Study on the Identification and Formation Environment Speculation of Common Rocks in Parks or Mountainous Areas

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Abstract: This paper introduces the identification methods and formation environment speculation of common rocks in parks and mountainous areas. First, this paper categorizes rocks into three types: magmatic rocks, sedimentary rocks, and metamorphic rocks. The identification characteristics of color, particle, and structure of common rocks, such as granite, basalt, sandstone, limestone, and marble, are described in detail for each category. Additionally, it combines the cooling rate, sedimentary environment, and metamorphic degree to infer the formation environment of rocks. For example, granite is formed in deep underground magma chambers, and limestone is mostly derived from ancient shallow seas. It offers practical steps for identifying rocks and making inferences, highlighting that rocks serve as "recorders" of the Earth's geological history. Understanding their identification can enhance people's appreciation of natural evolution and enrich outdoor experiences.

1. Introduction

1.1 Relationship between Rocks and Natural Environment

Rocks are the most intuitive natural archives of the Earth's surface. The rockeries in parks and the rock walls in mountainous areas are direct representations of the Earth's evolution over billions of years. Their presence not only shapes the landscapes we see - such as steep granite peaks and limestone-forming caves - but also reveals the code of local environmental changes: a sandstone patch with ripples that may indicate it was a beach in ancient times. The basalt with pores suggests that the area has experienced volcanic activity. Studying these rocks allows us to connect the current landscape with its geological history. For instance, it helps us identify whether a mountain was formed by the cooling of magma or by uplifting due to sediment accumulation. We can even speculate if the area was once a sea, lake, or the site of a volcanic eruption. For ordinary people, recognizing the rocks, like learning to understand natural language, makes what you see and hear during a walk or while mountaineering more meaningful.

1.2 Basic Classification of Common Rocks

Although there are many kinds of rocks on Earth, they can be simply divided into three categories based on their formation methods, and almost all the rocks visible in parks and mountains belong to these three categories. The first type is magmatic rock, which is formed by cooling underground magma (molten rock). For example, the rock solidified by lava from a volcanic eruption belongs to this category. The second type is sedimentary rocks, which are formed from sediment and gravel brought by wind and water, or animal and plant remains, that are piled up layer by layer over time. This process results in the formation of sedimentary rocks, including sandstone from river deposits and limestone from lake deposits. The third type is metamorphic rocks, which are formed when existing rocks (possibly magmatic rocks or sedimentary rocks) are subjected to high temperatures and high pressures underground, altering their original appearance. For example, limestone transforms into marble under high temperatures and pressures. The first step is to distinguish between these three categories and then identify the specific rocks. This process simplifies the disorganized elements into clear, defined categories.

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2. Types and Characteristics of Common Rocks in Parks and Mountainous Areas

2.1 Magmatic Rock: Rock Formed by the Cooling of Magma

2.1.1 Granite

Granite is a very common magmatic rock in parks and mountainous areas. Its color is mostly light gray, pink, or flesh red, and it looks "bright". Its particles are very coarse, and you can see the mineral particles inside with the naked eye: white quartz, flesh red or grayish white feldspar, and a small amount of black mica [1]. These particles stick together like gravel. Additionally, its texture is very hard, it sounds crisp when knocked by hand, and there is no stratification. The whole one is massive and looks very solid. In mountainous areas, the core of many ancient peaks is granite; park features like rockeries, stone tables, and benches are commonly made of this same granite. This material is favored for its resistance to wind and sunlight, as well as its durability against damage.

2.1.2 Basalt

Basalt is dark in color, mostly black, grayish black, or dark brown, which looks "heavy". The particles are so fine that specific mineral particles are barely visible to the naked eye, and the surface may feel slightly rough. The most obvious feature is that there are often many small pores: these are small holes left by the gas in the magma when it is ejected from the surface. Moreover, some basalts formed "columnar joints". Specifically, when it cools, it cracks due to shrinkage and becomes hexagonal or pentagonal columns, just like artificial columns. Basalt is easily visible in mountainous areas where volcanic activity has occurred, such as near some volcanic ruins [2]. The black rock landscape in the park may also be basalt.

2.1.3 Andesite

The color of andesite is between that of granite and basalt, mostly gray, brown, or purplish red, which appears less prominent and bright. Its particles are finer than those of granite and slightly thicker than those of basalt. A small number of tiny mineral particles may be seen with a magnifying glass, but the whole is still delicate. Its surface is often uneven, with a few small pores occasionally present, and the number of pores is fewer than that of basalt. Its structure is massive, no bedding, medium hard texture, and it sounds not as crisp as granite when knocked by hand. Andesite is commonly found in mountainous regions where moderate to low-intensity volcanic eruptions have taken place, particularly on hillsides near plate boundaries. If there are gray-brown and fine-grained rocks in the rock pile in the park, it may be andesite [3].

