

**BIENNIAL REPORT OF THE DIRECTOR**

**1914-1916**

**AND**

**REPORT ON RETRACEMENT AND PERMANENT**

**MONUMENTING OF THE MICHIGAN-**

**OHIO BOUNDARY**

MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY.

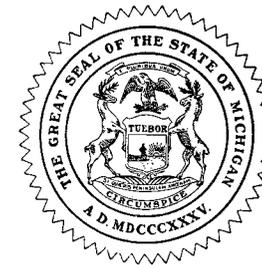
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BIENNIAL REPORT OF THE DIRECTOR

AND

REPORT ON RETRACEMENT AND PERMANENT  
MONUMENTING OF THE MICHIGAN-  
OHIO BOUNDARY.



PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF  
GEOLOGICAL AND BIOLOGICAL SURVEY FOR 1916.

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LANSING, MICHIGAN  
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS  
1916

BOARD OF GEOLOGICAL AND BIOLOGICAL SURVEY, 1916.

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EX OFFICIO:

THE GOVERNOR OF THE STATE,  
HON. WOODBRIDGE N. FERRIS.

THE SUPERINTENDENT OF PUBLIC INSTRUCTION,  
HON. FRED L. KEELER.

THE PRESIDENT OF THE STATE BOARD OF EDUCATION,  
HON. THOMAS W. NADAL.

---

DIRECTOR,  
R. C. ALLEN.

---

SCIENTIFIC ADVISORS.

Geologists.—Dr. L. L. Hubbard, Houghton; Prof. W. H. Hobbs,  
Ann Arbor; Prof. W. H. Sherzer, Ypsilanti.

Botanists.—Prof. E. A. Bessey, East Lansing; Prof. F. C. Newcombe,  
Ann Arbor.

Zoologists.—Prof. W. B. Barrows, East Lansing; Prof. J. Reighard,  
Ann Arbor; Dr. Bryant Walker, Detroit.

LETTER OF TRANSMITTAL.

*To the Honorable, the Board of Geological and Biological Survey of  
the State of Michigan:*

Gov. Woodbridge N. Ferris.

Hon. Fred L. Keeler.

Hon. Thomas W. Nadal.

Gentlemen:—I have the honor to transmit herewith an administrative report for the biennium ending June 30th, 1916, with the recommendation that it be printed and bound as Publication 22, Geological Series 18.

Very respectfully,

R. C. ALLEN,

Director.

Lansing, Michigan,  
July 30, 1916.

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## ORGANIZATION OF THE GEOLOGICAL AND BIOLOGICAL SURVEY.

The Board of Geological Survey was created in 1869 for the purpose of making a thorough *geological* and *mineralogical* survey of the state. In 1905 the Board was authorized and directed to make "a thorough *biological* survey of the state" and to engage with the federal government in a co-operative topographic survey of Michigan. In 1911 the duties which prior had devolved on a Commissioner of Mineral Statistics were transferred to the Board of Geological Survey, and in 1913 co-operative relations were established with the Board of State Tax Commissioners for the appraisal of mines and mineral lands for taxation.

The present organization of the Survey embraces three departments, viz.:

(1) The Geological Survey, including three separate divisions, which are

- (a) Division of Geology,
  - (b) Division of Appraisals,
  - (c) Division of Mineral Statistics.
- (2) The Topographic Survey.
- (3) The Biological Survey.

### EXPENDITURES.

The act of 1869 provides a fund of \$8,000.00 per annum for the Board of Geological Survey, but since 1905 this has been augmented by additional funds, through biennial appropriations by the legislature, necessary for progress with the topographic and biologic surveys and for the discharge of co-operative work with the Board of State Tax Commissioners. The total of appropriations for all purposes, for the fiscal year ending June 30, 1913, was \$20,500.00, and for the fiscal year ending June 30, 1914, \$36,300.00. I submit below classified accounts of expenditures for the biennium showing (1) the actual cost of the various activities and investigations and (2) a classified list of expenditures, as shown on vouchers paid by the State Treasurer

from the continuing or general appropriation and by the Treasurer of the Board of Geological Survey from the special appropriations. I present also the names of the persons employed by the Board of Geological Survey during the biennium, the capacities and length of time in which such persons were employed and total salary received.

EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY.  
1914-1915 and 1915-1916. (Fiscal years ending June 30th.)

Work.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
							Permanent.	Incidental.
Topographic survey, 1914-1915 and 1915-1916. . . . .	\$13,960 86	\$6,565 89	\$4,642 09	\$2,555 24			\$85 47	\$112 17
Appraisal of mines, 1914-1915 and 1915-1916. . . . .	11,192 62	9,678 56	497 33	402 79			317 71	296 23
General and miscellaneous office and correspondence work, etc., 1914-1915 and 1915-1916. . . . .	9,268 50	8,322 78	25 68	78 78	\$17 00	\$120 86	370 26	333 14
Michigan-Ohio Boundary line re-survey, 1915-1916. . . . .	4,006 31	2,262 53	622 24	416 88	24 50	635 98		44 18
Biological Survey, 1914-1915 and 1915-1916. . . . .	2,805 87	2,696 38	1 75	16 34	12 25			79 15
Geological Survey of west end of the Marquette range, 1915-1916. . . . .	2,458 44	1,606 86	263 30	332 43	48 40	40 80	4 00	162 65
Geological Survey of east end of Gogebic range, 1914-1915. . . . .	2,156 14	1,520 83	282 95	160 89	36 10	13 00	15 50	144 87
Mineral statistics, 1914-1915 and 1915-1916. . . . .	2,028 20	1,742 19	3 65	9 00	5 16		13 22	254 98
Study of limestones, 1914-1915 and 1915-1916. . . . .	1,610 48	1,220 17	66 60	66 50	104 70	3 10	3 53	145 88
Geological survey of Silver Mountain, 1915-1916. . . . .	923 12	576 25	172 06	148 78				26 03
Geological study of the Devonian formations, 1914-1915 and 1915-1916. . . . .	636 66	539 00						97 66
Geological study of the Marshall and Coldwater formations, 1915-1916. . . . .	431 19	183 25	168 00	38 24				41 70
Physiography of Michigan inland lakes, 1914-1915 and 1915-1916. . . . .	390 51	189 68		165 55				35 28
Geological survey of Mackinac Island, 1915-1916. . . . .	251 95	150 00	29 97	56 83				15 15
Gage reading on Escanaba river, 1914-1915 and 1915-1916. . . . .	72 90	72 90						
Total. . . . .	\$52,211 75	\$37,327 27	\$6,775 62	\$4,448 25	\$248 11	\$813 74	\$809 69	\$1,789 07
July 1, 1916:								
Unexpended balance, general appropriation. . . . .	167 71							
Unexpended balance, special appropriation. . . . .	847 40							
Unexpended balance, Michigan-Ohio appropriation. . . . .	4 22							
Unexpended balance, topographic survey appropriation. . . . .	4,979 53							
Total. . . . .	\$58,210 61							

CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1914-1915 AND 1915-1916.

