GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN No. 24

A SECOND REPORT

ON THE

PUBLIC ROADS

OF

GEORGIA

BY

S. W. McCALLIE

State Geologist

ATLANTA, GA.
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PREFATORY NOTE

In submitting this report on the public roads of Georgia to the public the writer wishes to express his thanks to the State Prison Commission for valuable assistance in the co-operative work of collecting data on the roads of the State. Special thanks are also due to Capt. Goodloe H. Yancey, Secretary of the Prison Commission, who rendered invaluable aid in compiling the statistical data. In addition to the assistance here accredited, the writer wishes, furthermore, to express his gratitude to the various public road officials throughout the State for information concerning the public roads of their respective counties.

This report is the second report on the public roads of the State published by the State Geological Survey. The first report was issued in 1901. This report may, in a measure, be considered an abridged form of the report of 1901, with the addition of a large amount of statistical data brought up to date with additional matter added. It is to be regretted that the statisitcal data which were collected by correspondence with the county road officials had to be estimated, in many cases, however, they are thought to be sufficiently accurate to give a fairly trustworthy idea of the general conditions of the public roads of the State.

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

ATLANTA, June 15, 1910.

To His Excellency, JOSEPH M. BROWN, *Governor, and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to submit herewith a second report on the Public Roads of Georgia, to be published as Bulletin No. 24, of this Survey.

Very respectfully yours,

S. W. MCCALLIE,

State Geologist.

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Public Roads of Georgia

MILEAGE AND EXPENDITURES

The statistical table of this report shows that the estimated public road mileage of the State of Georgia in 1909 was 82,182. Of this mileage, 554 miles were surfaced with stone and 56 with shells; 502 miles, with chert and gravel; and 3,421 miles, with sand-clay mixture. In addition to these more highly improved roads, there were also reported 13,156 miles of road which had been put in order by the use of the road machines, drags, etc. Omitting the 13,156 miles of roads which have been only partially improved, we still have a total of 4,533 miles of road surfaced with stone, shells, gravel, chert, and sand-clay mixture, which constitute about five per cent. of the total road mileage.

Of the 146 counties of the State, 107 employ convicts and 39 use statute or hired labor, the total number of convicts employed being 4,579.

The expenditures on public roads and bridges in 1909 were $1,437,652 property tax, $558,328 commutation tax and $61,000 bond issue, a total cash expenditure of $2,056,980. To this sum should be added $450,000, the estimated money value of the statute and the free labor employed in the State on the public roads. This makes the grand total for all road expenses for the year $2,506,980. In comparing the total road mileage of the State with the total estimated road expenditures it will be seen that each mile of public road cost last year $30.51 or $1.08 per inhabitant based on the census of 1909.

Public Road Data of Georgia Collected by the State Geological Survey in Co-operation with the State Prison Commission.

COUNTY	Area sqr. miles.	MILEAGE OF ROADS. Total of all public roads.	IMPROVED ROADS. Surfaced with stone or shells.	Surfaced with chert or gravel.	Surfaced with sand—clay mixtures	Otherwise improved. *c*	Average cost per mile. *d*	LABOR USED IN ROAD IMPROVEMENT. Number of convicts.	Salary of superintendent or warden per month.	Salary of guards per month.	Number of mules on public roads.	Value of mules.	Value of road machinery.	EXPENDITURES FOR ROAD IMPROVEMENT Commutation tax.	PROPERTY TAX[1]. For roads.	For bridges.	Total expenditures for roads and bridges.
Appling	583	600			15	69	*s-c* $ 400	15	$ 60	$ 30	6	$ ----	$ 1,400	$ 3,342	$ 8,531	$24,000	$35,873
Baker	366	275			35	50	*s-c* 300	20	50	25	4	700	650	4,000	6,000		10,000
Baldwin	250	335			30	175		35	65	35	20	4,500	1,000	3,000	11,000		14,000
Banks	216	300				10		31	50	25	18	4,500	1,000		2,810	2,810	5,620
Bartow	485	1,000						60	60	30	30	7,500	2,000	7,000	11,852	11,852	30,704
Ben Hill		250			50	60	*s-c* 200	28	50	25	14	4,000	800	400	23,810	5,952	30,162
Berrien		1,200			20	5	*s-c* 500	31	70	30		600	5,000	7,500	4,989		12,489
Bibb	254	500			200	300		139	150	40	65	13,000	3,500		44,043	5,110	49,153
Brooks	463	450				200	400	53	100	30	30	6,000	1,200	8,500	5,125		13,625
Bryan	427	600	20			53	100	20	100	25	8	1,000	700	1,300	1,600		2,900
Bulloch	930	900			50	700	*s-c* 400	41	150	30	34	6,800	1,800	9,000	10,330		19,330
Burke	883	700			400	300	*s-c* 400	64	125	40	30	6,000	1,100	10,000	7,318		17,318
Butts	179	300						*a*									
Calhoun	276	210				125		21	83	25	14	3,000	800	4,300	9,500	850	14,650
Camden	718	275	10			275	250	13	65	30	6	1,000	100	2,500	2,000	1,500	6,000
Campbell	205	465				30		16	75	30	23	5,000	1,000	5,000	4,444	5,555	14,999
Carroll	486	800	12				2,000	37	45	35	14	3,000	10,000	10,000	12,000	12,000	34,000
Catoosa	171	200		30				*a*							2,254		2,254
Charlton	1063	200				30	100	22	65	25			100	1,200	2,167		3,367
Chatham	400	220	1	105			3,500	153	100	50	23	4,600	3,000		40,000		40,000
Chattahoochee	231	262						*a*									
Chattooga	326	350						*a*									
Cherokee	434	1,000			10	25	250	40	75	30	24	6,000	1,500	8,000	4,404	2,936	15,340
Clarke	159	147	8		38	50	*s-c* 650	86	125	35	46	11,500	6,500	2,500			*b*20,000

[1]Estimate made on tax returns for 1908.