2.2 Sedimentary Rock: Rock Formed by Accumulation of Sediments

2.2.1 Sandstone

Sandstone is rich in color, ranging from yellow to gray, reddish-brown, and some are mottled, which is related to its mineral composition. With the naked eye, we can see the sand particles inside, mainly quartz or feldspar particles, resembling fine sand that has been stuck together by an adhesive, with a medium particle size and a slightly rough texture. Its most obvious feature is that it is layered, with layers of textures stacked like pages, and some of them can also be seen to have wavy marks (like water ripples printed on stones) or dry cracks (like cracks in soil after drying). The sandstone texture is not particularly hard, and shallow marks can be made with a fingernail. It can often be seen in riverbeds, hillsides in mountainous areas, or on stone walls and trails in parks.

2.2.2 Limestone

The color of limestone is mostly white, light gray, or light yellow, which gives it a cleaner appearance. Its particles are so fine that they are barely visible to the naked eye. The surface is smooth, and its texture is softer than that of sandstone. The most recognizable feature is that it bubbles when it meets dilute hydrochloric acid (household white vinegar may also have a slight reaction), because its main component is calcium carbonate. Limestone often exhibits distinct bedding, with one layer being significantly thicker than the other. Some limestone also contains biological fossils such as small shells and coral fragments. It is very common in mountainous areas with karst caves (such as those in Guilin) or rocky areas near lakes or parks, as they are easily eroded by water and form unusual landforms [4-5].

2.2.3 Shale

Shale is dark in color, usually black, dark gray, yellowish brown, and some are greenish, which is related to the clay or organic matter it contains. Its particles are extremely fine, and the naked eye can't see them at all. It feels somewhat like cardboard, and its texture is quite soft. It can be peeled into thin slices by hand along the grain, resulting in a slightly rough edge. Its stratification is the most obvious of all rocks, like a pile of thin paper stacked together; each layer is only a few millimeters thick, so it is also called "lamellation". Shale is often found in low mountains, valleys, or wet areas of parks because it absorbs water easily, weathers quickly, and frequently accumulates at the bottoms of rock piles.

2.3 Metamorphic Rock: Rock that Is Metamorphic from Original Rock

2.3.1 Marble Rock

Marble rock has a variety of colors, such as pure white and light gray, and some have black and green patterns because of impurities, which makes it look neat. Its particles are coarse, and white or light calcite particles can be seen with the naked eye, sticking together like tiny "sugar particles". Its texture is hard, but slightly softer than granite. Like limestone, it will bubble when it comes into contact with dilute hydrochloric acid (because the composition is still primarily calcium carbonate). Still, the difference is that marble often has a block or strip structure with more regular patterns, and some are like natural "marble patterns". Marble is commonly found in sculptures, park railings, and rock walls near magmatic rocks in mountainous regions. It forms when limestone transforms due to high temperatures and pressures.

2.3.2 Slate

Slate primarily appears in shades of black, dark gray, or grayish green, which can seem dull. Its particles are extremely fine and cannot be seen by the naked eye. Its surface is smooth but uneven, and its texture is hard. However, it has an obvious feature: it can be split along a flat surface, like a layer of thin boards. This structure is called "plate stratification ", and the edges of the split sheets are very neat. Slate feels harder than shale, and it sounds crisp when knocked, unlike shale, which does not break into powder. It is common in mountain rock walls with many folds, as well as in stone roads or stone walls in parks. It is formed by shale being slightly squeezed and metamorphosed after heating.

2.3.3 Gneiss

The color of gneiss is the most distinctive, with black and white or other mineral bands arranged alternately, like a "layered steamed sponge cake". Dark bands are mostly biotite and amphibole, while light bands are mostly feldspar and quartz. Its grains are coarse, and one can clearly see the grains of feldspar (flesh-red or grayish-white) and quartz (white and transparent) with the naked eye. It is very hard and not easy to break. These bands form because the minerals in the rock are rearranged after being squeezed under high temperature and pressure. The more obvious the bands, the stronger the metamorphism. Gneiss often appears in the core of ancient mountainous areas and occasionally in large-scale rock landscapes in parks. It is the result of the deep transformation of magmatic or sedimentary rocks.

