79.5	79.0	7.2
						10-30	17.2	18.0	5.1
Daviess	SW NW 5- 2N- 5W	Mine	coal-sh-ss	Penn	30	75-85	78.8	79.0	2.6
Daviess	NW NW 15- 5N- 5W	Rdct-otc	ss	Penn	42	40-85	69.6	67.0	13.9
Dearborn	NW NW 6- 4N- 1W	Qry-otc	sh-sls	Ord	45	10-25	17.6	17.5	4.9
						100-130	110.1	108.0	8.3
Decatur	NE SW 28-10N- 9E	Qry	ls	Sil	53	40-105	78.2	78.0	14.0
Decatur	SW SW 8-10N-11E	Qry	ls	Sil	53	60-115	83.8	84.0	11.0
Delaware	NW SE 20-20N- 9E	Qry	dol	Sil	33	65-90	78.6	78.0	6.0
Delaware	NE 25-21N-10E	Qry	dol	Sil	24	65-90	77.7	77.0	5.6
Dubois	SE SW 20- 2S- 4W	Rdct-otc	ss	Penn	57	0-50	27.0	28.0	13.7
Fayette	NW NW 19-14N-12E	Otc	ss	Ord	39	60-90	74.8	74.0	7.0
Floyd	NW 1- 3S- 6E	Otc	sh	Dev	55	70-85	76.9	77.0	3.2
Fountain	CSL NE 8-19N- 6W	Otc	sh	Penn	46	50-85	62.1	63.0	15.0
Fountain	NW SE 13-21N- 8W	Qry	ss	Penn	45	40-90	65.3	66.0	15.9
Franklin	SW SE 25- 8N- 2W	Otc	sh-sls	Ord	26	90-130	110.6	109.5	12.4
Franklin	CE NE 35-10N- 2W	Rdct	sh-sls	Ord	27	50-80	64.5	63.5	8.4
Franklin	SW SW 20-12N-12E	Qry	ls	Sil	53	65-95	78.6	76.0	7.4
Gibson	NE NW 22- 1S-10W	Rdct	ss	Penn	40	60-85	69.3	69.0	6.1
Grant	NE 12-23N- 6E	Qry-reef	ls-dol	Sil	32	75-110	88.3	87.0	9.0
						110-140	121.5	120.0	10.0
Grant	N 1/2 2-24N- 6E	Qry	dol	Sil	50	55-90	71.2	71.5	5.7
Grant	SE NE 31-25N- 8E	Otc	dol	Sil	78	25-55	41.2	42.0	7.6
						60-100	78.9	77.0	9.3
Greene	SE SE 2- 6N- 5W	Rdct	ss	Penn	58	65-100	82.6	82.0	8.1
Greene	SW NE 18- 8N- 7W	Mine	coal-sh-ss	Penn	30	70-95	81.1	82.0	4.2
Hamilton	SW 9-17N- 4E	Qry-mine	ls-dol	Sil-Dev	73	75-90	80.9	81.0	2.8
Hamilton	SE NE 3-18N- 5E	Qry	ls	Sil	37	70-85	76.4	76.0	4.5
Harrison	NW SE 4- 3S- 3E	Qry-otc	ls	Miss	23	75-85	78.5	78.5	3.8
Harrison	NW SW 34- 5S- 3E	Rdct	ls	Miss	56	5-40	22.1	23.0	9.0
						95-120	112.6	113.5	4.3
Hendrick	CW1/2 34-16N- 1E	Otc	sh-sls	Miss	51	50-110	77.9	76.0	13.7
						60-68	70.6	72.5	6.2
Howard	NE 3-23N- 3E	Qry	dol	Sil	59	65-90	76.9	76.0	4.4
Huntington	SE SE 11-27N-10E	Qry-reef	dol	Sil	31	55-90	70.4	70.5	10.0
Huntington	SE 12-28N- 9E	Qry-reef	dol	Sil	25	50-80	66.9	69.0	7.0
						95-115	104.2	104.5	4.2