Clay	216	360			7	75	*s-c* 125	18	75	30	10	2,500	1,000		4,103		4,103
Clayton	142	300				30		48	70	30	27	6,000	3,000	500	2,620		3,120
Clinch	1077	400	10			100		34	40	25				3,000			3,000
Cobb	321	800	15		6	20	*m* 3,000	65	125	35	34	6,800	1,575	7,500	12,443	11,199	31,142
Coffee	920	950			30	6	*s-c* 400	42	60	30	20	5,000	300	6,000	7,366		13,366
Colquitt	565	700			7	400	*s-c* 300	26	60	30	14	3,500	800	6,500			6,500
Columbia	306	350				350	*s-c* 300	27	60	25	16	3,000	900	2,000	3,591		5,591
Coweta	443	800			25	150		56		30	26	6,000	2,500	8,000	25,186	4,407	37,593
Crawford	334	300						*a*			2	400	135		2,869		2,869
Crisp	285	450				200		23	75	25	15	3,000	4,000	2,000	6,745		8,745
Dade	188	145		10				*a*							2,327		2,327
Dawson	209	300						*a*									
Decatur	766	1,000			100	150	50	80	150	40	81	16,000	5,000	10,000	13,000	4,000	27,000
DeKalb	271	1,300	16		15	600	6,500	65	90	35	60	18,000	30,000	5,000	14,000	7,000	26,000
Dodge	495	450			25	350	*s-c* 350	25	75	20	16	4,000	2,000	6,000	7,248	5,436	18,684
Dooly	400	700				500		43	100	40	23	4,400	6,000	10,000	6,383		16,383
Dougherty	339	350	10			250		49	75	35	24	6,000	6,000	3,000	6,500		9,500
Douglas	212	400						*a*			6	1,300	260	1,960	3,500		5,460
Early	503	1,000			50	100	*s-c* 100	43	75	35	20	4,000	9,000	7,000	16,000		23,000
Echols	365	175						*a*									
Effingham	419	500						20	75	30	4	1,030	750	3,000	5,600		8,600
Elbert	388	700			20	100	*s-c* 1,400	34	50	30	22	5,000	3,000	7,500	6,000		13,500
Emanuel	776	1,000			40	250	*s-c* 250	36	45	25	24	6,000	1,500	8,000	18,000	2,000	28,000
Fannin	390	200						*a*									
Fayette	215	300						20	45	25	8	1,400	600	700	2,438	853	3,991
Floyd	506	800	100			30	760	53	166	50	64	14,400	16,000	11,000	22,118	10,397	43,515
Forsyth	252	600						*a*									
Franklin	281	500			1	17	100	20	75	35	16	3,600			4,886	4,886	9,772
Fulton	174	400	300			25		549	300	37	235	58,750	40,000	8,000	210,000		218,000
Gilmer	450	1,000						*a*							842	3,000	3,842
Glascock	95	200			50		30		35		6	1,200	350	2,100	1,100		3,200
Glynn	468	150	20				*s* 2,000	39	100	50	4	400		2,300	6,581		8,881
Gordon	387	400						*a*							6,000		6,000
Grady	453	400						*a*									
Greene	400	850	3	3	3		200	23	45	25	26	6,000	1,200	6,000	5,774	5,774	17,548
Gwinnett	510	1,000				35		63	60	40	27	5,400	1,000		29,635	4,939	34,574
Habersham	280	400						*a*			4	1,150	150	3,855	3,000		6,855
Hall	449	600	8				1,500	*a*			4	800	1,500	6,000	6,800		12,800

COUNTY	Area sqr. miles	MILEAGE OF ROADS. Total of all public roads.	IMPROVED ROADS. Surfaced with stone or shells.	Surfaced with chert or gravel.	Surfaced with sand-clay mixtures.	Otherwise improved.	Average cost per mile. *d*	LABOR USED IN ROAD IMPROVEMENT. Number of convicts.	Salary of superintendent or warden per month	Salary of guards per month.	Number of mules on public roads.	Value of mules.	Value of road machinery.	EXPENDITURES FOR ROAD IMPROVEMENT Commutation tax.	PROPERTY TAX. For roads.	For bridges.	Total expenditures for roads and bridges.
Hancock	523	750			25	300	*s-c* $ 25	35	$ 75	$ 30	28	$ 5,870	$ 2,500	$ 6,500	$	$ 2,000	$ 8,500
Haralson	282	500						*a*					3,000		4,831		4,831
Harris	486	500						*a*					500				
Hart	257	500				25		24	50	30	12	2,400	700	4,600	3,750	3,750	12,100
Heard	313	310			10			26	75	40	8	1,800	450		2,200	750	2,950
Henry	337	900				30		32	100	30	21	4,600	1,100	7,500	6,549	12,281	26,330
Houston	591	1,400			50	800	*s-c* 50	40	75	30	26	5,000	1,500	4,000	7,000	5,000	16,000
Irwin	459	175			45	25	*s-c* 125	26	75	25	14	3,150	1,250		7,500	3,000	10,500
Jackson	460	1,000			10	100	*s-c* 400	32	75	35	19	5,000	2,500	12,000	10,108	10,108	32,216
Jasper	410	450						*a*									
Jeff Davis	395	500						*a*									
Jefferson	686	565			100	400	*s-c* 250	29			30	6,200	1,200	6,000	9,000		15,000
Jenkins	400	190				130		40	90	35	22	5,000	700	5,500	5,177	1,725	12,402
Johnson	258	200			35	110	*s-c* 50	34	100	30	16	2,400	1,020	2,766	4,183	2,384	9,333
Jones	397	600			50	100		26	60	30	25	5,500	3,000	4,200	3,346	2,007	9,553
Laurens	791	1,310			65	95	*s-c* 700	58	100	30	41	10,000	2,000	11,000	5,883		16,883
Lee	436	800			10	200	*s-c* 500	32	85	30	21	4,500	2,000	4,000	4,500	1,795	10,295
Liberty	976	500						*a*							3,701		3,701
Lincoln	290	900				100		10	50	30	15	3,000	2,500	3,500	4,000		7,500
Lowndes	455	1,250			60		*s-c* 700	54	85	25	28	6,000	1,500	2,500			2,500
Lumpkin	282	400						*a*							2,000		2,000
Macon	392	550			15		*s-c* 400	40	125	30	26	5,000	1,000	4,100	10,882	4,000	18,982
Madison	278	950				10		29	60	30	17	4,300	1,200	10,000	3,300	3,300	16,600
Marion	344	300			25	50	*s-c* 200	15	40		9	1,800		3,600	3,000		6,600
McDuffie	258	400			100	25	*s-c* 50	7	55	30	14	2,000	350	2,500	4,008		6,508

