IOWA

GEOLOGICAL SURVEY

VOLUME II.

COAL DEPOSITS OF IOWA

BY

CHARLES ROLLIN KEYES.

GEOLOGICAL CORPS:

Samuel Calvin, A. M., Ph. D., State Geologist.
Charles Rollin Keyes, A. M., Ph. D., Assistant State Geologist.
G. E. Patrick, A. M., Chemist.

DES MOINES:
Published for the Iowa Geological Survey.
1894.
GEOLOGICAL BOARD:

His Excellency, Horace Boies . . . . . . Governor of Iowa
Hon. C. G. McCarthy . . . . . . . . . . . . Auditor of State
Dr. Chas. A. Schaeffer, President State University of Iowa
Dr. Wm. M. Beardshear, Pres't Iowa Agricultural College
Prof. L. H. Pammel . . . President Iowa Academy of Sciences
SPECIAL AND TEMPORARY ASSISTANTS.

S. W. Breyer .................................. Artesian Waters
H. F. Bain ...................................... Coal
N. E. Newman .................................. Secretary
E. H. Lonsdale .................................. Clays
A. C. Spencer .................................. Building Materials
A. G. Leonard .................................. Lead and Zinc
F. C. Tate ....................................... Draughting
C. D. Jamison .................................. Cements
A. J. Jones ..................................... Local Geology
W. H. Norton .................................. Local Geology
J. L. Tilton ..................................... Local Geology
F. M. Fultz ..................................... Local Geology
C. H. Gordon .................................. Local Geology
J. P. Farnsworthji .............................. Local Geology
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Members of the Geological Board</td>
<td>3</td>
</tr>
<tr>
<td>Special and Temporary Assistants</td>
<td>4</td>
</tr>
<tr>
<td>Contents</td>
<td>5</td>
</tr>
<tr>
<td>List of Illustrations</td>
<td>11</td>
</tr>
<tr>
<td>Preface</td>
<td>19</td>
</tr>
<tr>
<td><strong>CHAPTER I.—Introduction</strong></td>
<td>29</td>
</tr>
<tr>
<td><strong>CHAPTER II.—Origin of Coal</strong></td>
<td>41</td>
</tr>
<tr>
<td>Sources of Materials</td>
<td>41</td>
</tr>
<tr>
<td>Conditions of Deposition</td>
<td>44</td>
</tr>
<tr>
<td>Associated Beds</td>
<td>52</td>
</tr>
<tr>
<td><strong>CHAPTER III.—Carboniferous Basin of the Mississippi Valley</strong></td>
<td>55</td>
</tr>
<tr>
<td>General Geological Features</td>
<td>57</td>
</tr>
<tr>
<td>Structure</td>
<td>57</td>
</tr>
<tr>
<td>Geological Provinces</td>
<td>60</td>
</tr>
<tr>
<td>Continental Interior Previous to the Carboniferous</td>
<td>65</td>
</tr>
<tr>
<td>Major Members of the Carboniferous</td>
<td>67</td>
</tr>
<tr>
<td>Mississippian, or Lower Carboniferous, Series</td>
<td>69</td>
</tr>
<tr>
<td>Derivation of the Limestones</td>
<td>70</td>
</tr>
<tr>
<td>Use of Term</td>
<td>72</td>
</tr>
<tr>
<td>Geographical Distribution</td>
<td>73</td>
</tr>
<tr>
<td>Geological Delimitation</td>
<td>74</td>
</tr>
<tr>
<td>Biological Definition</td>
<td>83</td>
</tr>
<tr>
<td>Subdivisions of the Mississippian Series</td>
<td>85</td>
</tr>
<tr>
<td>Upper Mississippi Region at the Beginning of the Coal Measure Epoch</td>
<td>90</td>
</tr>
<tr>
<td>Pennsylvanian, or Upper Coal Measure, Series</td>
<td>91</td>
</tr>
<tr>
<td>Occurrence of Coal</td>
<td>91</td>
</tr>
<tr>
<td>Coal Fields of the Interior Basin</td>
<td>94</td>
</tr>
<tr>
<td><strong>CHAPTER IV.—General Geology of the Coal Region</strong></td>
<td>99</td>
</tr>
<tr>
<td>Geographic Limits of the Iowa Area</td>
<td>99</td>
</tr>
<tr>
<td>Topography</td>
<td>100</td>
</tr>
</tbody>
</table>
## CONTENTS.