Jackson	NE NE 14- 6N- 2E	Rdct-otc	sh-ss	Miss	30	85-115	101.0	102.5	8.8
Jackson	NW NE 29- 6N- 4E	Otc	ss	Miss	23	65-95	82.7	84.0	6.0
Jasper	SE SE 30-29N- 6W	Qry-reef	dol	Sil	38	60-90	77.3	78.0	8.1
Jay	CW NW 30-23N-14E	Qry	dol	Sil	31	70-100	84.2	83.0	6.3
Jefferson	SW NE 18- 2N-10E	Qry-otc	ls-dol	Ord-Sil	31	95-130	113.9	117.0	8.3
Jefferson	SW NW 13- 4N- 8E	Qry-otc	ls	Sil-Dev	40	65-100	79.5	81.0	9.0
Jefferson	C NW 24- 4N-10E	Otc	ls-dol	Sil	54	70-105	90.7	92.0	10.3
Jennings	CE1- NE 25- 6N- 9E	Qry-otc	ls	Sil	96	95-120	105.7	103.0	7.6
Jennings	CS1-2 27- 7N- 8E	Qry	ls-dol-sh	Sil-Dev	78	60-80	68.5	68.0	4.0
						30-60	40.2	39.0	7.4
Johnson	NE NE 17-11N- 5E	Otc	sh	Dev	40	125-140	131.8	133.0	4.4
Knox	SW NW 3- 4N- 8W	Mine	coal-sh-ss	Penn	27	70-100	81.8	82.0	7.5
Lawrence	NW NE 34- 5N- 1W	Rdct	ls	Miss	43	50-85	71.1	72.5	6.5
Madison	NW NE 10-18N- 7E	Qry	ls-dol	Sil	16	80-100	88.7	86.5	6.8
Marion	NE 23-15N- 3E	Qry-mine	ls-dol	Sil-Dev	169	65-100	83.9	82.0	5.1
Martin	SW SW 15- 3N- 3W	Rdct	ss	Penn	56	60-100	86.1	88.5	9.6
Miami	CW1/2 29-26N-4E	Qry	ls-dol	Sil-Dev	30	60-100	78.9	78.0	7.9
Miami	SE SW 20-27N- 4E	Qry	ls-dol	Sil	42	70-85	78.6	78.0	4.9
Monroe	SW SW 27- 7N- 1W	Rdct	ls	Miss	23	65-95	81.2	79.5	8.7
Monroe	SE SW 33-10N- 1W	Rdct	ls	Miss	43	50-95	76.9	77.0	9.0
Montgomery	CSL NE 1-18N- 4W	Otc	sh-sh-ls	Miss	57	65-105	83.4	83.0	6.6
Morgan	SW NE 33-12N- 1E	Qry	sh-ss	Miss	36	70-90	82.3	84.0	5.4
						95-115	106.8	107.0	5.5
Orange	SW NW 18- 1S- 1E	Rdct	ss	Miss	35	75-110	89.7	90.0	8.4
Orange	NE NE 36- 2N- 1W	Rdct	ss	Miss	74	65-100	84.7	85.0	5.3
Owen	CWL SE 36-10N- 4W	Rdct	ls	Miss	44	75-110	85.8	84.0	9.2
Parke	SE SE 24-15N- 9W	Rdct-otc	ss	Penn	31	60-85	71.3	72.0	7.0
Parke	SW SW 29-17N- 7W	Otc	ss-sls-sh	Penn	64	70-90	80.7	81.0	5.0
Perry	SE NE 17- 7S- 2W	Otc	ss	Miss	74	15-60	35.9	36.0	9.9
Pike	SW SE 34- 2S- 7W	Mine	coal-ss-sh	Penn	29	60-90	78.2	79.0	6.8
Posey	NW SE 31- 3S-13W	Otes	ss-sh	Penn	17	15-40	28.7	30.0	6.6
Posey	SE 24- 7S-12W	Otes	ls	Penn	17	20-45	34.3	36.5	6.2
Pulaski	SW SE 16-29N- 4W	Qry-reef	dol	Sil-Dev	20	55-80	67.8	70.0	8.6