Number of voucher.	Name.	Classification.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
									Perman.	Incidental.
16, 46, 65, 80, 98, 135, 150, 49, 117, 77	Adams Express Co.	Transportation Co.	\$68 22							
459, 460, 505, 528, 550	Address Machine Co.	Supply house	1 00							
1, 5, 17, 19, 31, 28, 36, 40, 51	Allen, H. J.	Rodman	403 56	\$172 56	\$231 00					\$68 22 1 00
67, 82, 106, 59, 117, 136, 152, 153, 64, 170, 67, 2, 10, 22, 28, 37, 12, 35, 50, 62, 14, 63, 78, 84, 47, 97, 104, 50, 111, 54, 55, 16, 56, 59, 156	Allen, R. C.	Director, State Geologist and Appraiser of Mines	7, 911 76	6, 957 90	341 97	\$600 89			\$11 00	
121, 143	Allen Printing Co.	Supply house	41 42							18 47
16, 18, 50	Alverson, Miles C.	Rodman	73 11	70 00		3 11				22 95
18, 25, 45, 102, 114, 169, 185, 190, 36, 59, 72, 102, 130, 141, 153	American Express Co.	Transportation Co.	76 37							
14	Andrews, A. W.	Naturalist	75 00							76 37
85	Arbaugh Co., F. N.	Supply house	3 70					\$3 70		
40, 43, 95, 126, 17, 61, 127, 128, 149, 152	Auditors, State Board of	Supply house	66 62							
521	Baker, C. E.	Liveryman	12 00							65 53
518	Baker, John S.	Liveryman	15 00			12 00				
10	Baldwin, Dell	Teamster	25 50			15 00	\$24 50	1 00		
8, 15, 16, 18, 22, 37, 39, 54, 57, 85, 110, 120, 129, 156, 172, 2, 6, 13, 16, 21, 24, 31, 32, 38, 41, 44, 82, 99, 114, 132, 56, 64, 70, 485	Barrett, L. P.	Assistant Geologist	2, 664 67	2, 210 00	217 58	233 09		4 00		
	Barrow and Enright	Liverymen	43 00			43 00				
461, 489, 508, 530	Batson, Geo. R.	Rodman	218 94	101 94	117 00					
39, 73, 125, 179, 30, 68	Beaumont, Regis	Gage reader	72 90	72 90						
402	Bemis, E. L.	Topographic Aid	64 03	29 03	85 00					
467	Bennett, Clyde	Liveryman	36 00							
9, 15, 25	Bergeron, John	Liveryman	84 50			36 00	\$4 50			

430, 434, 462, 468, 492, 507, 519, 522, 525, 531, 537, 562, 563, 565, 566	Bibbee, E. C.	Topographic Aid	933 22	461 94	398 94	73 03			114 57	
50, 57	Bludeau, Geo. G.	Bookbinder	114 57							
22	Bottner, L.	Man agent	1 68							1 68
28, 133	Bovee, F. N.	Photographer	5 75							5 75
68	Brennan, P.	Provision house	83 01		83 01					
2, 8, 13, 21, 27	Brown, Floyd B.	Compassman	128 62	94 67	8 30	25 65				
531, 551	Bunge, Wm. H.	Rodman	65 17	30 67	34 50					
392	Burney, Alfred E.	Topographic Aid	46 69	24 19	22 50					
327, 332, 359, 357, 362, 363, 368	Burney, H. E.	Junior Topographer	307 45	170 20	115 20	22 05				
429, 459, 490, 505, 528, 550	Burrell, F. E.	Rodman	424 84	181 59	243 25					
3, 6	Campbell, C. Alfred	Chainman	191 50	100 00	91 50					2 88
42, 109	Carlson Supply Co.	Supply house	32 58						29 70	
488, 515, 568	Chamberlin, Geo. L.	Liveryman	166 50			166 50				8 00
47, 96, 86, 90	Chicago Press University	Publishers	24 25						8 00	16 25
6, 189	Chilson, McKinley & Co.	Publishers	10 00						10 00	
7, 10, 6, 41, 90, 143, 70, 105, 145	Christie, Wm. J.	Rodman	85 00	40 00	45 00					
21, 63, 105, 75	Citizens Telephone Co.	Telephone Co.	87 45							87 45
60, 127	Cleas-Bauer Co.	Cartage Co.	23 87							23 87
142	Com. Env. & Box Co.	Supply house	16 82							16 82
	Commercial Service Co.	Supply house	2 70							2 70
460, 491, 506, 529, 552	Cox, Richard S.	Rodman	350 42	162 92	187 50					
100	Crowell Co., Thos. T.	Publishers	1 65						1 65	
432, 461, 466, 487, 513, 538	Culbert, C. M.	Liveryman	290 75			290 75				
327, 357, 362, 368	Davis, C. M.	Rodman	162 52	110 02	52 50					
119	Demaray, D. E.	Rodman	13 00						13 00	
20	Detroit Coin Wrapper Co.	Supply house	1 50							1 50
106	Diamond Drill	Publishers	8 00							8 00
4, 8	Dietz, C. A.	Liveryman	262 50			262 50				
27, 47, 51, 58, 59, 77, 91, 129, 147, 181, 187, 19, 74, 136, 60, 76, 11, 29, 88	Dietzgen Co., Eugene	Supply house	163 04					8 12	28 60	126 32
61, 74, 103, 113, 128, 145, 80, 73, 85, 122, 146	Dodge, C. K.	Botanist	400 00	400 00						
76	Dudley Paper Co.	Supply house	77 00							77 00
124	Dwyer, Francis J.	Slide manufacturer	16 61						16 61	
76	Dyer, Jenson Barry Co.	Bookbinder	5 00							5 00
129	Economic Geology	Publishers	3 00						3 00	
75, 81, 4, 10, 14, 17, 26, 28, 61	Ehlers, Geo. M.	Palentologist	365 49	159 25	168 00	38 24				

CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1914-1915 AND 1915-1916.—Continued.

Number of voucher.	Name.	Classification.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
									Perman-ent.	Inciden-tal.
147	Elbe File & Binder Co.	Supply house	\$6 26						\$6 26	
123, 138	Eng. & Mining Journal.	Publishers	12 00						12 00	
520, 539	Folland, Christopher.	Rodman.	42 50	\$20 00	\$22 50					
3, 5, 6, 11, 13, 15	First Livery Co.	Liveryman	27 00		216 00	\$27 00		\$87 69		
94	Gannett, Samuel S.	Geographer	1,588 54	1,225 00		59 85				
58	General Land Office.	Supplies	6 00							
72, 38	Golden Rule Sup. House.	Supply house	5 00					6 00		
65	Grabau, A. W.	Faunontologist	450 00	450 00					5 00	
514	Grabau, James	Copyist	3 75				\$3 75			
	Grauger, C. B.	Liveryman	70 00			70 00				
29, 18, 32, 75	Gurley, W. & L. E.	Instrument dealers	28 31							
71, 84	Hagle, Mand.	Copyist	8 50							
461, 489, 486, 508, 530, 535, 551	Hahn, E. L.	Assistant topographer	834 23	576 00	226 62	31 61	8 50	15 00		\$13 31
430, 462, 492, 507, 525, 531, 562, 563	Hall, M. F.	Topographic aid	569 59	259 84	309 75					
1, 17, 28, 36, 53, 54, 55, 56, 57, 58, 60, 61, 62, 63, 66, 68, 12, 20, 30, 37, 42, 45, 46, 48, 49, 51, 52, 64, 72	Hamilton, O. R.	Mining engineer	5,421 58	4,800 00	390 81	240 77				
87, 90	Hankinson, T. L.	Biologist	200 00	200 00						
402	Harris, George	Rodman.	51 69	21 94	29 75					
469, 523	Harris, E. K.	Liveryman	16 50							
43	Heckman and Cayanus.	Provision house	13 28			16 50				
328, 334	Hicks, Wm. R.	Rodman.	51 61							
465	Hinkley Brothers.	Liverymen	47 50			47 50				
165	Hobbs, W. H.	Member Bd. of Advisers.	2 58			2 58				
56, 72, 87, 122, 176, 26, 67, 116, 69	Hodges, Wm. V.	Rodman.	42 50	20 00	22 50					
79	Hopper, W. E.	Geologist	525 06	500 00	3 25	11 65	10 16	6 00		
	Hotchkiss, W. O.	Geologist.	6 00							