### CHAPTER IV.—Continued.
- Geological Formations of the State ........................................ 103
- General Geological Relations of the Coal Measures of Iowa .......... 112
- Geological Subdivisions of the Coal Measures .......................... 118

### CHAPTER V.—Lithology of the Coal Measures .......................... 123
- General Considerations ...................................................... 123
- "Lower" Coal Measures ..................................................... 126
  - Shales ........................................................................... 126
  - Sandstones ..................................................................... 131
  - Calcareous Beds .......................................................... 135
  - Coals ........................................................................... 136
- "Upper" Coal Measures .......................................................... 137
  - Shales ........................................................................... 137
  - Limestones ..................................................................... 138
  - Arenaceous Materials .................................................... 138
  - Coal ............................................................................. 139

### CHAPTER VI.—Stratigraphy of the Coal Measures ..................... 141
- Introductory Remarks ............................................................ 141
- General Sections .................................................................. 142
- Form of the Coal Basin ....................................................... 143
- "Lower" Coal Measures ........................................................ 144
  - Description of a Detailed Section in Central Iowa ............... 145
  - Variability of Strata ...................................................... 152
  - Unconformities in the Lower Coal Measures ....................... 152
  - Thickness of Lower Coal Measures ................................... 153
  - Summary ........................................................................ 154
- "Upper" Coal Measures ........................................................ 155
  - Typical Section ................................................................ 155
  - Deformations ................................................................... 156
  - Thickness of Upper Coal Measures ................................... 159

  General Conclusions Regarding Local Stratigraphy of the Iowa
  - Coal Measures ............................................................... 160
  - Coal Horizons ............................................................... 162

### CHAPTER VII.—The Coal Beds ................................................. 173
- Extent of Individual Seams .................................................... 173
- Character and Number ......................................................... 175
- Interrupted Continuity ......................................................... 177
  - Irregularities of Deposition ............................................. 178
CONTENTS.

Chapter VII.—Continued.

Erosion .............................................. 181
Carboniferous Troughs ............................... 182
Preglacial Channels ......................... 183
Postglacial Valleys ......................... 185
Dislocations ........................................ 186
Clay Seams ......................................... 189
Availability ....................................... 190
Insufficient Thickness ...................... 190
Depth ............................................. 192

Chapter VIII.—Description of the Coal Beds Now Operated in

Northcentral Iowa ....................... 195
Humboldt county ............................ 196
Webster county .................................. 197
Hamilton county .................................. 211
Hardin county .................................... 214
Carroll county .................................... 218
Greene county .................................... 219
Boone county ..................................... 225
Story county ....................................... 236
Marshall county .................................... 237

Chapter IX.—Description of Coal Beds in Central Iowa ................... 241

Guthrie county ................................ 242
Dallas county .................................. 253
Polk county ..................................... 267
Jasper county .................................... 294
Poweshiek county ............................. 300
Madison county ............................... 304
Warren county .................................. 306
Marion county .................................... 317
Mahaska county ................................. 340

Chapter X.—Description of the Coal Beds of Southeastern Iowa .......... 357

Keokuk county .................................. 357
Lucas county .................................... 366
Monroe county .................................... 374
Wapello county .................................. 383
Jefferson county .................................. 393
Wayne county ..................................... 402
CHAPTER X.—Continued.