McIntosh	429	150	5					a	60		2	300	75	463	1,207		1,670
Meriwether	544	1,400			50	10		44	100	30	26	7,000	2,000	10,000	7,000		17,000
Miller	275	260						11	100	25	10	2,800	450	4,500			4,500
Milton	147	250						a						3,000	600		3,600
Mitchell	542	600			30	200	s-c 200	41	65	30	36	8,500	2,000	10,000	14,000		24,000
Monroe	480	1,000						30	75	25	26	5,000	1,000	5,500	10,000	5,000	20,500
Montgomery	642	800				100		26	75	40	22	5,000	1,000	6,000	4,850	1,375	12,225
Morgan	346	1,000			250	500	s-c 300	32	60	25	26	6,500		4,000			4,000
Murray	352	250		20				a					250		4,022		4,022
Muscogee	255	400	25		50			93	100	35	40	10,000	4,500	3,500	33,396		36,896
Newton	259	250	15		15	11	s-c 500	28	60		22	7,500	2,500	3,500	8,701	4,350	16,551
Oconee	184	350			2			29	50	30	12	3,000	300	3,300	1,418	1,418	6,136
Oglethorpe	575	940	10		50	30	s-c 500	33	50	30	20	5,000	1,250	7,000	6,000		13,000
Paulding	329	700						a			12	2,700		6,600	6,000		12,600
Pickens	219	500						a									
Pierce	518	250			10	75	s-c 200	22	50	22	2	450	200	1,700	5,951		7,651
Pike	294	900						53	85	35	35	7,500	2,000	5,000	9,404	1,567	15,971
Polk	292	600						a	65		27	6,750	2,010		11,000		11,000
Pulaski	477	580			50	250	s-c 22	38	100	40	31	8,525	1,500	5,500	10,000	3,000	18,500
Putnam	348	350	4		20	100	s-c 600	30	90	30	27	6,000	6,000	6,750	4,811	3,608	15,169
Quitman	152	250						a									
Rabun	344	400						a						4,000	2,000		6,000
Randolph	476	650			106			39	65	30	27	5,000	1,000	7,300	5,000		12,300
Richmond	272	900	7	100	80	100	g 1,600	168	100	40	70	14,000	10,000	900	64,000		64,900
Rockdale	121	238				5	s-c 1,200	27	75	35	17	3,000	2,750	3,500	4,282	4,300	12,082
Schley	188	280						10	75	30	6	1,500	300	1,600	2,050		3,650
Screven	654	625			100	350	s-c 100	32	75	35	16	3,200	1,000	6,500	4,922	2,461	13,883
Spalding	203	1,000			5	22	s-c 250	68	75	35	16	4,000	2,500	5,500	9,979	11,474	26,953
Stephens	155	340			15		s-c 350	24	50	40	16	3,600	1,500	3,000	8,688		11,688
Srewart	440	690				13		32	90	25	16	3,000	2,500	6,000	4,497	2,248	12,745
Sumter	534	1,150			100		s-c 1,000	78	125	35	75	16,875	6,000	6,500			50,000
Talbot	407	414						a									
Taliaferro	198	400						16	50	30	12	2,400	1,000	2,700		2,500	5,200
Tattnall	735	950			55		s-c 265	14	60	30	14	3,000	600	6,500	9,000		15,500
Taylor	338	350			5		s-c 400	a									
Telfair	412	400			50	100		30	75	25	14	3,500	1,500	5,000	5,616	4,212	14,828
Terrell	340	800			125	60	s-c 100	45	85	37	29	5,000	800	9,000	3,000		12,000

COUNTY.	Area sqr. miles	MILEAGE OF ROADS. Total of all public roads.	IMPROVED ROADS. Surfaced with stone or shells.	Surfaced with chert or gravel.	Surfaced with s a n d--clay mixtures.	Otherwise improved.	Aveage cost per mile.	LABOR USED IN ROAD IMPROVEMENT. Number of convicts.	Salary of superintendent or warden per month.	Salary of Guards per month.	Number of mules on public roads.	Value of mules.	Value of road machinery.	EXPENDITURES FOR ROAD IMPROVEMENT. Commutation tax.	PROPERTY TAX. For Roads.	For bridges.	Total expenditures for roads and bridges.
Thomas	504	600			50	300	s-c $ 350	66	$100	$ 30	$ 47	$ 9,400	$ 1,850	$ 9,000	$ 12,500	$	$ 21,500
Tift	271	350			90	40	s-c 200	34	75	25	12	3,000	1,000	5,500	9,300	3,000	17,800
Toombs	519	380				20		26	100	25	16	4,000	1,200	3,500	5,668		9,168
Towns	168	150						*a*									
Troupe	434	650			15		s-c 600	39	75	30	19	4,000	2,105	6,322	11,550		17,872
Turner	326	800			100	200	s-c 125	26	75	25	21	4,500	1,000	3,000	4,600	2,000	9,600
Twiggs	423	300				150		25	100	30	14	3,500	1,000	4,600	1,929	964	7,493
Union	325	200						*a*							723		723
Upson	310	400						*a*									
Walker	433	563		234		42	800	*a*					100		10,000		10,000
Walton	366	1,400				800		33	100	30	34	6,800	1,500		12,387	4,129	16,516
Ware	676	300			8			31	75	35	10	2,000	11,500	2,500			2,500
Warren	298	325				50		16	60	30	18	4,500	1,000	4,100			4,100
Washington	680	1,200			200	50	s-c 300	55	.85	25	48	9,000	3,000	10,000	10,000	18,500	38,500
Wayne	766	600			8	50	s-c 500	*a*					5,700	2,500	5,106	2,042	9,648
Webster	227	228			5	85	s-c 1,500	10	65	35	10	2,500	500	5,000	2,629	4,331	11,960
White	243	250						*a*						3,300	800		4,100
Whitfield	285	450	5			150		*a*							8,000		8,000
Wilcox	473	800						18	65	20	11	2,000	400	4,500			4,500
Wilkes	501	900	6			100		34	60	30	22	4,000	3,000	6,470	6,918	2,421	15,809
Wilkinson	431	500						20	40	25	9	2,200	1,500	5,000	2,641	3,301	10,942
Worth	604	800				400		29	100	25	18	3,600	1,000	10,000	10,000	3,000	23,000
Total		82,182	610	502	3,421	13,156		4,579			2,645	588,450	271,480	558,328	1,157,895	279,757	2,056,980

a–Roads kept up by statute or free labor or by both. *b*–Total expenditure, includes money raised by taxation and bond sale. *c*–"Otherwise improved" are roads partially improved by road machines, drags etc. *d*–The great variation in the cost of sand-clay roads is due to the width of roads, amount of grading, etc. *m*–Macadamized roads. *s-c*–Sand-clay roads. *g*–Gravel roads. *s*–Shell roads.

