AGRICULTURAL GEOLOGY

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REVISED
BY

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PREFACE TO THE SECOND EDITION

In preparing the revision it has been the intention to retain, as far as possible, the careful and extensive work of Dr. Emerson and only a few changes of minor importance have been made in it. The expanding scope of the subject, it is believed, is well represented in the outline of topics given on page four and calls for some additional material.

In teaching geology, one of the objectives is the development, in the student, of the power to think independently, to reason and to discover things for himself. The use of new material including some questions whose answers are not specifically given in the book and tables for the identification of minerals and rocks are introduced, in part, to increase the value of the book for these purposes and partly to place emphasis on certain practical phases of the relations of geology to farm life and work.

JOHN E. SMITH.

AMES, IOWA, June, 1928.

PREFACE TO FIRST EDITION

Because of the death of my husband, it is not possible to acknowledge all the helpful suggestions and criticisms offered by his various scientific friends, but I recall that he considered the suggestions of Doctor Heinrich Ries, of Cornell University, as very valuable, and that Professor L. E. Call, of Kansas State Agricultural College, and Professor A. F. Kidder, of Louisiana State University, both read several chapters and made helpful suggestions and criticisms. There were, however, other friends, whose names I do not know, who rendered similar services.

H. L. Emerson.

East Providence, R. I,, April, 1920.

FOREWORD TO FIRST EDITION

Geology and Agriculture are closely related, indeed it is due to geological processes that the hard rocks are broken down to soil, and essential mineral substances set free which in some cases affect the physical qualities of the derived soil, and in others serve as sources of plant food.

It therefore follows that the student of agriculture should have at least an elementary knowledge of the processes and principles of Geology, with especial reference to the geology of soils and fertilizers.

With this object in view the late Professor Emerson prepared the accompanying work, but unfortunately his untimely death prevented his seeing it through the press, the labor of this devolving on Mrs. Emerson.

The subject matter and mode of treatment are the outgrowth of some years of experience in teaching geology to agricultural students, and while Professor Emerson prepared the work primarily for class-room use, it was also his hope that it might prove serviceable for reading and correspondence classes.

On this account he endeavored to make the treatment as untechnical as possible, without sacrificing scientific accuracy.

Those who desire to follow the subject in greater detail can do so with the aid of the appended bibliographies and lists of soil and geological maps. Professor Emerson also gave considerable attention to the selection of illustrations, choosing them with the purpose of showing specific items on phenomena.

H. Ries.

Ithaca, N. Y., April, 1920.

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AGRICULTURAL GEOLOGY

INTRODUCTION

GEOLOGY as a whole is essentially the study of the earth's history. All the different lines of geological investigation contribute directly or indirectly to this end and the study of present-day processes helps to explain what has occurred in the past. To take an example, Fig. 1

FIG. 1.—A rock record of an ancient beach. Note the long rill marks made by running water and the round spots (rain prints) made by falling rain drops.

shows the rain pits and rill marks as contained in old sandstone which has preserved the evidences of beach conditions almost as perfectly as may be found after a storm on a modern beach. By these fossil rain prints and stream marks we know that this rock was accumulated near an ancient beach. The study of present peat beds leads to an understanding of how the ancient coal beds were formed. The traces of modern glaciers are similar to those of very ancient glaciers. Many other instances might be cited to show how the observation of present geological conditions enables us to work out past geological history.

Divisions.—Dynamical geology considers the forces that have changed and are now changing the earth. Physiographic geology, or physiography, deals with the processes that are now modifying the earth's surface. Structural geology is the study of the materials of the earth and their arrangement. Mining geology is that branch of the subject which is related to the mining industries. Engineering geology has to do with the subject in its relation to work on engineering projects. Agricultural geology treats of this science in its relations to the geological problems that are met with in agricultural enterprises and pursuits. In these relations it deals chiefly with the following topics:

1. Water supply for the farm and school;
2. Farm losses and gains due to geological processes;
3. Drainage and irrigation;
4. Road materials and building materials;
5. Minerals used on the farm and in the home;
6. Minerals of the soil;
7. Origin and distribution of soil materials;
8. Geological influences affecting the distribution of vegetation;
9. Geological history of domestic plants and animals;
10. The cultural value of a knowledge of geology to the people cf rural districts.