Appanoose county ........................................ 406
Davis county ............................................. 424
Van Buren county ........................................ 429

CHAPTER XI.—Description of the Coal Beds of Southwestern Iowa, 435

Harrison county ........................................ 436
Shelby county ........................................... 437
Audubon county ......................................... 438
Pottawattamie county .................................. 439
Cass county ............................................... 440
Adair county ............................................. 441
Mills county ............................................. 443
Montgomery county ..................................... 443
Adams county ............................................ 445
Union county ............................................ 450
Clarke county ............................................ 451
Fremont county ......................................... 452
Page county ............................................... 453
Taylor county ........................................... 457
Ringgold county ........................................ 461
Decatur county ........................................... 462

CHAPTER XII.—Carboniferous Deposits of Eastern Iowa .......... 465

Grundy county ........................................... 466
Delaware county ......................................... 467
Linn county ............................................... 467
Jones county ............................................. 468
Jackson county .......................................... 468
Clinton county .......................................... 469
Johnson county .......................................... 469
Iowa county ............................................... 470
Scott county ............................................. 470
Muscatine county ........................................ 475
Washington county ..................................... 478
Henry county ............................................. 480
Des Moines county ...................................... 483
Lee county ............................................... 484

CHAPTER XIII.—Composition of Iowa Coals ................. 491

Introductory ............................................. 491
## CONTENTS.

**Chapter XIII. — Continued.**

<table>
<thead>
<tr>
<th>Kinds of Coal</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite</td>
<td>492</td>
</tr>
<tr>
<td>Anthracite</td>
<td>492</td>
</tr>
<tr>
<td>Semi-Anthracite</td>
<td>493</td>
</tr>
<tr>
<td>Bituminous Coal</td>
<td>493</td>
</tr>
<tr>
<td>Lignite</td>
<td>495</td>
</tr>
<tr>
<td>Peat</td>
<td>496</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture</td>
<td>496</td>
</tr>
<tr>
<td>Hardness</td>
<td>498</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical Analysis</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determinations Made</td>
<td>499</td>
</tr>
<tr>
<td>Methods of Analysis</td>
<td>499</td>
</tr>
<tr>
<td>Moisture</td>
<td>501</td>
</tr>
<tr>
<td>Volatile Combustible Matter</td>
<td>501</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>502</td>
</tr>
<tr>
<td>Ash</td>
<td>502</td>
</tr>
<tr>
<td>Sulphur</td>
<td>503</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analyses of Iowa Coals</th>
<th>Page</th>
</tr>
</thead>
</table>

**Chapter XIV. — Waste in Coal Mining.**

<table>
<thead>
<tr>
<th>Waste Due to Methods of Mining</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste in Removal of Coal</td>
<td>512</td>
</tr>
<tr>
<td>Waste in Fine Coal</td>
<td>513</td>
</tr>
</tbody>
</table>

**Chapter XV. — Extent of Coal Industry.**

<table>
<thead>
<tr>
<th>Growth of Production</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Mines and Value of Product</td>
<td>525</td>
</tr>
<tr>
<td>Localities</td>
<td>525</td>
</tr>
<tr>
<td>Present Territory Supplied</td>
<td>527</td>
</tr>
<tr>
<td>Markets</td>
<td>527</td>
</tr>
</tbody>
</table>

**Index**

<table>
<thead>
<tr>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>529</td>
</tr>
</tbody>
</table>
LIST OF ILLUSTRATIONS.

PLATE.

i. Coal Fields of the United States.
ii. Geological Map of Iowa.
iii. General Geological Section of Iowa.
iv. Unconformity of Coal Measures and St. Louis Limestone, Keokuk.
v. Carboniferous Sandstone in old Devonian Gorge, Iowa City.
vi. Typical Development of Coal Measure Shales, Des Moines.
vii. Elk Cliff; Coal Measure Sandstone, Rousseau, Marion County.
viii. Quartzitic Concretions in Redrock Sandstone, Marion County.
ix. Cross-bedding in Coal Measure Sandstone, Redrock Quarry.
x. Overhanging Ledge; Basal Sandstone resting on St. Louis Limestone, Keokuk.
xi. Lower Coal Measure Limestone, Mystic.
xii. Upper Coal Measure Limestone, Earlham.
xiii. General Cross Sections of Coal Measure Basin of Iowa.
xiv. Detailed Geological Section in Central Iowa.
xv. Diagram showing Growth of Coal Production.
xvi. Map of Iowa, showing Relative Production of Coal by Counties.
xvii. Top Works of Typical Slope Mine, Evans, Mahaska County.
xviii. Top Works of a large Shaft, Hiteman, Monroe county.