7, 40, 76	Hubbard, Bela.	Geologist.	99 43	26 67	11 25	88 18				
66, 81	Hyde, Jos.	Compassman.	29 88		50	2 71				
524	Hyman, Charles.	Liveryman	6 00			6 00				36 95
7, 97, 115, 131, 151, 167, 186, 129, 63, 154	Ihing Bros. Everard Co.	Supply house	36 95							9 00
144	Imes, Lewis.	Photographer	9 00							1 50
86	Iron River-Stambaugh Rep.	Publishers	1 50						8 00	
78, 91	Iron Trade Review.	Publishers	8 00							
3, 6	Jackson, R. B.	Rodman.	153 50	80 00	73 50					
402	Johnson, A. B.	Rodman.	60 81	25 81	35 00					
429, 433, 459, 484, 509, 512, 532, 553, 569, 573	Jones, Oscar.	Topographic engineer	877 38	283 98	174 75	418 65				
429, 459, 490, 505, 528, 550	Jones, S. G.	Rodman.	431 05	184 30	246 75					
402	Kavanagh, A. J.	Junior topographer	84 05	50 81	33 25					
43	Kelly Brothers.	Supply store	29 70		29 70					
328	Kendrick, Geo. F.	Rodman.	31 94	31 94						
5, 22, 23	Kenton Store Co.	Provision house	194 47							
429, 459, 490, 505, 528, 550	Krise, Wm. Earl.	Rodman.	412 68	176 43	236 25					
46	Kurtz, Langbein & Swartz	Supply house	3 33						3 33	
361, 365, 366, 370	Lamb, W. E.	Liveryman	141 50	20 00	22 50	141 50				
460, 491, 506, 529, 552	Lan, Louis	Rodman.	42 50	108 08	192 00					
	Laughlin, Howard S.	Rodman.	360 08							
327, 329, 358, 357, 362, 367, 369, 389, 390, 391, 400	Lee, L.	Assistant topographer	1,355 04	757 98	344 93	252 13				
3, 6	Linton, L.	Recorder	241 50	150 00	91 50					
7	Lloyd Brothers.	Monument Mfgs.	450 00					450 00		
107	Longstreet Lbr. Co.	Lumber dealers	3 60						3 60	
21	McDonald, R.	Exploration manager	68 51							
	McGraw-Hill Book Co.	Publishers.	33 85						33 85	
11, 32, 46, 44	McKone, Don T.	Rodman.	432 11	346 67	19 70	65 74				
16, 18, 42, 44, 48, 78, 2, 11, 13, 21, 34, 66, 74	Michigan Drug Co.	Supply house	127 46							
6, 26, 34, 178, 188, 15, 16, 29, 35, 43, 93, 139, 62	Mich. Engineering Society.	Publishers	15 00					91 64		
49, 83, 80	Mich. Press Clipping Bu au.	News bureau.	4 00						4 00	
8, 33, 43, 93, 148, 162, 183, 21, 34, 47, 60, 95, 120, 137	Mich. State Tel. Co.	Telephone Co.	73 21							73 21
108	Michigan, University of	Educational institution.	104 70			104 70				4 00
30, 110	Mining Journal.	Publishers.	4 00							4 00
8, 149	Mining World.	Publishers.	6 00							6 00
65	Monroe Sales Co.	Supply house	250 00						250 00	

CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1914-1915 AND 1915-1916.—Continued.

Number of voucher.	Name.	Classification.	Total.	Salary.	Subsist- ance.	Travel.	Assist- ance.	Property.	Office.	
									Perma- nent.	Inciden- tal.
501.	Muck, E. C.	Provision house.	\$51 29		\$51 29					
490, 470, 491, 506, 517, 529, 534, 554.	Muldrow, Robert.	Topographic engineer.	1,074 17	\$766 17		\$96 70				
334, 336.	Murphy, J. J.	Rodman.	20 64	20 64						
184, 126.	Nelson, Alfred.	Rodman.	42 50	20 00	22 50					
13.	Newcombe, F. C.	Member Bd. of Advisers.	5 21			5 21				
27.	Nory, Frank.	Naturalist.	82 00	82 00						
327, 333, 360, 357, 364, 368.	Null, I. H. Harrison.	Rodman.	42 50	20 00	22 50					
23.	Nystrom & Co., A. J.	Supply house.	58 80							\$58 80
	Opdyke, Alfred L.	Topographic aid.	236 40	125 00	110 00	1 40				
	Penton Publishing Co.	Publishers.	3 50							3 50
160.	Phillips, R. H.	Rodman.	85 00	40 00	45 00					
191, 143, 155.	Folk & Co., R. L.	Publishers.	8 00							
10.	Postal Telegraph Co.	Telegraph Co.	4 41							
52.	Povah, H. W. Alvah.	Rodman.	182 00	182 00						8 00
64, 78.	Presquele Mining Co.	Exploration Co.	44 25		44 25					\$4 41
536, 557.	Proudit Loose Leaf Co.	Supply house.	13 75							
164.	Raymond, B. C.	Liveryman.	37 50			37 50				13 75
142, 159, 177, 79, 14.	Reighard, J.	Member Bd. of Advisers.	75 00			2 58				
5.	Reuter, Carl H.	Agent.	42 50	20 00	22 50					75 00
4, 2, 15, 24, 37, 55, 71, 86, 111, 121, 140, 157, 176, 138, 25, 41, 53, 66, 83, 101, 115, 134, 96, 64.	Richardson, G. R.	Rodman.	6 00							
331, 337.	Richmond, Marian.	Office assistant.	1,780 00	1,780 00		\$6 00				
9, 24, 163, 3, 19, 130.	Richmond, Mrs. K. V.	Stenographer.	8 50							
	Rogers Leather Gds. Store.	Supply house.	106 00			106 00				8 50
	Russell and Masten.	Liveryman.	805 66		50					
	Ruthven, A. G.	Chief naturalist.		800 00		5 16				