ROAD-BUILDING MATERIALS[1]

In the discussion of the road-building materials of Georgia, it is well to divide the State into three divisions, namely, the Paleozoic Area, the Coastal Plain, and the Crystalline Area.

ROAD-BUILDING MATERIALS OF THE PALEOZOIC AREA

The road-building materials of the last named area, the Paleozoic, which comprises all or a part of ten counties in the northwestern part of the State, consist of limestones, cherts, shales and sandstones.

LIMESTONE.—The limestones of the area are very abundant and well suited for macadamizing purposes. They are divided geologically into three divisions, namely, the Knox dolomite, the Chickamauga limestone, and the Bangor limestone.

THE KNOX DOLOMITE is the most extensive of the three formations. It attains a thickness, in places, of more than 4,000 feet, and occurs in the form of a number of broad belts traversing the area in a northeast-southwest direction, giving rise, usually, to broad, rounded ridges. The formation consists largely of compact, heavy-bedded, light-gray magnesian limestone, often oolitic and always containing a considerable amount of siliceous material in the form of chert. Its uniform texture and its semi-crystalline structure will adapt it for macadamizing purposes. It would, indeed, be a difficult matter to find a calcareous deposit better adapted for road-material than some of the beds of this formation. The stone is easily quarried and is readily crushed by the rock breaker;

1. For a more complete discussion of the road materials of Georgia, see Bulletin No. 8 on Roads and Road Materials of Georgia, published by this Survey.

but it has, at the same time, sufficient toughness to form a durable wearing surface.

THE CHICKAMAUGA LIMESTONE overlies the Knox dolomite. It occurs in the form of narrow belts, more or less parallel and often valley forming. The formation is so-called from Chickamauga valley, where, in the neighborhood of Chickamauga Park, it reaches its greatest development. Its various beds differ considerably, both in physical structure and mineral composition. In its western exposure it is a blue, flaggy, highly fossiliferous limestone with some local variations of minor importance. The compact, blue variety of this stone makes an excellent macadam. It has been extensively used for this purpose both at Chattanooga and in Chickamauga Park. It makes a hard, smooth road surface, comparatively free from dust. The Chickamauga limestone varies from 1,000 to 1,800 feet in thickness and is the underlying rock in many of the narrow, fertile valleys in Northwest Georgia.

THE BANGOR LIMESTONE is a pure, dove-colored limestone, attaining a thickness of about 900 feet. It is highly fossiliferous and contains, in places, crinoid stems in great abundance. The formation is well exposed along the flanks of Pigeon and Lookout mountains. The extent of the area covered by this formation is limited mainly to the narrow belts at the base of the above named mountains; and, as a consequence, it will probably never become of very great importance in road construction. However, its use for macadam in the vicinity of Chattanooga shows that it is well suited for that purpose.

CHERT.—The chert deposits of the Paleozoic Area are quite extensive and are widely distributed throughout the area. They occur in two different geological formations, namely, the Knox dolomite and the Fort Payne chert, the latter being the lowest member of the Carboniferous formation. The chert of the Knox dolomite is co-extensive with the dolomite itself, and is by far the more important deposit of the two, for road building material. It occurs in the dolomite in the form of nodules, and also in beds, frequently several feet in thickness. In the weathering of the dolomite, the chert remains as a residual product in the form of gray flinty nodules. This siliceous material frequently accumulates to the depth of many feet along the sides and slopes of ridges where it is often well exposed in railroad cuts. The chert is an impure variety of flint, frequently containing more or less calcareous material, and is readily crushed into sharp angular fragments. It has been extensively used for several years for surfacing roads and streets throughout North Georgia and Tennessee. The material is well suited for roads of light travel, but where the traffic is heavy it is inferior to limestone. It possesses an excellent binding quality, but after long drought and much travel it becomes somewhat dusty.

Shale.—The shales of the Paleozoic Area are of but little economic importance as road-building materials; however, the shales in the vicinity of Rome have been used to a considerable extent for road surfacing. This material makes a fair road surface; but it is objectionable, on account of its rapid wear and dusty condition during the dry season, especially when there is much travel.

Sandstone.—The sandstones of the Paleozoic Area are confined chiefly to Pigeon, Sand, and Lookout mountains. They are known as the Walden sandstone and the Lookout sandstone. The former constitutes the surface rock of the above named mountains, while the latter forms the cliffs and escarpments along thier slopes. The aggregate thickness of the formations is several hundred feet. These sandstones are so easily crushed that they are of but little value for road material.

THE ROAD-BUILDING MATERIALS OF THE CRYSTALLINE AREA

The road-building materials of the Crystalline Area consist of granite, gneiss, diorite, and trap rock.

GRANITE.—The granite is very generally distributed throughout the Crystalline Area where it occurs in the form of large intrusive masses in the gneisses and schists. These granitic masses often cover hundreds of acres, and occasionally, as in the case of Stone Mountain, form dome-shaped masses, having an elevation of several hundred feet above the surrounding country. In texture the granites differ widely. They vary from an exceedingly fine-grained, homogeneous, monumental stone to a very coarse-grained granite or pegmatite. The fine-grained varieties are quite extensively quarried at several localities in the State for building and monumental stone; and also for street paving purposes. The physical tests, which have been made on these granites, show that they have great strength, and are therefore among the best of this class of stone for road material.