Fundamental Ideas

One of the first ideas to be acquired in the study of geology is the vast length of time involved. The accumulation of an inch of limestone soils has required a vastly longer period than the length of known historical time, and a realization of this should lead to a conservation of our soils, which have required so long a time for their formation and will require an equally long time for their replacement. Even a moderately high hill has usually been tens of thousands of years in the making and, if a mountain range had been started when the Pilgrims landed at Plymouth in 1620, it is entirely probable that this would not be known to-day, so slow is the process of mountain making.

Although the study of soil origin is but one of the many viewpoints of geology, yet there is no agent or process of geology which is not in some way directly related to soils. Obviously when rocks weather or break up they form vast areas of residual soils so that we speak of granite soils, limestone soils and so forth, each rock usually contributing a distinctive soil. But even the soil from a rock like granite will vary under different conditions, for a granite soil in a dry country differs notably from one in a humid region and one in a hilly country has different features from one in a level region. Then soils from different rocks are usually different in composition; granite soils often have a somewhat high potash content and sandstone soils usually have a low content of mineral plant foods and, moreover, soils from different rocks often differ both in their soil minerals and in chemical composition so that the composition of the parent rocks must be considered.

About the most stable thing that we know is the earth's surface, yet geology teaches that the oceans and the lands of North America and elsewhere have many times changed places and, indeed, are doing so to-day. As a consequence of these movements there have been upward movements that have brought large areas of rocks and soils, like the Coastal Plain of North America, above the ocean while downward movements have submerged thousands of square miles of former soils.

Among the most important soils are those that have been transported and deposited so that some soils show but little relation to the underlying rocks. A heavy clay soil, for example, may have been deposited over sandstone, thus giving a soil much unlike the sandy soil which might be expected from a sandstone. Probably the most widespread transporting agent is the winds which, as we shall see, have carried and are now carrying vast amounts of soil-forming materials. Then, in the past, vast glaciers overrode more than half of North America and considerable areas in Europe. These glaciers had most notable effects on soils so that glacial soils are usually distinctive, for not only are glacial soil materials more or less mixtures of various materials that have been transported, but glaciers further modified the drainage and topography, both very important soil and agricultural features. Perhaps the most familiar transported soils are those laid down by running water, for except in very dry regions, there are many streams and all carry some sediment which they deposit at various places. There are large areas of alluvial soils like those of the Mississippi, but even in hilly regions with narrow valleys, these " bottom soils " are important in value if not in area.

But the geological story of soils is not concluded when we have considered their origin, for soils are affected not only by their origin and materials but also by the agents which have modified them since the soils were formed. Among these are the ground and soil water, which here may leach the soils of their soluble minerals and there may deposit materials in the soils. Furthermore the movements of ground and soil waters have an obvious relation to soil moisture and to wells and springs. Then, of course, soils, like rocks, are affected by weathering, that is by temperature changes, freezing and thawing and other agents. For example, soils from the same kind of rock in North Carolina and New Jersey differ because of the difference in the agents and processes to which the soils have been subjected since their formation. Thus it is seen that all the geological agents and processes combine in different ways to affect the soils.

In this study the rocks will first be considered since they are the ultimate source of nearly all soils. We shall also note the different processes by which soil materials are transported from place to place and in general how soils are affected by geological processes.

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On "Agricultural Geology"

Science, n. s., Vol. 52, pages 139–142, August 13, 1920.
Iowa Academy of Science, Proceedings, Vol. 27, pages 175–179, 1920.
Pan-American Geologist, Vol. 38, pages 283–288, November, 1922.