328, 330, 335, 334, 400.	Sadler, C. L.	Topographic engineer.	594 05	414 83	162 32	16 88				
4.	Sawyer, Mrs. M. M.	Office assistant.	6 00				6 00			
367, 389.	Saxon, Wm., Jr.	Rodman.	42 50	20 00	22 50					
2, 13, 221, 31, 66.	Schultz, Wm., Jr.	Rodman.	123 68	57 68	66 00					
	Schweitzer, Jos.	Cook.	270 00	270 00						
2, 3, 29, 32, 33, 34, 66, 73.	Scott, I. D.	Geologist.	433 85	239 68	2 85	185 07				6 25
17.	Senseney, H. S.	Topographer.	63 75	37 50	26 25					
3, 6.	Sherman, C. E.	Inspector.	200 00	200 00						
	Sherman, R. B.	Rodman.	134 50	70 00	64 50					
108.	Sherzer, W. H.	Member Bd. of Advisers.	3 40		3 35	3 05				
555.	Silver, Glen C.	Liveryman.	108 00			108 00				9 00
42.	Smith Bros., L. C.	Typewriter Mfgs.	9 00							
1, 2, 4, 17, 20, 28, 36, 52, 68, 83, 107, 118, 137, 154, 171, 69, 82, 11, 23, 39, 51, 64, 79, 98, 112, 131, 56, 64.	Smith, R. A.	Geologist.	3,553 88	3,384 66	72 20	90 40				3 62
3, 6.	Sorensen, F. G.	Chairman.	112 33	58 33	54 00					
463, 510, 511, 533, 556.	Sowersby, J. C.	Liveryman.	380 00			380 00				
77.	Sparks, M. F.	Tent manufacturer.	23 10				23 10			
504, 71.	Sponster, O. L.	Biologist.	200 00	200 00						
39.	Starr, J. G.	Topographic engineer.	105 37	79 12	26 25					
489, 508, 516, 530.	State treasurer.	Insurance fund.	53 48							
	Stone, Harry H.	Rodman.	168 67	78 67	90 00					53 48
92.	Supt. Public Documents.	Supplies.	3 70							3 70
73.	Taylor, Frank B.	Geologist.	150 00	150 00						
18.	Terry Engraving Co.	Engravers.	105 99					105 99		2 35
26, 35.	Thompson, Crystal.	Naturalist.	200 00	200 00						
38, 66.	Tobin, James.	Cook and compassman.	110 00	110 00						
99.	Toerring Co., C. J.	Supply house.	2 35							
80.	Tomlinson, W. Harold.	Slide manufacturer.	11 50	150 00				11 50		
89.	Transeau, E. N.	Biologist.	150 00	150 00						
10.	Turnoull, W. D.	Draftsman.	50 25	50 25						
9, 44, 134, 158, 69, 77.	U. S. B. P. Paper Co.	Supply house.	52 42							3 50
1, 17, 28, 36, 53, 54, 55, 57, 60, 62, 63, 66, 62, 20, 30, 37, 42, 45, 48, 51, 56, 64.	Vance, E. E.	Draftsman.	2,400 00	2,400 00						
161, 125.	Walker, Bryant.	Member Bd. of Advisers.	7 00			7 00				1 25
	Wagenvoort & Co.	Binders.	15 00							15 00
118.	Washington Loose Leaf Co.	Supply house.	17 45							
45, 29.	Wellborn, W.	Copyist.	17 45							

CLASSIFIED LIST OF EXPENDITURES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS 1914-1915 AND 1915-1916.—Concluded.

Number of voucher.	Name.	Classification.	Total.	Salary.	Subsistence.	Travel.	Assistance.	Property.	Office.	
									Perma- nent.	Inciden- tal.
460, 491.	Wellington, C. F.	Rodman.	\$159 52	\$74 02	\$85 50					
9, 19, 30, 48, 81, 104, 166, 180, 18.	Western Union Co.	Telegraph Co.	66 06							\$66 06
23, 48, 57, 71, 94, 124, 144, 151.	Whitmore, Morris T.	Rodman.	122 77	56 77	66 00					
461.										
3, 1, 3, 13, 14, 23, 36, 38, 53, 62.										
69, 79, 84, 88, 109, 112, 119, 123.										
138, 141, 155, 173, 174, 192, 74.										
12, 20, 24, 31, 40, 45, 52, 55, 65.										
80, 81, 96, 100, 103, 113, 140, 96.										
64, 67.										
402.	Wight, Harry R.	Secretary.	3, 107 70	2, 400 00	45 00				\$47 64	660 06
	Wilson, J. H.	Assistant topographer.	115 97	70 97						
564, 567.	Winn, Edward	Liveryman.	24 00							
403.	Wohrline Auto. Co.	Transportation Co.	63 00			\$24 00				
17.	Wood, Frank E.	Supply agent.	4 00			63 00				4 00
12, 27.	Wood, N.	Naturalist.	200 00	200 00						
8, 35, 75, 101, 146, 168, 54, 87, 135.	Wyckoff Hallen'k C'rd Co.	State printers.	115 36						28 50	\$7 06
429, 431, 459, 490, 505, 528, 550.	Yeakum, B. H.	Topographic aid.	499 34	235 22	252 00	12 12				
Total.			\$52, 211 75	\$37, 327 27	\$6, 775 62	\$4, 448 25	\$248 11	\$813 74	\$809 69	\$1, 789 07
Unexpended balance July 1, 1916.			5, 998 86							
Total.			\$58, 210 61							

EMPLOYEES OF THE BOARD OF GEOLOGICAL SURVEY FOR THE FISCAL YEARS JULY 1, 1914 TO JUNE 30, 1915 AND JULY 1, 1915 TO JUNE 30, 1916.

Name.	Position.	Amount of salary received.	Period of time employed.	How employed.						
				Mineral Statistics.	Geology.	Appraisal of Mines.	Topography.	Biology.	Michigan-Ohio boundary.	
Allen, H. J.	Rodman.	\$172 56	4 months, 10 days				*			
Allen, R. C.	Director, State Geologist, Appraiser of Mines.	6, 957 90	2 years		*	*	*	*	*	*
Alverson, Miles C.	Rodman.	70 00	2 months		*					
Andrews, A. W.	Naturalist.	75 00	Contract.		*					
Barrett, L. P.	Assistant Geologist.	2, 210 00	2 years.		*					
Batson, Geo. R.	Rodman.	101 94	2½ months.				*			
Beauchamp, Regis	Cage Reader.	72 90	1 year, 1 month, 6 days.		*					
Bennett, E. L.	Topographic Aid.	29 03	20 days.		*	*	*	*	*	*
Bibbee, E. C.	Topographic Aid.	461 94	6 months.		*	*	*	*	*	*
Brown, Floyd B.	Compassman.	94 67	2 months, 11 days.		*	*	*	*	*	*
Bunge, Wm. H.	Rodman.	30 67	23 days.				*			
Burney, Alfred E.	Topographic Aid.	24 19	15 days.				*			
Burney, H. E.	Junior Topographer.	170 20	2 months, 22 days.				*			
Burrell, F. E.	Rodman.	181 59	4½ months.				*			*
Campbell, C. Alfred.	Chainman.	100 00	2 months.				*			*
Christie, Wm. J.	Rodman.	40 00	2 months.				*			
Coy, Richard S.	Rodman.	162 92	4 months, 3 days.				*			
Davis, C. M.	Rodman.	110 02	2½ months.				*			
Dodge, C. K.	Botanist.	400 00	Contract.				*			*
Ehlers, Geo. M.	Paleontologist.	159 25	2 months, 22 days.		*					
Folland, Christopher.	Rodman.	20 00	½ month.				*			*
Gannett, Samuel S.	Geographer.	1, 225 00	3½ months.		*					*
Grahan, A. W.	Paleontologist.	450 00	Contract.		*					*
Graham, Jane	Copyist.	3 75	16 hours.				*			*
Hagte, Maud.	Copyist.	8 50	16 hours and contract.				*			*

BIENNIAL REPORT OF THE DIRECTOR.