GNEISS.—Gneiss is far more abundant in the Crystalline Area than granite; and, as a general rule, it is much more suitable for road material. The gneisses are divided into two varieties, namely, the true gneiss, made up of quartz, feldspar and mica, and the hornblende-gneiss, which contains, in addition to these minerals, hornblende as an essential constituent. Hornblende-gneiss is generally superior to the true gneiss for road purposes on account of its finer texture and greater toughness. It occurs, in places, throughout North Georgia, where it is found in narrow belts underlying the so-called "red lands." The great amount of iron which the rock carries adds probably to its binding quality. It wears well and is comparatively free from dust. The true gneiss makes a fair road-surfacing material, when it is fine-grained and composed largely of quartz. Nevertheless, it is usually inferior to hornblende-gneiss.

Diorite.—Diorite, which is more or less abundant throughout North Georgia, is a green or dark gray rock resembling very closely in general appearance the hornblende-gneisses. It occurs mostly in the form of narrow belts or zones, intercalated with the gneisses and schists. Most of the diorites of the Crystalline Area have a schistose or laminated structure which injures it for road macadamizing purposes. The diorites, when fine-grained and not too distinctly laminated, make an admirable road material, second only to diabase. The toughness, hardness and binding quality of this stone are all excellent. Large exposures of this rock are to be seen throughout the Piedmont Plateau.

Trap or Diabase.—Trap rock is very generally distributed throughout the Crystalline Area. It occurs always in the form of dikes, which have originated from the filling of fissures by molten matter forced up from below. The dikes have generally northwest-southeast trend and a nearly vertical dip. They almost invariably cut the gneisses and the schists at a considerable angle, and rarely ever show any evidence of shearing or crust movement since their formation. All the larger dikes of Georgia, so far as known, are usually quite uniform in thickness, and frequently extend for many miles, with but few interruptions. A good example of one of the larger dikes is to be seen in a cut on the Central of Georgia Railway a few miles east of Newnan. This dike continues for about 65 miles in a southeasterly direction through Coweta, Meriwether and Talbot counties, finally disappearing beneath the recent sands about four miles south of Talbotton. These rocks are of dark gray or black color, usually fine-grained and quite difficult to break with a hammer. As a road-surfacing material, this class of rocks has no equal. Its great hardness and its remarkable toughness make it an ideal road-building material.

THE ROAD-BUILDING MATERIALS OF THE COASTAL PLAIN

The road-building materials of the Coastal Plain are limestone, clay and gravel. In the vicinity of the coast, shells also have had limited use in road surfacing.

LIMESTONE.—The limestones of South Georgia outcrop at many points throughout the Coastal Plain. They are exposed most abundantly along the streams and in the vicinity of lime-sinks or lakes. They are also occasionally seen in the cuts of the various railroads traversing this part of the State. These limestones are usually soft and of a porous nature; though, occasionally, they become quite compact and are partly crystallized. The softer varieties, in places, consist mainly of fragments of shells and a limited amount of sand cemented together by a calcareous matrix. This class of limestone has been used to a limited extent for road and street surfacing both in South Georgia and Florida, where it seems to give general satisfaction. It readily cements into a compact, hardened surface, comparatively free from dust. This material has been used in the last few years on some of the streets in the city of Macon, where it has given fair results. The hard limestones of South Georgia appear to have had but little use, so far, in road construction; nevertheless, they are more or less widely distributed, and they seem to be fairly well adapted to that purpose.

GRAVEL.—Gravel deposits are quite plentiful along the northern border of the Coastal Plain, where they are often seen in thick beds outcropping beneath the superficial layers of sand. The pebbles are all water-worn, and evidently mark the limit of an old shore line. They are often cemented by ferruginous, sandy clays, and make excellent material for road surfacing. Many exposures of these gravel deposits are to be seen in the vicinity of Augusta, Milledgeville, Macon and Columbus. These gravel deposits are well exposed just across the Savannah River from Augusta, near the Charleston and Western Carolina Railway. At this point, the gravel has been extensively worked for the last few years and shipped to Augusta, Savannah and other points, where it is used for both street and road surfacing. The binding material of this gravel is a ferruginous, sandy clay, which readily hardens into a compact mass on being dampened and rolled, forming an excellent road surface, which is both durable and free from dust.

CLAY.—The clays of the Coastal Plain and the other divisions of the State are quite abundant and are well suited for mixing sand-clay roads. At nearly all points through the Coastal Plain, such clays can be found from one to three feet below the surface.

ROAD CONSTRUCTION[1]

LOCATION OF ROADS

The first thing to be considered in the location of a new road is the topography of the section through which the road is to pass. Where topographic maps are to be had, they can be used to great advantage in locating the most practical line for the proposed road. When these maps are not accessible,

1. For a more complete discussion of road construction see Bulletin No. 8, Roads and Road Materials of Georgia, published by this Survey.

there must be a preliminary survey made, showing the location and trend of the streams and ridges, together with the relative positions of the objective points to be reached by the road. Having obtained this desired information, the road builder proceeds to locate the line of road which will best accommodate the traffic for which it is to be constructed. The easiest grades and the shortest distances, consistent with the cost of construction, together with conveniences and necessities of the community, all should receive due consideration before the line of road is permanently located.

As a general rule, in mountainous or hilly countries, the best and most important highways are located along streams or ridges. Each of these locations has its advantages and disadvantages. Ridge roads are often dry and easily drained, but the descent of these roads to the valleys below are likely to present difficult problems in securing practical grades. The location of roads along valleys, on the other hand, although they may serve to a better advantage a larger number of people, is frequently objectionable on account of the extra expense of keeping up bridges. Even if the line of road does not cross the main stream of the valley, there are always many small tributaries or deep gorges to be bridged.

One of the most important questions to be solved by the road builder in Georgia, is not so much the question of location of new roads as it is of changing the location of roads already in existence. This is especially true where the roads were originally laid out along lot lines or division boundaries between properties, regardless of grades and other conditions. These mistakes must be corrected, in a great measure, before it will be possible to construct first-class roads with easy grade, throughout the State, at anything like a reasonable cost. The road authorities of the several counties should by all means see to it that their roads are always properly located before attempting any permanent improvement. Such conditions as these practically prohibit the construction of good roads in many localities until they are re-located. Changing the location of established roads frequently presents a simple problem; but, at the same time, it may save hundreds of dollars per mile in the cost of grading.

Grades

Grade, as used in highway construction, means the degree of inclination from the horizontal, or the slope of the road surface. The grade is usually expressed either in the form of a simple ratio, as, for example, 1:20, or terms of percentage. The ratio 1:20 indicates a rise of 1 foot in every 20, or a 5 per cent. grade.