FIGURE.

1. Section of peat swamp of northern Iowa.
2. Ideal section of peat swamp after being covered by sediments and compressed.
3. Section of small coal basin in Redrock quarry, Marion county.
5. Generalized section along Mississippi river from Minnesota line to mouth of the Ohio, showing geological relations of formations.
LIST OF ILLUSTRATIONS.

6. Bennington section (Marion county), showing inclination of coal strata.
7. Composite section showing structure of Lower Coal Measures of Iowa.
8. Ideal cross-section of the Iowa Carboniferous rocks.
9. Popular idea of the relations of the Lower and Upper Coal Measures.
10. Actual relations of Lower and Upper Coal Measures as now understood.
11. Stratigraphy of coal beds.
12. Coal horizon at time of formation; parallel to shore-line.
13. Coal horizon as it now exists; parallel to shore-line.
14. Coal horizon viewed at right angles to shore-line.
15. Stratigraphical arrangement of Iowa coal beds.
16. Uneven character of surface upon which coal was deposited.
    Markham mine, Marion county.
17. Ideal section across Mahaska county, showing unevenness of Coal Measure floor.
29. Section across Des Moines river valley, showing arrangement of geological formations. Ft. Dodge, Webster county.
LIST OF ILLUSTRATIONS.

32. Coal bed at the Martin shaft. Tara.
33. Portion of shaft at Collins mine, No. 4. Coalville.
34. Cannel and bituminous veins at the Johnson mine. Kalo.
37. Coal bed at Crooked Creek mine, No. 3. Lehigh.
38. Section of coal at Crooked Creek, No. 1. Lehigh.
39. Section of Bluff near the Silver mine. Below Webster City, Hamilton county.
40. Coal bed at Stockdale opening. Ten miles below Webster City.
42. Coal bed at Chaffin mine. Eldora.
43. Coal bed in Dale and Goodwin mine. Grand Junction, Greene county.
44. Section of Kennedy shaft. Rippey.
45. Tripartite seam at Kennedy mine. Rippey.
47. Section of bluff near Bussey drift. Southwest of Rippey.
49. Part of shaft in Angus mine. Angus, Boone county.
52. Coal seam, at Potter slope on Des Moines river. Below Moingona.
53. Vein at White Smoke mine. Moingona.
54. Bottom of shaft, Milford mine. Boonesborough.
55. Section in McBrinnie shaft. Boonesborough.
56. Coal bed in Hutchinson mine near Squaw Creek. Zenorsville.
57. Section of coal in Johnson shaft. Gilbert, Story county.
59. Coal bed at Greenbrier mine. Jamaica, Guthrie county.
60. Bluff on Middle Raccoon. Near east county line of Guthrie.
63. Section of Scott shaft. Fansler.
64. Bed at Eclipse mine. Fansler.
LIST OF ILLUSTRATIONS.

66. Section of bluff on Deer creek. Stuart.
68. Bluff near Pritchard drift. High Bridge, Dallas county.
69. Bluff near Raccoon river. One mile east of Van Meter.
70. Bed of Van Meter and Chicago mine. Van Meter.
71. Section at Chaney drift. Four miles north of Adel.
73. Coal seam at Tudor shaft. Dawson.
74. Section on Bulger creek. DeSoto.
75. "Hanging Rock" section. Redfield.
76. Bed at old Leeper mine. Redfield.
77. Coal vein near Redfield mine. Redfield.
78. Bluff at Cotton drift. Linden.
81. Terrace Hill section. Des Moines.
82. Railroad cutting near Rose Hill mine. Four miles west of Des Moines.
85. Section showing undulatory character of the coal seam in Bloomfield mine. Des Moines.
86. Fault in Bloomfield mine. Des Moines.
89. Ironstone mass, in coal bed of Bloomfield mine. Des Moines.
90. Bluff on Des Moines river. Near High Bridge.
91. Shaft of Giant mine No. 1. East Des Moines.
93. Railroad cutting. One mile north of Avon.
94. Railroad cutting. One mile east of Hastie.
95. Preglacial channel in coal bed, at Acme mine. Runnels.
96. Railroad cutting near east county line, below Runnels.
97. Shaft of mine, at Altoona.
98. Shaft of Black Oak mine. Lynnville, Jasper county.
LIST OF ILLUSTRATIONS.