Name.	Position.	Amount of salary received.	Period of time employed.	How employed.					
				Mineral Statistics.	Geology.	Appraisal of mines.	Topography.	Biology.	Michigan-Ohio boundary.
Hahn, E. L.	Assistant Topographer.	\$576 00.	2 months, 8 days.				*		
Hall, M. F.	Topographic Aid	259 84	6 months.				*		
Hamilton, O. R.	Mining Engineer.	4,800 00	2 years.		*		*		
Hankinson, T. L.	Biologist.	200 00	Contract.					*	
Harris, George.	Rodman.	21 94	17 days.				*		
Hicks, Wm. R.	Rodman.	51 61	1 month, 9 days.				*		
Hodges, Guy.	Rodman.	20 00	1 month.				*		
Hoppe, W. E.	Geologist.	500 00	2 years.	*			*		
Hyde, Jos.	Compassman.	26 67	1 month.		*		*		
Jackson, R. B.	Rodman.	80 00	1 month, 18 days.				*		
Johnson, A. B.	Rodman.	25 81	20 days.				*		
Jones, Oscar.	Topographic Engineer.	283 98	1 1/2 months.				*		
Jones, S. G.	Rodman.	184 30	4 months, 18 days.				*		
Kavanagh, A. J.	Junior Topographer.	50 81	21 days.				*		
Kendrick, Geo. F.	Rodman.	31 94	22 days.				*		
Krise, Wm. Earl.	Rodman.	176 43	4 months, 12 days.				*		
Lau, Louis.	Rodman.	20 00	1 month.				*		
Laughlin, Howard S.	Rodman.	168 08	2 months, 8 days.				*		
Lee, L. L.	Assistant Topographer.	757 98	6 months.				*		
Linton, L. L.	Recorder.	150 00	2 months.				*		
McKone, Don. T.	Rodman.	346 67	6 1/2 months.		*		*		
Muldrow, Robert.	Topographic Engineer.	766 17	4 months.				*		
Murphy, J. J.	Rodman.	20 64	16 days.				*		
Nelson, Alfred.	Rodman.	20 00	1 month.				*		
Novy, Frank.	Naturalist.	82 00	Contract.				*		

Null, H. Harrison.	Rodman.	20 00	1/2 month.				*		
Opdyke, Alfred L.	Topographic Aid.	125 00	2 1/2 months.				*		
Phillips, F. H.	Rodman.	40 00	1 month.				*		
Poyah, H. Y. Alvah.	Botanist.	182 00	Contract.				*		
Richardson, G. R.	Rodman.	20 00	1/2 month.				*		
Richmond, Marian.	Office Assistant.	6 00	6 days.		*		*		
Richmond, Mrs. K. V.	Stenographer.	1,780 00	2 years.		*		*		
Ruthven, A. G.	Chief Naturalist.	800 00	2 years.		*		*		
Sadler, C. L.	Topographic Engineer.	414 83	2 months, 9 days.		*		*		
Sawyer, Mrs. M. M.	Office Assistant.	6 00	6 days.		*		*		
Saxon, William, Jr.	Rodman.	20 00	1/2 month.				*		
Shultz, William, Jr.	Rodman.	57 68	1 1/2 months.				*		
Schwetzer, Jos.	Cook.	270 00	4 1/2 months.		*		*		
Scott, I. D.	Geologist.	289 68	2 months, 3 days.		*		*		
Sensney, H. S.	Topographer.	37 50	1/2 month.				*		
Sherman, C. E.	Inspector.	200 00	Contract.				*		
Sherman, R. B.	Rodman.	70 00	1 month, 12 days.				*		
Smith, R. A.	Geologist.	3,384 66	2 years.		*		*		
Sorensen, F. G.	Chauffeur.	58 33	1 month, 5 days.				*		
Sponster, O. L.	Biologist.	200 00	Contract.				*		
Staack, J. G.	Topographic Engineer.	79 12	1/2 month.				*		
Stone, Harry H.	Rodman.	78 67	2 months.				*		
Taylor, Frank B.	Geologist.	150 00	Contract.		*		*		
Thompson, Crystal.	Naturalist.	200 00	Contract.		*		*		
Tobin, James.	Cook and Compassman.	110 00	1 month, 11 days.		*		*		
Transeau, E. N.	Biologist.	150 00	Contract.				*		
Turnbull, W. D.	Draftsman.	50 25	8 days.				*		
Vance, E. E.	Draftsman.	2,400 00	2 years.		*		*		
Wellborn, W.	Copyist.	17 45	6 1/2 days.		*		*		
Wellington, C. F.	Rodman.	74 02	1 month, 27 days.				*		
Whitmore, Morris T.	Rodman.	56 77	1 month, 13 days.		*		*		
Wight, Harry R.	Secretary.	2,400 00	2 years.		*		*		
Wilson, J. H.	Assistant Topographer.	70 97	22 days.		*		*		
Wood, N. A.	Naturalist.	200 00	Contract.		*		*		
Yeakum, B. H.	Topographic Aid.	235 22	4 months, 21 days.		*		*		

## PROGRESS OF THE GEOLOGICAL SURVEY.

Modern trends in the work of the state and federal geological surveys indicate a rapid awakening to opportunities for useful adaptations of their activities to administrative needs of the governments. Another significant trend is toward a closer adaptation of survey work to industrial progress, particularly in the development, use, and perpetuation of natural wealth in soils, rocks, and minerals, and in some states, including Michigan, game life.

These more direct services to the government and people are made possible, however, only through investigations of a strictly scientific character and it should not be overlooked by legislatures and governing boards that progress in purely scientific geology and biology is and will ever remain the basis of progress in economic directions. A survey which fails to make the most of its resources in both of these directions fails to discharge the obligations which opportunity and public need place upon it.

The Michigan Geological Survey co-operates with other departments of the government which have use for its services. Such co-operation now extends to the Board of State Tax Commissioners in appraising mineral lands and mines for taxation, to the Michigan Securities Commission in the administration of certain phases of the "blue sky" law, to the Public Domain Commission in certain matters affecting the state lands and waters, and to the Mackinac Island State Park Commission in certain work in progress on Mackinac Island. An account of this co-operative work during the biennium is given below:

### COOPERATIVE WORK.

*Cooperation with the Board of State Tax Commissioners.* In 1913 the Board of Geological Survey entered into co-operation with the Board of State Tax Commissioners, at the request of the former, in making appraisals of mines and mineral lands for taxation. The results of this co-operation are fully accounted for in the current biennial report of the Board of State Tax Commissioners.

The appraisal of mines and mineral lands for taxation is an important responsibility and demands the best efforts and professional skill of the Survey. The permanent record of this work during the biennium

is embraced in two annual reports to the Board of State Tax Commissioners comprising several volumes of typewritten matter, plats, statistical tables, reports of the mining companies, and a number of communications on special subjects.

REPORTS OF THE STATE GEOLOGIST TO THE BOARD OF STATE TAX COMMISSIONERS.

1914.

Volume 1. Contains formally executed general and financial statements of owners and operators of iron mines for the five years preceding January 1, 1914. 510 pages.

Volume 2. Contains complete record of appraisals of iron mines and iron ore bearing lands, and appraiser's descriptions and discussions of the properties. 484 pages.

Volume 3. Contains complete statistical tables for reference. 36 pages.

Volume 4. Contains statements of tonnage and value of ore in stock at the mines. 146 pages.

1915.

Volume 1. Contains formally executed general and financial statements of owners and operators of iron mines for the five years preceding January 1, 1915. 620 pages.

Volume 2. Contains complete record of appraisal of iron mines and iron ore bearing lands, and appraiser's descriptions and discussions of these properties. 560 pages.

Volume 3. Contains complete statistical tables for reference. 37 pages.

Volume 4. Contains complete statistical tables for iron mines, 1906-1915 inclusive. 128 pages.

Mr. O. R. Hamilton, Mining Engineer, has rendered efficient service throughout all of the work of mine appraisals.