The grade of a road should depend, in a large measure, upon the character of the traffic for which the road is to be constructed. If the traffic is heavy and the individual loads are large, it is always advisable to reduce the grade to the lowest possible minimum consistent with the cost of construction. Most road builders place the maximum grade of macadamized roads at 1:20. Such high grades as this, however, should be short, as they overstrain the team and render frequent stops necessary. The tractive force required to move a given load over a road with a grade of 1 to 30 is nearly three times as great as that required to move the same load over a level road. It is nearly always practicable to reduce the grade of a road to the above maximum limit, even in mountainous regions, by making the line of road sinuous or zig-zag, without greatly increasing the distance between the objective points or the cost of construction. A good example of a mountain road laid out on this plan is the newly constructed public highway extending from Dahlonega to Murrayville.

Besides reducing the efficiency of tractive force, steep grades also greatly increase the cost of keeping roads in repair. It is a well known law of running water, that its erosive power varies as the square of its velocity; it therefore follows that a slight increase in grade will greatly increase the effective force of this destructive agent. The extra expense in maintaining a road with high grades will frequently aggregate, in a short time, a sum sufficient to pay the entire expense of relocating the road.

Drainage

Drainage is one of the most important questions which confronts the road builder. Unless a road is properly drained, it is practically impossible to keep it in first-class condition. Water must be removed from the roadway or it will sooner or later destroy the hardened surface and thus render the road imperfect. This is true, not only of common dirt roads, but also of macadamized roads.

Road drainage is divided into two divisions, namely, surface drainage and subdrainage. Surface drainage conducts the water which falls on the surface of the road into the side ditches or drainways, while the subdrainage removes the water from beneath the surface.

Surface drainage is accomplished by giving the surface of the roadway a slight inclination or slope from its center to its sides and is known as "crowning" the road.

The angle of the slope which the crown of the road should have depends largely upon the character of the surfacing material used; that is, the angle of slope should be greater for permeable, such as sandy clays, than for the more impermeable materials. The usual grade for the crown of a macadamized road is about 1 in 30; that is, a roadway 30 feet in width should be six inches higher at the center than at the sides. The crown of a dirt road should be somewhat greater; but in no case should it be so great as to cause an undue lateral erosion of the surface from heavy rains. The water, as it flows from the surface of the roadway, should be received in properly constructed drains on either side of the road. These drains should have sufficient slope to conduct the water off as rapidly as it accumulates.

A road properly crowned and supplied with suitable side ditches needs no further drainage. In some instances, however, subdrainage is also necessary to secure the proper drainage. The object of subdrainage is not only to remove the water which may penetrate the surface from above, but also to draw off the water which, by lateral seepage, enters the roadbed from below. Subdrainage may be accomplished by the use of either side or central drains. Side drains may be open or closed, and should always have a depth of two feet or more below the surface of the roadway, and sufficient slope to carry off the water. Open drains perform the double office of carrying off both the surface and the underground waters; and, for this reason, they are often preferable to closed drains. These drains, however, on account of their depth and proximity to the roadway, are frequently dangerous and are therefore objectionable.

Closed drains are variously constructed. One of the simplest consists of a narrow, properly graded ditch, about two feet or more in depth, and partly filled with water-worn, rounded stones. In constructing a drain of this character, it is always advisable to place the largest stones on the bottom and the smallest on the top. Such an arrangement gives ample space at the bottom for the free circulation of the water and prevents the washing in of the earth from above. To guard more completely against the filling of the spaces between the stones by earth, it is often best to overlay them with grass or straw before filling the upper part of the ditch with earth. Where stones are not to be had, a drain can be made of logs, poles, and brush, which will answer all practical purposes.

For a more detailed discussion of the question of sub-drainage, including cost, etc., the reader is referred to Bulletin No. 8, on Roads and Road-Building Materials of Georgia, published by this Survey.

Road Surfaces

The roadway having been properly graded and drained the next step is the preparation of the surface. This is accomplished by covering the roadbed to the depth of several inches with broken stones, or some other suitable material.

Stone.—When stone is used for this purpose, it is customary to prepare the roadbed by first giving it the proper grade and crown, after which the roller is passed over it until the surface is thoroughly consolidated and hardened. The surface, having been prepared as above described, is now ready to receive its covering of broken stones.

It is always best to place the broken stone on the prepared sub-grade surface in two or more layers, in order that it may be more completely consolidated by traffic or by the use of the roller. The total thickness of these layers should depend both on the character of the traffic for which the road is constructed and, to some extent also, upon the nature of the road foundation. If the traffic is heavy and the individual loads are large, the thickness of the road-covering should be greater than when the opposite conditions exist. Furthermore, even when the traffic is light, the road-covering should be increased in thickness wherever the foundation is unstable or insufficiently drained. The road coverings vary from 4 to 12 inches, an average, probably, being about seven inches.

The first layer of stones should be spread as evenly as possible over the prepared roadbed to the depth of three or four inches, and then thoroughly compacted by rolling. It is always desirable to have the stones as nearly cubical as possible; and, in no case, should they exceed two or three inches in their greatest dimensions. The more cubical the stones, other things being equal, the easier they are to become consolidated into a compact mass.

The first layer of stone having been compressed from about six inches to four inches, it is ready for the reception of the second layer. This layer of stone, in first-class roads, is usually, when consolidated, about three inches in thickness, and consists of fragments one and one-half inches and less, in diameter. As the layer constitutes the actual wearing surface of the road, it is essential that the stone used should be as hard and tough as possible.

The road covering is finally completed by placing on the surface a layer of binding material, one-half inch or more in thickness, which is sprinkled and continuously rolled until it becomes thoroughly consolidated. One of the best and most satisfactory materials to use as a binder is the chips and dust obtained by screening the broken stones. When such material is not at hand, small gravel, sand or loam will answer the purpose. The object of the thin superficial layer is to form an impervious covering for the roadbed, and, at the same time, to unite the fragments of stone into a perfect bond.

Having constructed the roadbed as above described, and given to its surface a sufficient crown to conduct the water quickly into the gutters or side ditches, we have an excellent country road, and one, if kept in proper repair, that will last for many years, even under heavy traffic. Such roads are but little affected by the seasons, and they are as serviceable for traffic in winter as in summer.

