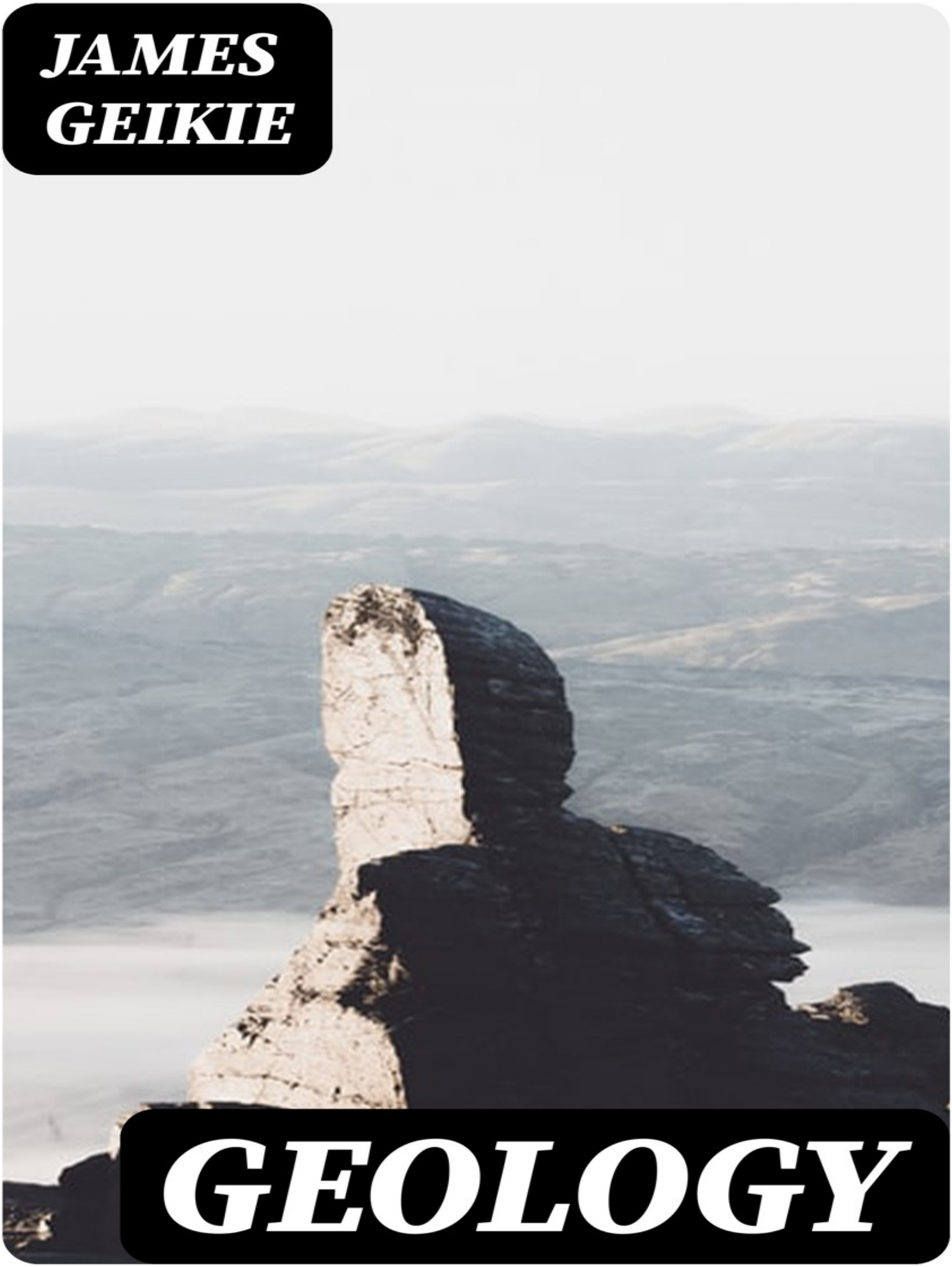
JAMES GEIKIE



GEOLOGY

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I N T R O D U C T O R Y .