Putnam	SW NW 1-12N- 4W	Qry	ls	Miss	26	65-95	77.2	75.0	7.8
Putnam	NE NW 15-15N- 4W	Qry	ls	Miss	34	55-100	74.8	74.5	11.3
Putnam	SW SE 30-16N-5W	Otc	ls	Miss	46	55-95	79.6	78.0	7.5
Randolph	NW SW 11-21N-12E	Qry	dol	Sil	37	60-90	77.2	78.0	8.0
Randolph	NE SE 12-21N-13E	Qry	dol	Sil	43	60-90	73.4	74.0	7.2
Ripley	SE NW 26- 7N-11E	Qry	ls	Sil	37	70-105	84.5	84.0	8.1
Ripley	SW SW 21- 9N-11E	Qry	ls	Sil	59	50-95	79.7	83.5	9.7
Rush	SW SE 8-12N- 9E	Qry	ls-dol	Sil	17	70-90	77.2	77.0	4.8
Scott	NE NW 29- 3N- 8E	Qry	sh-ls-dol	Sil-Dev	52	50-95	75.6	76.0	7.5
Scott	SE SE 9- 4N- 7E	Qry	sh	Dev	21	70-85	76.7	75.0	4.5
Shelby	NE SW 32-11N- 7E	Qry	ls-dol	Sil-Dev	51	65-90	79.6	81.0	5.5
Spencer	NE NE 35- 6S- 5W	Qry	ss	Penn	54	25-55	36.8	37.0	6.6
Sullivan	NW NE 25-9N-11W	Otc	sh	Penn	50	30-80	55.1	56.0	10.2
Sullivan	SW SW 7- 7N-10W	Otc	ss	Penn	33	50-85	73.8	74.0	7.3
Switzerland	NE NW 9- 5N-12E	Qry	ls-sh	Ord-Sil	31	35-50	40.6	42.0	5.7
						105-120	109.1	108.0	4.2
						130-160	141.8	141.0	9.6
Tippecanoe	SW NE 15-22N- 6W	Otc	chert-ls	Miss	42	70-80	74.3	74.0	1.5
Vanderburgh	SE SE 22- 4S-10W	Otes	ls	Penn	25	65-95	80.0	81.0	7.0
Vanderburgh	SW SE 34- 5S-10W	Rrct	sh-ss	Penn	35	25-40	32.7	32.0	3.4
						115-135	124.3	125.0	4.8
Vermillion	SE NE 29-13N- 9W	Otc-rrct	ss	Penn	83	60-90	73.1	74.0	8.0
Vigo	NW 30-11N- 8W	Mine	coal-sh-ss	Penn	31	55-80	70.1	72.5	8.0
Wabash	NE RES 11-27N- 5E	Qry-reef	ls-dol	Sil	54	65-90	75.7	75.0	5.2
Wabash	NW NW 2-27N- 7E	Qry	dol	Sil	25	55-80	65.6	66.0	7.6
Warrick	NW NW 6- 5S- 7W	Mine	coal-sh-ss	Penn	28	70-95	83.5	84.0	6.0
Washington	CSL 18- 1S- 5E	Otc	sh-ss	Miss	48	0-20	7.8	6.0	4.8
						80-115	99.3	101.5	10.4
Washington	NW 19- 2N- 4E	Qry	ls	Miss	39	75-100	86.5	87.5	6.5
Washington	NE NW 29- 4N-4E	Otc	sh-ss	Miss	35	65-90	82.1	82.0	4.2
Wayne	NW NE 1-14N- 1W	Qry	ls-dol	Sil	46	65-85	72.0	71.5	5.4
Wells	NW 28-27N-12E	Qry-reef	dol	Sil	45	70-100	85.3	86.0	8.4
						70-135	96.4	94.5	16.9
White	SE 28-28N- 4W	Qry	dol	Sil	32	40-65	49.4	48.0	5.8
						105-135	119.9	123.5	8.8