Gravel.—Instead of broken stone, gravel is often used for surfacing material. The gravel used for this purpose may be either rounded or angular. The rounded pebbles are found in the greatest abundance along old coast lines or occupying the beds of streams. The angular pebbles, on the other hand, are the result of a peculiar disintegration of the parent rock, and frequently occur, in considerable beds mixed more or less with clay. The water-worn pebbles are usually quartz, or some other hard rock well suited for wear on a road surface. Intermingled with the rounded pebbles in the natural bed, is invariably to be found either sand or clay filling the interstices and forming a matrix, which binds the materials together. The value of a gravel as a road material depends, in a large measure, upon the nature and physical condition of the matrix. If the matrix consists of sand alone, no amount of rolling or traffic will suffice to compact the material into a hardened road covering; but if, on the contrary, the matrix is made up of a sandy clay, with considerable iron oxide, the material is readily consolidated and forms an excellent road surface. A fair idea of the binding quality of the matrix of a gravel bed can usually be obtained from an examination of the gravel pit. When the walls of the pit stand perpendicular for any length of time, without signs of disintegration from freezing or other physical cause, the material will be found in most cases to give satisfactory results on the roadway.

Angular, or what is usually called pit gravel, binds readily into a compact mass; and, on this account, it is commonly preferred to water-worn gravel. This kind of gravel always contains a considerable amount of clay, which should be separated from it by screening before it is put on the road. It is, furthermore, desirable, in order to obtain a uniform and smooth surface, to remove all the stones having a greater diameter than two inches. When it is not convenient to screen the gravel, the larger stones may be readily removed with a rake, as they are distributed over the surface of the road. Before the gravel is placed in position, the roadbed should be properly prepared by giving it the necessary crown and by compacting its surface either by the roller or by traffic. The thickness of the gravel forming the road covering should be greater than that of broken stones. They should have a total thickness of eight or ten inches, and should be put on the prepared road surface in two or more layers, each layer being thoroughly rolled before the succeeding layer is placed in position.

One of the strongest arguments in favor of gravel roads is the cheapness of construction. If the gravel has to be transported only a short distance, this kind of road covering is inexpensive, and at the same time forms a road surface well suited for country roads, where the amount of traffic is light.

Sand-Clay Road.—A sand-clay road is a road surfaced with a mixture of sand and clay in such a proportion that when the mixture is compacted it forms a firm surface suitable for traffic. Roads of this class have in the last few years attracted much attention throughout the Southern States by reason of their cheapness and suitableness for common country highways. The sand-clay mixture may be either an artificial mixture or a natural mixture, but in either case, other things being equal, the relative proportions of the two different ingredients remain the same. It not infrequently happens that common earth roads have for long stretches the right proportioning of sand and clay to make a typical sand-clay road, in which case it is only necessary to give them the proper drainage and grade to form them into first-class sand-clay roads. It must not be inferred from the above statement that any kind of clay is equally suitable for the construction of sand-clay roads. A clay, in order to give the best results, should be highly plastic, and at the same time it should shrink but little in drying. In addition to these two physical properties, the clay should also have good slaking qualities, otherwise it will form lumps and will not mix readily with the sand.

Many clays, especially the high grade kaolins and fire clays, possess but little plasticity and as a result give very unsatisfactory results when used in constructing sand-clay roads. A fair idea of the plasticity of a clay may be had by rolling out a small pencil of it between the fingers and note the degree to which it will bend before breaking.

Shrinkage is the amount of contraction which a clay undergoes in the process of drying. The shrinkage of the Georgia clays, as shown by a large number of tests made in the Survey laboratory, varies from 1 to 17 per cent. Before using a clay for sand-clay roads, it is always advisable to determine its shrinkage. This may be readily done by making the clay into small bricklets and noting the degree of shrinkage upon drying. A clay with a high shrinkage leads to cracking and breaking up of the surface during the process of drying and a corresponding expansion when again wet by rain, conditions highly detrimental to a good road surface.

The rate of slaking of a number of South Georgia's clays, together with the condition of the slaked product is shown by the following table:

Slaking Tests of Georgia Clays[1]

		Time	Degree of slaking
Paper clay, Georgia Kaolin Co.	6	Min.	fine powder
Paper clay, American Clay Co.	3	min.	fine powder
Paper clay, Atlanta Mining & Clay Co.	5	min.	fine powder
Paper clay, Albion Kaolin Co.	4	min.	fine powder
Flint clay, Gibson		....	no slaking
Paper clay, Butler	4	min.	pulverulent
Plastic white clay, Gibson	5	min.	flaky
White clay, Perry	2½	min.	lumpy
Fire clay, Copperas Bluff	2½	min.	coarse granules
Fire clay, Carr's Station	7	min.	flaky
White, plastic clay, J. T. Hatfield	7	min.	granular
White clay, Rico mine	4	min.	complete
Pottery clay, I. Mandel	10	min.	slightly mealy
Fuller's earth, Twiggs county	20	min.	very fine flakes
White clay, Van Buren	6	min.	fine powder
White clay, Carswell, McIntyre	3½	min.	slightly granular
White clay, Chalker	5	min.	coarse granules
White clay, Byron	5	min.	coarse flakes
Terra cotta clay, Aragon		splits into coarse flakes, but does not show complete disintegration.	

The above slaking tests were made by immersing one-inch cubes of clay, previously dried at a temperature of 212 degrees F., in 250 cubic centimeters of water. A slaking test of sufficient accuracy for road building clays may be made by dropping fragments of thoroughly dried clay into a glass of water and noting the rate and the degree of disintegration.

The relative proportion of sand and clay to be used in sand-clay roads may be determined by the following method as given by W. L. Spoon:[1]

"Two ordinary glass tumblers of the same size are filled to the brim, one with the dry sand to be tested and the other with water. The water is then poured carefully from one glass into the sand in the other until it reaches the point of overflowing. The volume of water removed from the glass which was originally full of water can be taken as an ap-

1. For a more complete discussion of the physical properties of the Georgia clays, see the Report on the Clay Deposits of Georgia issued by this Survey.

1. Farmer's Bulletin No. 311, U. S. Department of Agriculture, page 10.

proximate measure of the voids in the unit volume of sand contained in the tumbler. A simple calculation will reduce this to percentage volume."