1. *Definition.*—Geology is the science of the origin and development of the structure of the earth. It treats of the nature and mode of formation of the various materials of which the earth's crust is composed; it seeks to discover what mutations of land and water, and what changes of climate, have supervened during the past; it endeavours to trace the history of the multitudinous tribes of plants and animals which have successively tenanted our globe. In a word, Geology is the Physical Geography of past ages.

2. *Rocks.*—Every one knows that the crust of the earth is composed of very various substances, some of which are hard and crystalline in texture, like granite; others less indurated and non-crystalline, such as sandstone, chalk, shale, &c.; while yet others are more or less soft and incoherent masses, as gravel, sand, clay, peat, &c. Now, all these heterogeneous materials, whether they be hard or soft, compact or loose, granular or crystalline, are termed *rocks*. Blowing sand-dunes, alluvial silt and sand, and even peat, are, geologically speaking, rocks, just as much as basalt or any indurated building-stone. The variety of rocks is very great, but we do not study these long before we become aware that many kinds which present numerous contrasts in detail, yet possess certain characters in common. And this not only groups these diverse species together, but serves also to distinguish them from other species of rock, which in like manner are characterised by the presence of some prevalent generic feature or features.

Classification of Rocks.—All the rocks that we know of are thus capable of being arranged under *five* classes, as follows:

I. MECHANICALLY FORMED.

II. Chemically formed.
III. Organically derived.
IV. Metamorphic.
V. Igneous.

3. The Mechanically formed class comprises a considerable variety of rocks, all of which, however, come under only two subdivisions—namely, *Sedimentary*, and *Eolian* or *Aërial*, the former being by far the more important. Of the *Sedimentary* group, there are three rocks which may be taken as typical and representative—namely, *conglomerate* or *puddingstone*, *sandstone*, and *shale*. A short examination of the nature of these will sufficiently explain why they come to be grouped together under one head. *Conglomerate* consists of a mass of various-sized rounded stones cemented together; each stone has been well rubbed, and rolled, and rounded. It is quite obvious that the now solid rock must at one time have existed in a loose and unconsolidated state, like gravel and shingle. Nor can we resist the conclusion that the stones were at one time rolled about by the action of water—that being the only mode in which gravel-stones are shaped. Again, when we have an opportunity of examining any considerable vertical thickness of conglomerate, we shall frequently observe that the stones are arranged more or less definitely along certain lines. These, there can be no question, are *lines of deposition*—the rounded stones have evidently not been formed and accumulated all at once, but piled up gradually, layer upon layer. And since there is no force in nature, that we know of, save water in motion, that could so round and smooth stones, and spread them out in successive layers or beds, we may now amplify our definition of conglomerate, and describe it as a *compacted mass of stones which have been more or less rounded, and arranged in more or less distinct layers or beds, by the action of water*.

4. *Sandstone* may at the outset be described as a *granular non-crystalline rock*. This rock shews every degree of coarseness, from a mass in which the constituent grains are nearly as large as turnip-seed, down to a stone so fine in the grain that we need a lens to discover what the particles are of which it is composed. When these latter are examined, they are found to exhibit marks of attrition, just like the stones of a conglomerate. Sharp edges have been worn off, and the grains rounded and rubbed; and whereas lines of deposition are often obscure, and of infrequent occurrence in conglomerate—in sandstone, on the contrary, they are usually well marked and often abundant. We can hardly doubt, therefore, that sandstone has also had an *aqueous* origin, or in other words, that it has been formed and accumulated by the force of water in motion. In short, sandstone is merely compacted sand.

5. If it be easy to read the origin of conglomerate and sand in the external character of their ingredients, and the mode in which these have been arranged, we shall find it not less easy to discover the origin of *shale*. Shale is, like sandstone, a granular non-crystalline rock. The particles of which it is built up are usually too small to be distinguished without the aid of a lens, but when put under a sufficient magnifying power, they exhibit evident marks of attrition. In structure it differs widely from sandstone. In the latter rock the layers of deposition, though frequently numerous, are yet separated from each other by some considerable distance, it may be by a few inches or by many yards. But in shale the layers are so thin that we may split the rock into *laminæ* or plates. Now we know that many sedimentary materials of recent origin, such as the silt of lakes, rivers, and estuaries, although when newly dug into they appear to be more or less homogeneous, and shew but few lines of deposition, yet when exposed to the action of the atmosphere and dried, they very often split up into layers

exhibiting division planes as minute as any observable in shale. There is no reason to doubt, therefore, that shale is merely compacted silt and mud—the sediment deposited by water. It becomes evident, therefore, that conglomerate, sandstone, and shale are terms of one series. They are all equally sedimentary deposits, and thus, if we slightly modify our definition of conglomerate, we shall have a definition which will include the three rocks we have been considering. For they may all be described as *granular non-crystalline rocks, the constituent ingredients of which have been more or less rounded, and arranged in more or less distinct layers, by the action of water*.