*Co-operation with the Public Domain Commission.* The resources of the Survey and the services of some of its members have been utilized by the Public Domain Commission in various ways, more especially in comparative valuations of lands involved in exchange with private parties in furtherance of its policy of consolidating the state lands and forests. The State Geologist has also acted for the Commission in

investigation of trespass of sand and gravel dredgers in Lake Superior, Lake Michigan, and Lake St. Clair, and in consideration of royalty rates on sand and gravel dredged from waters wholly or partially under control of the state. On a number of occasions the State Geologist has attended meetings of the Commission, and has at all times endeavored to assist in those matters wherein his services are requested.

*Co-operation with the Michigan Securities Commission.* The general work of the Geological Survey and the services of some of its members are useful to the Michigan Securities Commission in the administration of the "blue sky law," particularly in considering applications of mining companies and, in some cases, land companies, for permission for sale of stocks and bonds in Michigan. Some of the matters on which advice is asked by the Commission from time to time demand very careful treatment involving investigations extending over a considerable time. In such cases the cost is borne by the applicant and paid to the individual charged with the work, who, under the regulations of the Board of Geological Survey, has the option of relief from duties without pay while engaged in such work or a corresponding reduction in vacation and sick leave.

During the biennium ending June 30, 1916, reports on the applications of the following companies were rendered to the Michigan Securities Commission:

Date.	Name and Address of Company.	Report by.
1914.		
Nov. 17	Regal Collieries, Ltd., Taber, Alberta, Canada.....	R. C. Allen.
Jan. 9	Lake Superior Land Co.....	R. C. Allen.
1915.		
June 16	White Pine Extension Copper Co.....	R. C. Allen.
July 31	Central Michigan Clay Products Co., Williamston, Michigan....	R. C. Allen.
Sept. 24	Cheboygan County Limestone Products Co., Mackinaw City, Michigan.....	R. A. Smith.
1916.		
Jan. 24	Minook Gold Dredging Co., Seattle, Wash.....	L. P. Barrett.
April 3	Assets Realizing Mines Corporation.....	R. C. Allen.
April 25	Jerome Victor Extension Copper Co. of Arizona.....	R. C. Allen.
April 27	Butte-Elk Park Extension Mining Co. of Montana.....	R. C. Allen.
May 5	Plattville Consolidated Lead & Zinc Mining Co., Beloit, Wisconsin.....	R. C. Allen.
May 9	Silica Brick Co., Detroit, Mich.....	R. A. Smith.
June 9	Breitung Hematite Mining Co., Ltd.....	R. C. Allen.
June 29	Fullers Earth Company of America.....	R. C. Allen.

*Co-operation with the Mackinac Island State Park Commission.* The following is quoted from my last biennial report: "Probably no other locality in Michigan holds more of historical interest than the Island of Mackinac. Its natural beauty combined with its location have made it the most popular of Michigan's summer recreation grounds. A considerable part of the island is under the administration of the

Mackinac Island State Park Commission, which is doing a commendable work of improvement and beautification and is maintaining and preserving the old buildings and military works of historical interest.

The geologic history of Mackinac Island is no less fascinating than its human history for there is recorded in the series of abandoned beaches, bars, spits, stacks, sea cliffs, and other shore features, a large part of the history of the ancestral Great Lakes. At the highest or Algonquin stage of the Great Lakes, Mackinac Island consisted of only a few acres of ground forming the highermost part now occupied by old Fort Holmes. As the waters of the ancient Great Lakes receded from their earlier shore lines and fell to lower and lower levels until the present stage was reached each successive lower stage was marked by its corresponding shore line features on the Island of Mackinac.

In the mapping and interpretation of these natural features of Mackinac Island the Geological Survey is not only doing an important educational work but is also furthering the plan of the Mackinac Island State Park Commission to add to the interest and enjoyment of the several hundred thousand people who annually visit the island. During the summer season of 1914 field investigations were completed, and it is planned during the winter to construct a map of the Island on a rather large scale on which the geologic and physiographic features will be delineated, this map to be accompanied by a brief descriptive text. It is also planned to call attention to the meaning and interpretation of the natural features of the island through a system of guide posts and signs to be erected by the Mackinac Island State Park Commission. The work on Mackinac Island is in charge of Mr. Frank B. Taylor to whose indefatigable labors we are indebted for much of our present knowledge of the history of the Great Lakes."

I regret to state that Mr. Taylor's health has been such that he has been unable to complete his monograph, but it is expected that publication will be made before the end of another year.

### GEOLOGICAL WORK.

The geological work accomplished during the biennium includes, (1) preparation and completion of a general geologic map of Michigan, (2) completion of investigations and report on Michigan commercial limestones, (3) continuation of field and laboratory studies of the pre-Cambrian rocks of the Northern Peninsula and preparation of a report covering these investigations in 1910-14, (4) completion of studies and preparation of a report in two volumes on the Devonian

formations of Michigan, (5) continuation of studies of the Mississippian formations, (6) preparation of a report on the physiography of the inland lakes, (7) current work in connection with publication of the annual report on mineral resources and statistics of mineral production and (8) miscellaneous investigations connected with correspondence and conferences.

*A Geological Map of Michigan.* I am pleased to report that a geological map of Michigan has been compiled and is now in the hands of the engraver and printer. Surprising as the statement may seem, it must be said that no adequate geological map of this state has ever been published. Certain parts of the state, particularly the iron and copper districts and a few counties, have been studied in detail and correspondingly accurate geological maps of these areas have been published. But for many years there has been a great need for a general geological map of the whole state representing in considerable detail the distribution and order of succession of the rock formations. We have had the compilation of such a map under way for several years but publication has been postponed pending study of certain districts in which information has been meagre or unsatisfactory, particularly in the Northern Peninsula. There still remain certain areas in which the mapping is doubtful and others in which satisfactory differentiation between the formations of different ages is impossible. It is not deemed advisable, however, to longer delay the publication of a general map pending solution of doubtful questions of geology, some of which will require years of study. The map in its present form will be very useful, particularly in connection with an amply explanatory legend which accompanies it. This legend is an epitome of the geological history of the state and describes the different formations and their economic products in popular terms. The map will be especially valuable for instructional work in the schools and colleges of Michigan.

*A Report on Michigan Limestone.* Limestone is one of the important resources of Michigan. The production, particularly of the higher grades, is steadily increasing and will continue to increase as demanded in the expansion of the iron, chemical, paper and sugar industries. Michigan is peculiarly favored in the occurrence of extensive beds of high grade limestone on and near Lakes Huron and Michigan within reach by low cost transportation of the great limestone consuming industries of the Great Lakes region.

I am pleased to report that the investigation of the limestone resources of the state, which has been in progress since 1913 under charge of Mr. R. A. Smith, has been completed. Mr. Smith's report appears in Publication 21, Mineral Resources of Michigan. It was expected that

this report would be published in 1915 but it was found necessary to extend the investigations into 1916 to insure a thorough treatment of the entire subject. Mr. Smith has made a field examination of all of the districts and localities wherein limestone of commercial grade occurs, and has mapped the areas underlain, by commercial limestone in those regions to which development has not yet extended. The field investigations have been supplemented by thorough laboratory studies. In this work we have had the co-operation of all of the companies and individuals engaged in the Michigan limestone industry. Hundreds of drill records and thousands of limestone analyses have been supplied by the limestone operators. Without this co-operation the report would have been much less complete and valuable.