100. Coal at the Cooke mine. East of Mitchellville.
102. Coal at Smith and Barrowman mine. Searsboro, Poweshiek county.
103. Section near old Petit mine.
104. Seam in Evans shaft. Near south county line of Poweshiek.
105. Coal at Clocks stripping. Southeast of Earlham, Madison county.
109. Section of shaft at Bennum mine. Summerset.
111. Tripartite seam at Randolph mine. Five miles southwest of Indianola.
112. Seam at Mitchell mine. Milo.
113. Coal bed at Miller pit. Lacona.
115. Section at Hickman slope. Lacona.
116. Section along Des Moines river, near Bennington, Marion county.
118. Cliff. Opposite Redrock.
120. "Rise" in Markham mine. Pella.
121. Section at Coalport.
122. McElrea drift. Near Star P. O.
123. Shaft at Gambel mine. Knoxville.
124. Coal bed in Rollins mine. Flagler.
125. Bed in Rollins mine. Flagler.
126. Bluff on Cedar creek, near Staats mine. Marysville.
127. Bluff on Cedar creek, showing Coal Measures resting on St Louis limestone. Near Bussey.
128. Coal bed in Williams mine. Near Sharon, Mahaska county.
129. Seam of coal in Columbia shaft. Rose Hill.
130. Coal bed, having erosive channel filled with drift material. Carbondale mine. Oskaloosa.
LIST OF ILLUSTRATIONS.

134. Coal bed at Consolidation mine No. 7. Muchachinock.
137. Part of Quarton prospect shaft. Fremont.
138. Section at mouth of Cedar creek. Below Bellefountaine.
139. Bluff on Coal creek at Richardson mine. Three miles southeast of Ferry P. O.
140. Ideal cross-section through the What Cheer district, from Rock creek to the North Skunk river.
141. Seam at What Cheer mine No. 5. Coal cut out through erosion. What Cheer, Keokuk county.
142. Coal bed at Pioneer mine. Thornburg.
144. Seam in Smith mine. Richland.
145. Coal bed at Lucas and Cleveland mine. Cleveland, Lucas county.
146. Section on Whitebreast creek. Four miles northeast of Cleveland.
147. Section of strata on Little Whitebreast creek, at Smith mine. Near Chariton.
148. Strata encountered in "Williamson shaft". Near Chariton.
149. Coal bed at Richman pit. Northeast of Chariton.
150. Bluff on Des Moines river showing coal seam. Opposite Eddyville, Monroe county.
152. Coal in Smoky Hollow mine. Avery.
153. Part of Fredric shaft. Fredric.
154. Coal bed and "horseback" in Iowa and Wisconsin mine. Albia.
158. Section of shaft of Phillips mine No. 4. Ottumwa.
162. Coal bed, with fault, in Appanoose mine. East of Blakesville.
LIST OF ILLUSTRATIONS.