3. Speculation on the Formation Environment of Common Rocks

3.1 Forming Environment of Magmatic Rocks

For the formation environment of magmatic rocks, the main factors are the "speed" and "position" of magma cooling: whether it cools slowly deep underground or solidifies quickly when erupted on the surface.

The magma of granite is "hidden" in the magma chamber deep underground, where the temperature drops slowly, and there is enough time for mineral particles to "grow" slowly, thus forming coarse particles visible to the naked eye. Later, with the uplift of the earth's crust, the granite originally buried underground was gradually exposed and became the core rock in mountainous areas. It is often used in park rockeries because of its slow cooling process, hard texture, and resistance to weathering.

The magma of basalt is "quick-tempered", which is sprayed directly to the surface (such as during a volcanic eruption) or in the shallow layer of the surface. It cools quickly after coming into contact with air, and the mineral particles solidify before they can grow, resulting in extremely fine particles. Before the gas in the magma escaped, it was frozen in the rock and formed small pores. The rock mentioned mostly appears in volcanic active areas, such as mountainous regions with volcanic eruptions, or near fault zones, because magma there is easily able to gush out of the surface along cracks [6].

The cooling rate of andesite magma falls between these two extremes, and it is mostly formed in shallow underground locations or during moderate-intensity volcanic eruptions. It undergoes a cooling process that is neither as slow as granite nor as rapid as basalt. As a result, the particles are finer than those of granite but slightly coarser than those of basalt. Additionally, it contains fewer pores, which are typically found in volcanic regions along plate boundaries, such as those near some mountainous volcanic ruins.

3.2 Forming Environment of Sedimentary Rocks

For the study of the forming environment of sedimentary rocks, the key lies in determining "where did the sediments come from" and "how did they pile up." What should be considered is whether it is washed by water, blown by the wind, or slowly sinks in calm water.

Sandstone consists of sand grains, primarily quartz and feldspar, that are transported by water (such as rivers), wind (such as deserts), or waves and accumulated in environments like riverbeds, beaches, and deserts. Layer by layer, sandstone gradually bonds to rock through the action of minerals. As a result, the layering of sandstone serves as a historical record of the water flow or wind patterns that occurred during that period. For instance, sandstone displaying wave marks may have originated from ancient beaches.

Limestone is mostly composed of calcium carbonate—either from the accumulation of corals, shells, and other marine organisms after death, or from the direct precipitation of calcium carbonate in water. These processes require a warm, calm shallow-water environment, such as shallow seas, lakes, or coral reefs, because only in such environments can organisms thrive and calcium carbonate precipitate easily. Therefore, when we encounter limestone, we can infer that there used to be an ocean or a lake.

The composition of shale is the finest clay particles. Because they are too light, they can only slowly settle, one layer at a time, in almost no water flow, calm wind environments (such as the bottom of a shallow lake, swamp, or deep sea). Due to the stable environment, each layer of clay is very thin, resulting in a thin stratification of bedding that can be peeled off. If the shale is black, it might indicate a lack of oxygen in the environment at that time, which led to the accumulation of numerous animal and plant remains, suggesting that it was a humid swamp.

3.3 Forming Environment of Metamorphic Rocks

The forming environment of metamorphic rocks focuses on the extent to which the original rocks have been transformed. The appearance after transformation varies with higher temperatures and pressures.

The predecessor of marble rock is limestone. When limestone encounters underground magma, such as magma intrusion, it is subjected to high temperatures or high pressure generated by crustal movements. The calcium carbonate particles inside rearrange, crystallize, and become thicker, resulting in the formation of marble. The transformation mostly occurs near magmatic rocks (magma provides heat) or in the compression zone of ancient mountains. Therefore, marble rock often "neighbors" with magmatic rocks.

The "predecessor" of slate is shale, and its transformation is relatively "moderate", mainly due to the compression of shallow crust (such as rock folds). Moreover, because the temperature is not high, the clay particles in the shale will be rearranged to form a flat plate bedding; however, the particles remain very fine. Therefore, slate mostly appears in mountainous areas with many folds, where the crust has been slightly compressed and deformed.

The "predecessor" of gneiss can be granite or sandstone, which undergoes significant transformation deep underground, often in areas like plate collision zones. Under intense pressure and high temperatures, the minerals in the original rock are "stretched" into strips. As a result, dark minerals (such as mica) and light minerals (such as feldspar) become arranged separately, forming distinct bands. This environment is more prevalent in the central areas of ancient mountains, where rocks have undergone repeated squeezing and heating over hundreds of millions of years due to plate collisions, ultimately transforming into gneiss.