*Studies of the pre-Cambrian Rocks of the Northern Peninsula.* Field and laboratory studies of the pre-Cambrian rocks of the Northern Peninsula have been continued throughout the biennium. The main results of these investigations in 1910-14 have been summarized and published in Publication 18, Geological Series 15. During the summer of 1915 Mr. L. P. Barrett assisted by Messrs. Bela Hubbard, Don T. McKone, and Floyd B. Brown, were engaged in field mapping in the area between Gogebic Lake and the west end of the Marquette iron range. During the summer of 1916 these studies will be continued in the field by Mr. Barrett, in charge, assisted by O. R. Hamilton and Prof. I. D. Scott, geologists, and Messrs. Don T. McKone, James Tobin, and Joseph Hyde, compassmen. The area to be studied extends from the west end of the Marquette iron range westward and northward around the Huron Mountains, attention being mainly concentrated on the rocks of Huronian age and their relations to the overlying Keweenawan and underlying Archean terranes.

*Studies of the Devonian Formations.* During the biennium Dr. A. W. Grabau completed his studies on the Dundee, Traverse, and Antrim formations and has presented his report for publication. Dr. Grabau's work is an exhaustive treatment of the entire Devonian section and is abundantly illustrated, particularly the description of the faunal life of the Devonian seas. The work will be published in two volumes during the next biennium as the second of a series of monographs on the Paleozoic formations of the state.

*Studies of the Mississippian Formations.* Under a co-operative arrangement with the United States Geological Survey Dr. Geo. H. Girty, Paleontologist, has continued his studies of the Mississippian, comprising the formations known as the Coldwater shale and Marshall sandstone. Up to this time Dr. Girty's studies have been mainly

concentrated on the Marshall fauna and his report on this formation is almost completed. During the summer of 1915 Mr. George M. Ehlers was employed in field examinations of the Mississippian and the collection of fossils from its exposures under the supervision of Dr. Girty. It is probable that some additional collections will need to be made from the Coldwater formation.

*Studies of the Paleozoic Formations of the Northern Peninsula.* Our knowledge of the lower Paleozoic formations which form the Northern Peninsula east of a line from Marquette to Menominee is unsatisfactory. It is based on early observations of Houghton, Winchell, and Rominger supplemented by later somewhat cursory study by A. C. Lane and others. This area connects the much more studied and better known areas of correlative formations in Ontario and New York on the east and Wisconsin on the west and the solution of a number of important problems awaits a comprehensive investigation of the Michigan section. It would hardly be worth while to undertake a study of this large area except under a general plan providing for several years continuous field and laboratory studies by competent stratigraphers and paleontologists. Such a plan is under consideration. Pending the formulation of a definite program for this work Mr. Geo. M. Ehlers has been employed to make extensive fossil collections and general field study of the Niagaran formations during the summer of 1916 under the supervision of Prof. E. C. Case and R. A. Smith.

*A Study of the Physiography of Michigan Inland Lakes.* In my last biennial report a full account was made of the work of Dr. I. D. Scott on the physiography of Michigan inland lakes. Dr. Scott has had the preparation of a report on this subject under way during the biennium and should be able to finish it before the end of the present year.

The report will consist of two parts. Part 1 is intended to familiarize the lay reader with the manner of formation of lake basins, the forces which are active on the shores, the effects of these forces, and the processes through which lakes eventually become extinct. It includes a general statement of the topography of Michigan, a brief discussion of the work of running water and glaciers, a classification of lake basins and the manner of formation of the types found in this state, a statement of the work of waves, currents and ice and the resultant forms. Part 2 will contain descriptions of the shores of the various lakes treated individually. The physiographic forms and the manner of their formation will be discussed together with an account of the origin of the basin and the factors working towards the extinction of the lake.

*Mineral Resources and Statistics.* The annual report on statistics of production and progress of the mineral industries is one of the most generally useful and popular publications of the Survey. In this work we have the indispensable co-operation of the mineral producers as well as that of the United States Geological Survey. In addition to the statistical matter this report contains a directory of all of the mineral producers, statements of progress of the industries and each year a leading article on one of the mineral resources. The report for 1914 contains a very useful treatment of the copper deposits by Mr. R. E. Hore, the report for 1915 a valuable contribution on Michigan commercial limestones by Mr. R. A. Smith.

### PROGRESS OF THE TOPOGRAPHIC SURVEY.

The topographic mapping of Michigan is part of a general plan which embraces all of the states and territories. The work is being executed by the United States government acting through the United States Geological Survey and in co-operation with many of the states. The plan of the survey in Michigan provides for the construction of a topographic map of the state in units or quadrangles of 15' of latitude by 15' of longitude. The area of a quadrangle is about 200 square miles. Each quadrangle map will be published on a scale of 1:62500 and will register with those of adjacent quadrangles making it easy to combine the separate sheets to form a map of a larger area such as a county, drainage system, or natural physiographic province. The vertical distance between contours will, however, not be the same for all quadrangles but will vary with the character of the topography. Flat lands, such as constitute the Saginaw basin, are mapped with a contour interval of five feet, hilly areas with twenty feet and other areas with ten feet.

It has been found by experience in many states that the best results in topographic mapping are obtained through co-operation with the federal government. The United States Geological Survey maintains a large organization of trained topographic engineers with ample equipment and experience necessary for the attainment of lowest possible cost consistent with a high standard of work. Furthermore the United States government desires to make a topographic survey of the whole country under a uniform plan applicable to all of the states and it is desirable that such topographic work as may be undertaken by the several states or by them in co-operation with the United States should conform to this general plan or should be of such character that it may be adapted to this plan without additional expense for field surveys.

The topographic survey of Michigan under the co-operative plan now in force began in 1903. Following are the expenditures by the state and federal governments including appropriations for the fiscal year 1916.

## EXPENDITURES OF THE CO-OPERATIVE TOPOGRAPHIC SURVEY OF MICHIGAN.

Year.	By the State of Michigan.	By the United States Geological Survey.
1903.....	\$800 00	\$800 00
1905.....	2,000 00	2,000 00
1906.....	3,000 00	3,000 00
1907.....	3,000 00	3,000 00
1908.....	2,000 00	2,000 00
1909.....	2,000 00	2,000 00
1910.....	2,000 00	2,000 00
1911.....	2,000 00	2,000 00
1912.....	2,000 00	2,000 00
1913.....	2,500 00	2,500 00
1914.....	2,500 00	2,500 00
1915.....	15,000 00	15,000 00
1916.....	15,000 00	15,000 00

On June 30, 1916 there had been mapped in Michigan 7554 square miles or 13 per cent of the area of the state. The accompanying map shows the areas which have been completed and those in which work is in progress. In addition, many miles of transit and level lines have been run through areas to which topographic mapping has not extended.

*Importance of the Topographic Survey to the Development of the State.* The permanent bench or elevation marks, established by the topographic survey and the surveyors' notes are useful to county and state road engineers, particularly as all of these are on sea level datum. The use of a common datum in drainage, road, and other engineering will make possible direct correlation of level work throughout the state. In so far as possible the topographic survey adjusts its level lines to the needs of the State Highway Commissioner wherever a direct saving can be made by so doing.

The topographic survey of the whole country is one of the most important of the preparedness measures which are now occupying the attention of Congress and the nation. Only an insignificant fraction of the national border is topographically mapped and less than 40% of the country as a whole. A topographic map is essential to strategic distribution of troops and offensive and defensive maneuvers of infantry, artillery and cavalry. In regions where topographic maps are unavailable the needs of the military are not met with such hurried sketch maps as the army engineers are able to construct often in immediate advance of moving troops. The topographic survey today is not only

ographic map, but military viewpoint deal of information y the topographers

ates is insignificant int alone. It has ralleling the entire mall cruiser. The completed for the Michigan National

gricultural develop-study and mapping

It is particularly a good topographic l artificial drainage e basis for drainage ys. A topographic rain work to bene-units as townships

ll kinds of hydro-ed by villages and ies and in various able for a general trol, water powers,

graphic maps are eliminary surveys. w roads and trunk

aphic maps among

e plant and animal cal and biological or water with good

rd crop zones, and nd animals.

rious insects and



## EXPENDITURES OF THE CO-OP

Year.