These various tests are only given to enable the road constructor in the beginning to get a rough idea of the material to be used in constructing his sand-clay surface. By making these simple tests and also by a critical study of the mixture in a natural sand-clay road, in a short time, the road builder learns to select the material with a fair degree of accuracy without the use of tests.

The methods of building sand-clay roads are variable, depending upon the character of the subsoil and the nature of the material to be used. In the case the subsoil consists of sand, the method of surfacing, after the roadway has been properly drained and graded, is to cover the roadbed with a layer of clay from six to eight inches in thickness in the center, thinning gradually to the outer edge to five inches or less. As each load of clay is dumped on the road it should be spread uniformly over the surface to the desired thickness. The surface is now ready for its coating of sand, which should be spread evenly over the surface. Where the clay is not too lumpy, the sand may be allowed to be worked into the clay by traffic, more being added from time to time as it is needed. This method of making a sand-clay road is quite slow, unless the materials are especially adapted for the purpose for which they are used. To hasten the process of mixing the sand and clay, often the harrow and the plow are resorted to. Where this is done, it is best to use the plow and harrow just after a rain, when the surface of the road is in such a condition that it readily works up into a thin mud.

In case the subsoil is clay, the road is first drained, graded and crowned, as before, when the surface is loosened up and pulverized by the plow and the harrow to a depth of about four inches. It is then covered to a depth of six or seven inches with sand, after which the sand and clay are mixed dry by harrowing. To get the best results, the road surface should be again mixed and puddled after a rain and then given the proper crown by a road machine or a drag.

These methods are usually employed when the sand-clay road surface is an artificial mixture, but when the sand-clay is a natural mixture the method is somewhat different. The method of constructing sand-clay roads with a natural sand-clay mixture, as adopted in Clarke county, and described by Prof. C. M. Strahan[1] in the Engineering Annual of the University of Georgia, is here given:

"First. The grading of the road bed is first done to a width of 30 feet.

"Second. In the center a bed of top soil 10 inches deep and 16 feet wide is laid. The teams haul over this bed as the work progresses. With clay foundation, it would be a mistake to prepare a trench to receive the top soil.

"Third. The road machine excavates flat-side ditches six inches deep and four feet wide; throwing the earth as a shoulder against the top soil bed, and then crowning the whole from ditch to ditch.

"Fourth. The construction teams and traffic pass over the green bed and pack it down chiefly in the center. When several hundred yards are thus partially packed, the road machine pulls in the material from the sides and resurfaces the bed. New top soil is delivered for weak places and shaped up.

"Fifth. As fast as the grading of the bed is finished, the

1. Engineering Annual, University of Georgia, Vol. IX, No. 10a, June, 1909, pp. 18-19.

top soil layer is spread on it. Thus by the time one-half mile of road has been graded and covered with top soil, the first one-fourth mile has undergone considerable packing and resurfacing and getting into good shape.

"Sixth. For some weeks close attention is paid to the new bed, watching for weak places, doctoring them, maintaining the grade with new top soil and keeping the crown fully up to one inch per foot.

"Seventh. Wet weather hastens the period of consolidation if followed by a dry spell. When packed quite wet, the wheels consolidate the material from the bottom upward. In dry or moist weather, the top layer only is consolidated and may cut through at the next rain. A period of wet weather is usually necessary for a full packing down of the top soil into permanent firmness.

"Eighth. Usually, in two months, a new top soil roadbed is consolidated, shaped to its correct crown, and able thereafter to withstand the rains and the traffic. Much of the reshaping and doctoring of the surface coat is done at odd times incidental to the main grading work while the teams are in transit from barracks to the work."

The cost per mile to Clarke county of putting on this "top soil" coat, according to Prof. Strahan's estimate, using convict labor at 50 cents per day and the county teams at $1.00 per day, is $400.00.

The material which is used for road surfacing in Clarke county, designated as "top soil," is a residual sandy clay, resulting from the weathering of granites and granite-like rocks. It usually contains 50 per cent. or more of hard, coarse residue, consisting of quartz and feldspar, the latter often partially altered into kaolin. Experience shows that the best "top soil" is found in cultivated fields where the fine particles of mica are wanting and the clay has the essential plasticity. The results which have been obtained in Clarke county with the natural sand-clay mixture are very satisfactory, and the work fully demonstrates what can be done throughout the Crystalline Area region of Georgia where like material for building sand-clay roads is abundant.

A somewhat different material from the above natural sand-clay mixture has recently been extensively used in road construction in Sumter and other counties in South Georgia. The material here referred to is a reddish sandy clay widely distributed throughout the Coastal Plain. It, like the clays of the Crystalline Area, is often partially residual, having resulted from the weathering of the underlying formations. In Sumter county excellent results have been obtained by using the clay directly from the roadway without any previous mixture. The only attention necessary to keep these roads in first class condition, after they have been once properly graded and drained, is an occasional use of the split log drag, which fills up all ruts and washes and at the same time restores the former crown and leaves the surface in a smooth, even condition. These roads, which I had the pleasure of examining a few weeks ago, are what may be termed ideal country roads, over which from 8 to 10 bales of cotton may be drawn by a two-horse team with comparative ease. Such roads as those here referred to, namely, roads constructed of natural sand-clay mixture, may be found in a large number of other counties of South Georgia. In many places throughout this part of the State, it is true, surface sands occur, in which case artificial sand-clay mixtures must be resorted to, but, fortunately, even here only a few inches, or at most a foot or so, beneath the surface sands generally occurs an abundance of clay suitable for sand-clay mixtures.

BULLETINS OF THE GEOLOGICAL SURVEY OF GEORGIA.

1. Marbles of Georgia, by S. W. McCallie, 1894, 87 pp., 16 pl., and 2 maps. *Out of print.*
1. Marbles of Georgia, Second Edition, Revised and Enlarged, by S. W. McCallie, 1907, 126 pp., 52 pl., and 2 maps. *Postage, 13 cents.*
2. Corundum Deposits of Georgia, by Francis P. King, 1894, 133 pp., 6 pl., 1 map. *Postage, 9 cents.*
3. A Part of the Water-Powers of Georgia, by C. C. Anderson and B. M. Hall, 1896, 150 pp., 10 pl., and 2 maps. *Postage, 9 cents.*
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