165. Section of coal seam. Coalport.
166. Coal bed at Bates mine. Fairfield.
168. Section of Frey shaft. Confidence.
169. Coal seam in Frey mine. Confidence.
170. Coal bed in Burns mine. Confidence.
171. Part of Seymour shaft. Seymour.
173. Coal bed at Young mine. Milledgeville, Appanoose county.
175. Coal seam at Whitebreast No. 19. Forbush.
179. Fissure in seam at Thistle mine. Cincinnati.
181. Section of Albert shaft. Cincinnati.
182. Coal bed in Pearl City mine. Four miles south of Cincinnati.
183. Seam in Dickinson mine. Hilltown.
188. Base of shaft at Cox mine. Hillsboro, Van Buren county.
189. Coal beds at Lafever mine. Selma.
190. Section of bluff at Douds mine. Douds station.
194. Coal bed in Plowman shaft. At Briscoe, in Adams, near south county line of Cass county.
196. Bluff near Glenwood, Mills county.
197. Coal bed at old Westrope mine. In northeastern corner of Montgomery county.
LIST OF ILLUSTRATIONS.

199. Coal seam at Spurrier opening. Eureka.
200. Section at Wyles shaft. Carbon.
201. Vein at Syfert and Jones mine. Carbon.
202. Section on east bank of Grand river. Talmage, Union county.
203. Section of bluff. Southeast of Bartlett, Fremont county.
204. Bluff at Shambaugh mill, on Nodaway river. Clarinda, Page county.
205. Section on the Nodaway river, below Bradyville. Near south county line of Page.
207. Section at Beynon shaft. Hawleyville, Taylor county.
208. Coal bed at Wilcox mine. Five miles north of Newmarket.
211. Section on creek. Near Spring Valley, Decatur county.
212. Coal bed at Friedley mine. Jamestown, Scott county.
213. Seam in Hanlon and Blackwell opening. Jamestown.
214. Coal at Hoor drift. East of Muscatine, Muscatine county.
216. Contact of Coal Measures and St. Louis limestone, on branch of Big creek. Mt. Pleasant, Henry county.
218. Coal bed at Cox mine. Hillsboro.
221. Outcrop southeast of Denmark.
222. Coal bed at old Hardwick mine. Near Westpoint.
PREFACE.

No systematic investigation of Iowa's coal deposits has ever been accomplished. The state is regarded by her citizens and outsiders alike so preeminently agricultural that usually her mineral resources are almost entirely overlooked. Yet her geological features are none the less interesting scientifically, none the less important from an economic standpoint.

The mineral wealth of a community can only be developed through a liberal appreciation of its proper functions. Geology ranking first among the useful sciences, has for one of its leading objects the investigation of the natural resources of a region. It considers the character of the different soils and their capabilities for agricultural purposes; the extent and value of the different deposits of coal and lead, iron and other ores; the distribution, properties and uses of the exhaustless beds of valuable clays; the accurate determination of the areas for artesian waters; the analysis of the mineral, well and river waters; the relative value and durability of the numerous kinds of building stones; and all kindred subjects which are of the utmost importance to the great body of the people.

Agriculture and geology are daily becoming more and more intimate in their relations. Nowhere has this interdependence been more clearly understood and nowhere have the benefits been more apparent than in certain
European countries. Some of the older states of the Union, especially those along the Atlantic border, have followed the same line of work with the most happy results. For to-day it is almost universally conceded that a good geological map of the region is practically a soil map also. The proper appreciation of the close relations of the two sciences cannot fail therefore to impress the truth of the statement.

In pointing out the various mineral deposits of Iowa a knowledge of the distribution of the geological formations is of prime importance. The sequence of strata is measurably complete, and will be briefly considered farther on.

Although the greatest factor in her mineral wealth, the coal industry of Iowa has been allowed from the beginning to take care of itself. Until recently not a single area in the state had been accurately mapped, nor the extent, thickness and stratigraphical peculiarities of the deposits made out. Surprising as it may seem, carefully made estimates show that more money is wasted in many counties every year in ill-advised and poorly conducted efforts to discover coal and other minerals than would annually support a well conducted, systematic investigation of the entire state. Throughout the region are to be seen numberless abandoned diggings, most of them the fruitless attempts to obtain coal in places where success is as utterly hopeless as can be imagined. Deserted shafts tell of useless expenditure and loss of capital that might easily have been avoided had some authoritative information concerning the geological structure of the particular localities been accessible.