1903.....
1905.....
1906.....
1907.....
1908.....
1909.....
1910.....
1911.....
1912.....
1913.....
1914.....
1915.....
1916.....

On June 30, 1916 there has been mapped 13 miles or 13 per cent of the map shows the areas which have been run through areas extended.

*Importance of the Topographic*

The permanent bench or elevation survey and the survey of road engineers, particularly the use of a common datum will make possible direct correlation. In so far as possible the topographic needs of the State Highway can be made by so doing.

The topographic survey of the important of the preparedness of the national border is topographic of the country as a whole. A distribution of troops and offensive artillery and cavalry. In regard available the needs of the military maps as the army engineers advance of moving troops. T.

responsible for the construction of an accurate topographic map, but also for a minute inspection of the country from a military viewpoint under the guidance of the army engineers. A great deal of information of important military value is obtained each year by the topographers for the permanent records of the War Department.

The cost of topographic mapping of the United States is insignificant considering its importance from a military standpoint alone. It has been calculated that a zone twenty miles wide paralleling the entire national border could be made for the cost of a small cruiser. The topographic map of the state of Michigan can be completed for the cost to the state of mobilizing and supporting the Michigan National Guard at war strength for two months.

The topographic survey is an important aid to agricultural development because it renders possible the correlation, field study and mapping of soils with respect to topography and drainage. It is particularly valuable to development of artificial drainage because a good topographic map not only shows the areas which have natural and artificial drainage and those which need drainage but is also an adequate basis for drainage plans and saves the cost of preliminary drainage surveys. A topographic map is almost indispensable in prorating costs of drain work to beneficiaries and between two or more local governmental units as townships and counties.

Topographic maps are an indispensable aid to all kinds of hydrographic studies, local and general. They are needed by villages and cities for location and development of water supplies and in various forms of sanitary engineering. They are indispensable for a general investigation of stream flow, stream gaging, flood control, water powers, artesian flow, and general water supplies.

In road building and road improvements topographic maps are essential. They eliminate the cost of many preliminary surveys. They are especially useful in choosing routes for new roads and trunk lines for development and improvement.

There are many other important uses for topographic maps among which may be mentioned:

For improving rivers and smaller waterways.

In making investigations for the improvement of the plant and animal industries, and in a comprehensive study of physical and biological conditions in connection with the stocking of interior water with good fish and the locating of fish culture stations.

In locating and mapping the boundaries of life and crop zones, and in mapping the geographic distribution of plants and animals.

In plotting the distribution and spread of injurious insects and germs.

As a base map for the plotting of information relative to the geology and mineral resources.

In connection with questions relating to state, county and town boundaries.

As a means of promoting an exact knowledge of the country and serving teachers and pupils in geographic studies.

As base maps for the graphic representation of all facts relating to population, industries, and products or other statistical information.

In connection with legislation involving the granting of charters, rights, etc., when a physical knowledge of the country may be desirable or necessary.

## PROGRESS OF THE BIOLOGICAL SURVEY.

A. G. RUTHEVEN, Chief Naturalist.

The biological work of the Survey has made satisfactory progress during the last two years. As stated in the last biennial report (pgs. 83-7), a five year plan was recommended by the Board of Advisors to begin in 1915, and this plan has been followed with slight modifications. The field work may be listed as follows:

1914.

Investigation of the reptile-amphibian fauna of the Manistee Region, by Crystal Thompson.

A biological survey of the Whitefish Point Region, by N. A. Wood (birds and mammals), A. W. Andrews (beetles and flies), C. K. Dodge (flowering plants), A. H. Povah (lower plants).

1915.

Investigations toward a monograph on Michigan Algae, by E. N. Transeau.

Investigations toward a monograph on Michigan Fish, by T. L. Hankinson.

Investigations on the distribution of the phanerogamic plants of Michigan, by C. K. Dodge.

Excepting the work of Prof. Kaufman on the Agaracacae of Michigan, the manuscript of which has been submitted for publication in two volumes, none of the larger investigations were completed during the two years, and but one report was published by this division—a volume of miscellaneous papers on the zoology of Michigan. Manuscript reports upon the progress of the various pieces of work are in the hands of the Chief Naturalist, and a number of short papers have been published elsewhere with his permission. The papers based entirely or in part upon Survey material which have appeared during 1914 and 1915 are as follows:

Gaige, Frederick M. The Birds of Dickinson County, Michigan. 16th Rept. Mich. Acad. Sci., 74-91.

Gaige, Frederick M. The Formicidae of the Shiras Expedition to Whitefish Point, Michigan, in 1914. Occ. Papers Mus. of Zool., Univ. of Mich., No. 25, 1-4.

Wood, Norman A. Results of the Shiras Expeditions to Whitefish

Point, Michigan. Mammals. 16th Rept. Mich. Acad. Sci., 92-97; Birds, 55-73.

Thompson, Crystal. The Reptiles and Amphibians of Manistee County, Michigan. Occ. Pap. Mus. of Zool., Univ. of Mich., No. 18, 1-6.

Thompson, Crystal and Ruthven, A. G. On the Occurrence of *Clemmys insculpta* (LeConte) in Michigan. Ibid., No. 12, 1-2.

Cockerell, T. D. A. Bees from the Northern Peninsula of Michigan. Ibid., No. 23, 1-10.

Hankinson, T. L. Young Whitefish in Lake Superior. Science, Vol. XL, No. 1024, 239-240.

Miscellaneous Papers on the Zoology of Michigan. Michigan Geological and Biological Survey, Publication 20, Biological Series 4.

Andrews, A. W. The Beetles of Charity Island, Michigan.

Hankinson, T. L. The Fish of Whitefish Point, Michigan.

Hankinson, T. L. The Fish of Houghton County, Michigan.

Colbert, Roy J. An Ecological Study of the Fish Fauna of the Douglas Lake Region, with Special Reference to the Mortality of the Species.

Evans, Arthur T. Dragonflies of the Douglas Lake Region, Michigan.

Thompson, Crystal. The Reptiles and Amphibians of Monroe County, Michigan.

#### PLANS FOR 1916.

As stated, the five year plan becomes effective on July 1, 1915. This plan provides for the following investigations in 1916:

Continuation of the survey of Michigan wood-lots.

Investigations of the phanerogamic flora of the State.

Investigations toward a monograph of the fishes of Michigan.

The wood-lot survey will be under the direction of O. L. Sponsler, the study of the distribution of the higher plants of the state will be made by C. K. Dodge, and the work on the fishes will be done by T. L. Hankinson.

The Chief Naturalist desires to call attention to the loyal support which is being given to the Survey by the naturalists who are making the investigations for this division. Every man has included in his estimates of the cost of proposed investigations only field expenses. It is the interest and cooperation of these men, which have not seldom been attended by real sacrifices, that makes it possible to obtain the maximum results upon the available appropriations.

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## RETRACEMENT AND PERMANENT MONUMENTING

OF THE

### MICHIGAN - OHIO BOUNDARY

R. C. ALLEN,

S. S. GANNETT,

Engineer.

C. E. SHERMAN,

Commissioners.

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