QUESTIONS [1]

1. Approximately what length of time is covered by recorded human history? Into what major periods of time is human history divided? Why are these divisions necessary?
2. Why should divisions of time and scope be made in a subject like geology?
3. Why is it necessary to have a somewhat definite conception of geologic time?
4. If a line 100 miles long be taken as an equivalent of geologic time, what part of it would correctly represent the time length of recorded human history? A rod? A foot? An inch? What fraction of an inch?
5. What is meant by historical geology? By petroleum geology?
6. Why should agricultural geology be considered a branch or subdivision of the science? What general topics should it include?

[1] To some of the questions in this set and in the sets given at the close of the chapters respectively, direct answers are not made in the text. Such questions should be kept on a special list until an answer to each is improvised.

CHAPTER I

MINERALS [1]

An observer by the lower Mississippi where the river has deposited fine soils may see no connection between his soil and a rock, say, like granite. But if he examines the very fine materials of soil through a microscope he is likely to find minerals which came originally from granite-like rocks. Hence it is that we begin the geological study of soils with a consideration of rocks because practically all soils except muck must at one time or another have been a part of some rock. Furthermore, since rocks are usually composed of two or more minerals, the study of minerals will be taken up first, in order the better to understand the materials of which rocks are made.

Fortunately for simplicity of study, the common and important minerals are relatively few, although hundreds have been identified. Likewise the mineral composition of the earth's crust is comparatively simple. According to Clarke's estimate the relative percentages in the earth's crust are as follows: [2]

Oxygen	47.33	Titanium	.46
Silicon	27.74	Carbon	.19
Aluminum	7.85	Phosphorus	.12
Iron	4.50	Manganese	.08
Calcium	3 47	Sulphur	.12
Magnesium	2.24	Barium	.08
Sodium	2.46	Strontium	.02
Potassium	2.46	Chlorine	.06
Fluorine	.10		

It will be seen that the elements oxygen and silicon comprise 75 per cent and these with eighteen other elements comprise nearly 99 per cent of the rocks so far as they have been studied. Many important

[1] It is hardly necessary to state that the student must study actual specimens in order to gain a knowledge of minerals.

[2] The Data of Geochemistry, Bulletin No. 619, U. S. Geological Survey, 1916, page 34.

elements, such as lead and copper, show a very small fraction of 1 per cent and do not appear in the above table.

These elements are nearly always combined. Silicon and oxygen unite to form the familiar mineral quartz (SiO_2) composed of one part of silicon and two parts of oxygen. Pure iron, for example, is very rare although it is very common in compounds the world over. The number of important minerals is comparatively small since scarcely more than a dozen of great groups include most of the minerals to be found in average rocks. Thus the student may hope by comparatively brief study to recognize most of the minerals which he is likely to find.

General Characters of Minerals

Color is a quality which is easily noted but with many minerals the color is variable. Pyrite, "fools' gold," is brassy yellow, while calcite, the common lime mineral, may have many colors although it is usually white.

Luster is due to reflection of light from surfaces of minerals. Luster may be *glassy* like fractured glass; *resinous* as in sphalerite; *pearly* as in mother-of-pearl; *silky* as with fibrous minerals like satin spar and *dull* as in kaolin. Many minerals, as for example, pyrite, have *metallic* luster.

Streak is the color of powdered mineral and with fairly soft minerals it may be obtained by rubbing the mineral on a surface like that of unglazed porcelain. Harder minerals may be pulverized. Streak sometimes varies from color, and being fairly constant is a useful characteristic.

Hardness of fresh minerals refers to the ease with which they are scratched. Hardness is often stated in terms of Mohs' scale as follows, the type minerals being in order of hardness from soft to hard:

1. Talc
2. Crystallized gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

For field determinations and for most purposes the following scale will be sufficient:

Very soft, No. 1, easily scratched by finger nail.

Soft, No. 2, just scratched by finger nail.

Hard, No. 3, scratched by a copper coin; not scratched by finger nail.