4. Practical Method of Rock Identification and Formation Environment Speculation

4.1 Identification and Speculation of Magmatic Rocks

To identify magmatic rocks, the first step is to observe the color and texture of the particles, and then determine the environment based on the structure. If the color of the rock is light gray, pink, or other light colors, and the particles are coarse enough for the naked eye to see quartz and feldspar clearly, it is likely to be granite without stratification. In this case, it can be inferred that it originated from deep underground. Because the magma there cools slowly, the particles become so big. If the rock is black and gray-black, with particles that are too fine to see clearly and small pores, it is classified as basalt. It shows that the rock originates from volcanic activity on the surface, and the magma cools rapidly after being ejected, leaving pores before the gas can escape. Suppose the rock has a gray, brown, or purplish-red color and features finer particles than granite but slightly coarser than basalt. There are a few pores present. In this case, it indicates it is likely andesite, which is typically formed in environments associated with medium to low-intensity volcanic eruptions. The cooling rate of the magma lies between the first two categories.

4.2 Identification and Speculation of Sedimentary Rocks

The identification of sedimentary rocks is predicated on the concepts of "stratification" and "particles." Furthermore, we hypothesize that the environment, in conjunction with specific reactions, plays a pivotal role in this process. The presence of obvious stratification and medium-sized grains, similar to fine sand, along with discernible quartz and feldspar grains, suggests the likelihood that the rock is sandstone, presumably of fluvial, coastal, or desert origin. The accumulation of sand grains in these regions is attributed to the transportation of these particles by water or wind. The presence of white and gray pigments, accompanied by fine particles and bubbles within a hydrochloric acid context, serves as an indication of the rock's mineralogical composition. Specifically, the presence of these characteristics suggests that the rock is limestone, which, in turn, indicates its genesis in warm, shallow seas, lakes, or coral reefs. These environments, being conducive to the accumulation of biological remains or calcium carbonate, are considered primary sources for the formation of limestone. If the rock is stripped into thin slices along its thin stratification and the particles are extremely fine, it is shale; presumably, it comes from a calm, shallow lake, swamp, or the deep sea. Here, clay particles are slowly deposited in still water.

4.3 Identification and Speculation of Metamorphic Rocks

The key point in identifying metamorphic rock is "metamorphic structure," and then the environment is guessed by combining the characteristics of the original rock. If the rock is white, gray, blocky, or banded, bubbles in hydrochloric acid, and the particles are like fine sugar particles, then it can be judged as marble rock. It is speculated that it comes from the place where limestone is subjected to high temperatures and pressures (such as near magma or the mountain core). Limestone was transformed into it. For another example, suppose the rock is black and gray and can be split into flat slices (plate stratification) with extremely fine particles. In that case, it can be determined as slate, indicating that it comes from a place where shale is slightly squeezed (such as a folded mountain area), where shale has been slightly transformed and changed. Additionally, when the rock exhibits black-and-white bands and coarse particles (such as feldspar and quartz), it can be identified as gneiss, and it is inferred that it originated from a deep underground or plate collision zone. Because high temperatures and pressures transformed the original rock (granite or sandstone), the minerals were arranged into distinct bands [7].

5. Conclusion: Seeing the Earth's Changes from the Rocks

5.1 Rock is the "Recorder" of Geological History

Every rock is a "diary", which records the history of the Earth over billions of years. The story of granite hiding underground, slowly cooling, tells us that a deep-buried magma chamber was present here. Shell fossils in limestone indicate that this land was a warm, shallow sea thousands of years ago. The belt of gneiss shows the traces of crustal compression and collision. They are not as straightforward as words; instead, they utilize particles, stratification, and colors to indicate where volcanoes have erupted, where rivers and deserts have existed, and where the Earth's crust has shifted. By piecing these diary fragments together, we can reconstruct the growth track of the Earth: from an ocean to continuous mountains, from volcanic activity to calm deposition, rocks make distant geological history tangible and accessible.

5.2 The Significance of Recognizing Rocks by Their Characteristics

Learning to identify rocks goes beyond just acquiring knowledge; it's like putting on a new lens through which to see the world. For example, as we walked along the roadside, we noticed sandstone, which allowed us to infer that a river once flowed through this area. Similarly, when we encountered basalt with pores while climbing the mountain, we could deduce that this place had experienced a volcanic eruption. We have the ability to distinguish, so naturally it is no longer a "strange landscape", but a "living teaching material" full of stories. For children, identifying rocks is the key to discovering the mysteries of nature. For adults, it adds interest to everyday life. We don't need to be geological experts; as long as we can read a bit of the Earth's history from a stone, we can make every experience in parks and mountains more enriching and meaningful.

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