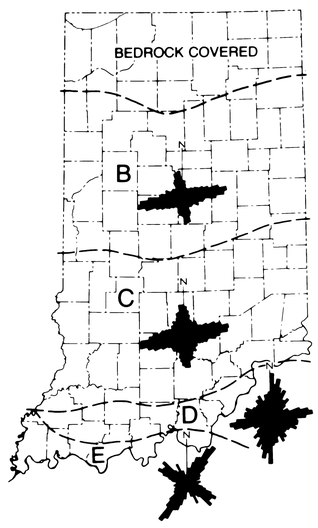
County	Location	Outcrop type	Gross lithology	Period	Measurements	Selected degree ranges	Average	Median	Std. dev.

Abbreviations: CMG-Clark Military Grant, Dev-Devonian, dol-dolomite, ls-limestone, Miss-Mississippian, Ord-Ordovician, otc-outcrop, Penn-Pennsylvanian, qry-quarry, rdct-roadcut, rrct-railroad cut, sh-shale, Sil-Silurian, sls-siltstone, ss-sandstone, std. dev.-standard deviation.

EXPLANATION FOR TABLE 1

Selected degree ranges are well-defined clusters of histogram bars that represent prominent directions of jointing. Within the degree ranges, about two-thirds of the measurements can be expected within one standard deviation from the average and about 95 percent of the measurements can be expected within two standard deviations. This apportionment is only approximate, however, because there is commonly not an exact normal distribution of measurements around the average.





Combined Measurements

Areas A, B, C, D, and E above were selected by examination of the detailed jointing map for histograms with similar orientations. All measurements within each area are in the combined histograms. Area A is divided into B and C to help show the exceptional similarity of jointing directions throughout a large part of the state. Discussions of some of the causes and effects of jointing in Indiana are given by the authors listed under "Selected References on Jointing in Indiana."

Table 2. Selected degree ranges, averages, means, and standard deviations for the above histograms.

Area	Number	Selected degree range	Average	Median	Standard deviation
A	3754	65-90	78.0	78.0	6.5
		60-95	78.1	78.0	8.3
B	1714	70-90	79.4	78.0	5.2
C	2040	65-90	78.0	78.0	6.7
		60-95	78.4	78.0	8.7
D	401	65-90	78.7	80.5	5.9
		0-20	8.8	9.0	6.0
E	253	15-50	33.0	34.0	7.9
		100-140	121.5	122.5	9.4

See explanation for table 1.

EXPLANATION

For this map joints are defined as fractures or partings in rock with little or no discernible displacement. Measurements of joint directions were made with K & E or Brunton surveying compasses. The accuracy of measurements is within 1° or 2°. Measurements were made mostly by sighting along joints with a compass, particularly in quarries and mines where joints exposed on high faces were the only joints that could be measured.

Each joint, whether prominent or obscure or long or short, is counted as one measurement on the equal-area rose histograms shown on this map. The number of measurements of joint directions in 5° arcs is shown by the area of each bar of the histograms.

As far as possible, measurements were made on all mine and quarry faces to prevent directional bias, and care was taken to differentiate blasting fractures from natural joints. (See Ault, 1986, for a discussion of the criteria used in quarries.) Where possible, natural outcrops that allowed measurements of joints in all directions were selected. Some variability in measurements is inherent between investigators or in different visits by the same person because of different recognition and selection of joints to be measured. Major directions of jointing are generally apparent, however, after a sufficient number of measurements at a site, even though the proportionate number of joints measured in each direction may not be exactly reproducible in subsequent visits, particularly in quarries and mines where mining operations remove some joints and reveal others.

SELECTED REFERENCES ON JOINTING IN INDIANA

Ault, C. H., 1988, Cause and effect of jointing in quarries in central and northern Indiana, *in* Colton, G. W., ed., Proceedings of the 22d Forum on Geology of Industrial Minerals: Arkansas Geological Commission Miscellaneous Publication MP-21, p. 17-29.

Ault, C. H., Harper, Denver, Smith, C. R., and Wright, M. A., 1985, Faulting and jointing in and near surface mines of southwestern Indiana: U.S. Nuclear Regulatory Commission Report NUREG/CR - 4117, 27 p.

Ault, C. H., and Haumesser, A. F., 19__, A central Indiana model for predicting jointing characteristics in underground limestone mines: Proceedings of the Forum on Geology of Industrial Minerals: South Carolina Geological Commission [in preparation].

Powell, R. L., 1974, Joints in carbonate rocks in south-central Indiana: Proceedings of the Indiana Academy of Science, v. 84, p. 343-354.

_____ 1976, Some geomorphic and hydrologic implications of jointing in carbonate strata of Mississippian age in south-central Indiana [Ph. D. thesis]: West Lafayette, Ind., Purdue University, 168 p.

ACKNOWLEDGEMENTS

Some measurements of joint directions in the southern quarter of the map were by Christopher Smith and Michele Sims. Jimmy Johnson, systems analyst-programmer for the Indiana Geological Survey, wrote the computer programs for the equal-area histograms and statistical analyses. Quarry and mine operators were most helpful in allowing access to their operations.

This map can be purchased from the Publications Section, Indiana Geological Survey, 611 North Walnut Grove, Bloomington, IN 47405 (812) 855-7636.

Drafted by Lori A. Zinn.

MAP OF INDIANA SHOWING DIRECTIONS OF BEDROCK JOINTING

By Curtis H. Ault

1989

Miscellaneous Map 52