The subject of coal in Iowa is so important in its bearings upon the material prosperity of the state that it
requires a careful treatment in all its numerous phases. This treatment is a work of great magnitude. It cannot be accomplished in a few months; for several years are required to make the observations, accumulate the facts, and carry on the proper tests.

There is contemplated, therefore, in this connection a series of publications, which will eventually resolve itself into four or five categories more or less closely related. Each of the groups of facts will probably be embraced in separate parts, the first of the series appearing with the present volume. There is proposed:

(1) A preliminary report, somewhat general in its character, perhaps, but something which will supply temporarily a great and ever increasing demand for information pertaining to the coal deposits of the state. This desire for authoritative accounts of the different portions of the great Iowa Coal field is shared not only by the citizens of the state but by many persons with means who now reside in distant parts of the Union, but who are desirous of making safe investments in the state, of starting new industries and of becoming soon, perhaps, residents.

(2) A detailed account of the geological features of the coal districts. This should embrace a full description of the different kinds of beds and their associations, the minute structure of the coal-bearing strata in all its details, the exact relations of the different seams, the distances from the surface that it is necessary to go in order to reach them, the pointing out of notable and easily recognized strata which will act as guides in searching for particular seams of coal, and all kindred information of practical import.
(3) A discussion of practical mining in the state, the methods employed and improvements to be made, the kinds of machinery used and its advantages, the best methods and apparatus for prospecting and like information tending toward a greater development of the industry, including the utilization of coal dust, slack and the lignites of the Cretaceous strata of northwestern Iowa.

(4) A description of the uses and properties of Iowa coals, together with chemical analyses of all the principal varieties from the different counties, the adaptabilities of the various kinds for steam, domestic, and metallurgical purposes and for gas-making.

Since the work of investigating the coal deposits of the state has been taken up, innumerable calls have been received from persons and corporations in more than two-thirds of the entire number of counties to look into their localities "first." In addition there has been a multitude of letters asking for special information and advice and numerous personal visits made by persons residing outside, as well as within, the limits of the state. All these demands have been satisfied as far as reliable information upon the particular phases of the question would permit. But, it was clearly manifest from the beginning that it would be an absolute physical impossibility to answer every earnest call in the manner that was perhaps expected. Nevertheless every effort has been made to give advice of practical importance in the specific cases. These inquiries indicate how deep and how active is the interest in regard to the greatest of Iowa's natural resources; how urgent is the need for organized work in determining the exact nature and extent of the mineral wealth of the state.
It was foreseen at the outset that but little progress could be made in extending the examination of the coal deposits to all parts of the state in which there was any likelihood of obtaining the mineral in quantities of commercial value unless the subject was taken up in a perfectly systematic way. With this object always in view localities were visited first, which, it was thought, would furnish most readily a key to the structure, character and disposition of the coal beds over large areas. After the geological features of these districts were thoroughly understood the investigations were extended in all directions into the neighboring regions as rapidly as was consistent with accurate work. In this way the extent of territory covered and the amount of practical information secured was far in excess of that which it would have been possible to obtain in any other way.

When it is remembered that the area of the Coal Measures in Iowa is over 20,000 square miles, and that the numerous Carboniferous outliers, or isolated basins, and the regions bordering the productive coal deposits which must be gone over in determining even approximately the limits of the formation, occupy fully 5,000 square miles more, the magnitude of the undertaking and the amount of labor that has been expended may be readily appreciated. Many details, of course, still remain to be brought out, yet within the limited time allowed it is not to be expected that the work could be made symmetrically complete. However, the report is comprehensive in its nature, giving all the leading facts connected with the industry, and the occurrence and distribution of the coal throughout the state.