6. The *Eolian* or *Aërial* group of rocks embraces all natural accumulations of organic or inorganic materials, which have been formed upon the land. The group is typically represented by *débris*, such as gathers on hill-slopes and at the base of cliffs, by the *sand-hills* of deserts and maritime districts, and by *soil*. All these accumulations owe their origin to atmospheric agencies, as will be more particularly described in the sequel. As the *Sedimentary* and *Eolian* rocks are the results of the *mechanical* action of water and the atmosphere, they are fitly arranged under one great class—the MECHANICALLY FORMED ROCKS.

7. CHEMICALLY FORMED ROCKS constitute another well-marked class, of which we may take *rock-salt* as a typical example. This rock has evidently been deposited in water, but not in the manner of a sedimentary bed. It is not built up of water-worn particles which have been rolled about and accumulated layer upon layer, but has been slowly precipitated during the gradual evaporation of water in which it was previously held in solution. Its formation is therefore a chemical process. Various other rocks come under the same category, as we shall afterwards point out.

8. The ORGANICALLY DERIVED class comprises a number of the most important and useful rock-masses. *Chalk* may be selected as a typical example. Even a slight examination shews that this rock differs widely from any of those mentioned above. Conglomerate, sandstone, shale, &c. are built up of pebbles, particles, grains, &c. of various inorganic materials. But chalk, when looked at under the microscope, betrays an organic origin. It consists, chiefly, of the hard calcareous parts of animal organisms, and is more or less abundantly stocked with the remains of corals, shells, crustaceans, &c. in every degree of preservation; indeed, so abundant are these relics, that they go to form a great proportion of the rock. *Coal* is another familiar example of an organically derived rock, since it consists entirely of vegetable remains.

9. The METAMORPHIC class, as the name implies, embraces all those rocks which have undergone some decided change since the time of their formation. This change generally consists in a re-arrangement of their constituent elements, and has frequently resulted in giving a crystalline texture to the rocks affected. Hence certain sedimentary deposits like sandstone and shale have been changed from granular into crystalline rocks, and the like has happened to beds of limestone and chalk. *Mica-schist, gneiss*, and *saccharoid marble* are typical of this class.

10. The IGNEOUS rocks are those which owe their origin to the action of the internal forces of the earth's crust. Most of them have been in a state of fusion, and betray their origin by their crystalline and sometimes glassy texture, and also, as we shall see in another section, by the mode of their occurrence. *Lava*, *basalt*, and *obsidian* are characteristic types of this group of igneous rocks. Another group embraces a large variety of igneous rocks which are non-crystalline, and vary in texture from fine-grained, almost

compact, bedded masses, like certain varieties of *tuff*, up to coarse, irregular accumulations of angular stones imbedded in a fine-grained or gritty matrix, like *volcanic breccia* and *volcanic agglomerate*.

M I N E R A L O G Y.

11. Having learned that all the rocks met with at the surface of the earth's crust are capable of being arranged under a few classes, we have now to investigate the matter more in detail. It will be observed that the classification adopted above is based chiefly upon the external characters of the constituent ingredients of the rocks, and the mode in which these particles have been collected. In some rocks the component materials are crystalline, in others they are rounded and worn; in one case they have been brought together by precipitation from an aqueous solution, or they have crystallised out from a mass of once molten matter; in another case their collection and intimate association is due to the mechanical action of the atmosphere or of water, or to the agency of the organic forces. We have next to inquire what is the nature of those crystals and particles which are the ingredients of the rocks? The answer to this question properly belongs to the science of mineralogy, with which, however, the geologist must necessarily make some acquaintance.