Of special and practical import to prospector and miner alike are the facts brought out in regard to the stratig-
raphy of the coal-bearing strata of the state. In this line of work the natural outcrops have been by far the most valuable. Records of shafts, diggings and borings have also been of value but not to the extent that might be supposed at first glance. These records have been kept by many different persons and their worth for geological purposes has varied greatly. Of the many hundreds, or thousands, of drill holes which have been made in the different parts of the state very few are of much use in checking geological observations. With the great majority of the holes put down in prospecting for coal no record of the strata passed through has been kept and as a rule only the presence or absence of coal noted. It does not appear to have occurred to many prospectors that other horizons are often just as valuable aids in the search for coal as the coal seams themselves. In nearly every coal district there are certain beds which are easily recognizable and which have a definite position in regard to the coal beds themselves; that is, their position is constantly a certain number of feet above particular coal veins. When these beds are encountered and recognized it is easy to calculate within a very short distance how far down it is necessary to go in order to reach the given coal horizon. When no attention is paid to such beds as are here considered it is possible that borings may be stopped within a few feet of a valuable coal seam without its presence being detected. The money spent in prospecting under such circumstances is of course wasted. In the same way carefully kept records of borings of artesian wells, and records of drillings for other purposes would be of great value to the community in pointing out the probable occurrence of particular mineral deposits.
There is another element in the uncertainty which usually surrounds the average drill record. Aside from the unfortunate employment of incompetent persons who really know little or nothing about the character of the rocks and the geology of the region the use of the ordinary churn drill is to be deplored. The claims of drillers are in most cases very extravagant. Even under the most favorable circumstances there is already great difficulty in ascertaining the exact thickness and the lithological character of the several strata passed through, so that only in a general way can the record be relied upon. At best every precaution must be taken to get even approximate results. The larger coal operators and those who are most successful in prospecting for coal on a large scale use the diamond drill altogether, which furnishes a core of the rocky layers passed through. By means of the core, which is essentially a small vertical column passing through the successive strata, all details relating to the composition and thickness of the different layers are readily obtained and may be referred to at all times by a simple examination of the section secured. All the important horizons may be determined, whether they are the coal veins themselves or the more persistent beds which are capable of serving as guides in determining the location of the seams. The cost of the diamond drill outfit is somewhat greater to be sure at first than that of ordinary drilling apparatus and this fact probably explains why, notwithstanding its many advantages, it is not more generally used. The record and information obtained, however, are very much more satisfactory and accurate than where other instruments are employed. There remains evidently the same ultimate cost of prospecting whatever form of apparatus be employed.
The statistics of the Iowa coal production during past years have been published independently by the statistical department of the United States Geological Survey and by the Iowa State Mine Inspectors. The former does not take into consideration country banks, and consequently a very considerable percentage of the coal production is not noted, while more than a quarter of the total number of counties producing coal are not mentioned at all. According to law the State Mine Inspectors confine their labors to only those mines working more than ten men, so that here too a very considerable portion of the annual production is overlooked. The importance of the country bank is much greater than is commonly regarded. The leading coal producing districts of to-day are in many cases simply the localities where twenty-five years ago only a few country banks were operated. The development of these fields has been in large part made possible through the building of railroads over which the product of the mines may be shipped to less favored localities. The country banks thus often determine the line along which railroad building is to be carried. The location of the deserted mines is also of importance as indicating the presence of coal. The abandonment of the old openings do not necessarily imply that the seams have been entirely exhausted. In the majority of cases, mines of this class often suggest rather that the work has been interfered with, or that the territory owned or leased, being somewhat limited, has been exhausted.

In most cases it has been found unadvisable to designate by special names the different coal seams as is done in the fields of the Eastern United States. In only a few instances are the Iowa coal seams extensive enough to warrant the application of distinctive names; though
whenever they assume sufficient prominence they are called after the leading places where they are mined.

To Professor Calvin sincere thanks are due for many kind suggestions in connection with the work. In the preparation of the chapters on the coal mines operated in the various districts the field notes of the different members of the Survey have been freely drawn upon. Messrs. E. H. Lonsdale, A. C. Spencer, A. J. Jones, C. H. Gordon, and especially H. F. Bain, have contributed liberally in the descriptive matter. The drawings illustrating the work were made chiefly by Mr. F. C. Tate. The chemical analyses have been made by Prof. G. E. Patrick, chemist to the Survey. A few other analyses have been included, among them those made by Profs. Whitney and Emory.