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Review of Carbonate Breccia Genetic Classification in West Hill, Beijing

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Abstract. This thesis proposes genetic classification for carbonate breccia in West Hill, Beijing, summarizes the genesis mechanism and features of 14 types of carbonate breccia there, and raises research questions. Not at all of types were included in this classification, mainly which are not so commonly discussed, such as impact breccia formed by meteorolite. Among other things, it raises the issue of overlapping the concept, which requires further research.

1. Introduction

Study of lithologic features of carbonate breccia can help speculate genesis of carbonate breccia and indicate the sedimentary environment of carbonate breccia upon its formation. Thus, to study the genetic mechanism of carbonate breccia is of vital significance to learn its sedimentary environment. Different types of carbonate breccia in West Hill, Beijing are a general research interest among Chinese scholars.

An in-depth research has been conducted of carbonate breccia there from the perspective of the genetic mechanism, shape features, microscopic features and secondary classification. However, the author finds out that classification of carbonate breccia is comparatively superficial. Some scholars classify based on shape features. For example, edgewise conglomerate is an outcome of shape-based classification. The classification method can only give a simple description of rocks, but cannot reflect essential attributes of rocks, let alone imply the sedimentary environment. By referring to a large number of literatures, this paper attempts to classify carbonate breccia into sedimentary breccia, non-sedimentary breccia and breccia with unclear genesis. The following part is a detailed introduction of breccia under each type.

2. Genetic mechanism and basic features of carbonate breccia

Carbonate breccia is classified into the following three types based on the genetic mechanism.
2.1 Sedimentary carbonate breccia

Under sedimentary carbonate breccia, there are six types of carbonate breccia, including gravity flow breccia, avalanche breccia, reef front collapse breccia, storm breccia, seismite breccia and weathered residual breccia.

Table 1. Classification of carbonate breccia

| Genetic classification | Sedimentary breccia                          | Non-sedimentary breccia | Breccia with unclear genesis |
|------------------------|----------------------------------------------|-------------------------|-----------------------------|
|                        | A. Gravity flow breccia                      | A. Karst breccia        |                             |
|                        | B. Avalanche breccia                         |                         |                             |
|                        | C. Reef front collapse breccia               | B. Gypsum breccia       |                             |
|                        | D. Storm breccia                             |                         |                             |
|                        | E. Seismite breccia                          |                         |                             |
|                        | F. Weathered residual breccia                |                         |                             |
|                        | G. Glaciers breccia                          |                         |                             |

2.1.1 Gravity flow breccia. Gravity flow breccia, as the name implies, is formed due to the effect of gravity flow on sediments, which is a rock type of gravity sediments. Middleton and Hampton [1] divided gravity flow of sediments into four types based on the support mechanism, including debris flow, grain flow, liquid sediment flow and turbid low. Among them, only clast flow, grain flow and turbid flow can form breccia or, to be exact, gravity flow breccia. Breccia has complex components. Rounded or sub-angular clast of different sizes and ranging from poor grade to medium grade is common to see. There is clear demarcation between clast and matrix. Clast comes from a shallow sea, a slope or a basin; while matrix is sedimentary fine grain or comes along with the clast to the basin.

2.1.2 Avalanche breccia. Avalanche breccia is made up of coarse and angular rock fragments caused by slipping of rocks from cliffs or slopes. Avalanche breccia is usually polymineral. Angular and sub-angular ones are common to see. The rounded clast is mostly caused by dissolution, thus resulting in a poor sorting. There is also an obvious boundary between clast and matrix in that the matrix is usually made up of micrite or fine clast.

2.1.3 Reef front collapse breccia. The reef front is often subject to erosion of strong waves. When the reef front sedimentation is saturated, the reef will collapse because of gravity or other effects, and slip down along the slope. The reef clast sediment along the gentle slope, in which there are complex grains.
In the relatively peaceful areas, the sedimentation forms rock. The reef front collapse breccia formed along the sea slope is made up of remnants of reef and biological skeletons near the reef or the front slope. Breccia of the type has simple lithological features. The clast size ranges from poor sorting to medium sorting, and is varied in shape, including angular ones and rounded ones. The boundary between clast and matrix is clear [2]. The matrix features fine grains of a poor sorting.

![Figure 1. The sketch of avalanche breccia under the microscope](image1)

![Figure 2. The sketch of reef front collapse breccia under the microscope](image2)

2.1.4 Storm breccia. When the hurricane goes across the sea surface, the storm causes surges of the seawater. The sedimentation base is disturbed, scoured and sapped. The semi-condensed limestone formed in the early period is rolled up and smashed, and flows along with the surge. The semi-condensed limestone is turned into long-striped, rounded or irregular clast. The bamboo-shaped intraclast and the intraclast of other shapes will re-sediment to form storm breccia after the weakening or disappearance of the storm. Storm breccia is mostly monomineral. It includes sand-scale grains, including spherulite, zoolite and bone grain, and is varied in shape. Plenty of well-rounded cast forms breccia [3-5]. The matrix features the granular carbonate matrix usually formed via dolomitization.
2.1.5 Seismite breccia. Seismite breccia belongs to marine sediment, which is formed by autochthonous fragmentation and collapse of rock because of earthquakes. As a part of seismite, seismite breccia does not include gravity flow breccia formed by earthquakes. The breccia on the above suffers serious fragmentation. The breccia diameter is small, the angle is clear and the breccia is ranked out of order. Seismite breccia is also varied in shape, including triangle, polygons and quadrangles. The breccia below has a large diameter, but almost no displacement or reversion has occurred, so the breccia keeps the original rock formation. The breccia looks mosaic [6-8], and the matrix is of a poor sorting.

![Image](image_url)

**Figure 3.** The sketch of storm breccia under the microscope

| Breccia type                  | Sketch | Lithological features                                                                                                                                 |
|------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Earthquake shattered breccia | ![Image](image_url) | The earthquake shattered breccia features shattered rectangles or triangles. It is distributed along the stratum. The breccia angle is clear. The adjacent breccia can sometimes be pieced together. |
| Earthquake collapsed breccia | ![Image](image_url) | The earthquake collapsed breccia has a diameter larger than that of diamicite, and shows soft sediment wrinkling.                                         |

2.1.6 Weathered residual breccia. Due to the effect of weathering, the underlying formation is complex. The stratum with a strong resistance against weathering remains; while the stratum with a poor resistance against weathering is eroded and disappears. The residual clast is varied in shape and composition. Breccia of the kind is called weathered residual breccia. The breccia has complex composition. The gravel is clithiferformed, uneven in rim, obvious in angle and varied in size. Weathered residual breccia is defined to be of an extremely poor sorting. Some long axes are perpendicular to the under surface. The matrix features fine grains, with the major composition being carbonate rock mud, clay and chitern.
2.2 **Non-sedimentary carbonate breccia**

Non-sedimentary carbonate breccia consists of seven types of breccia, including karst breccia, gypsum breccia, fault breccia, fluid dynamic breccia, pressure solution compaction breccia and glaciers breccia.

2.2.1 **Karst breccia.** During the effect of karst, the unsaturated carbonate meteoric water and underground water penetrate through carbonate minerals with an active chemical property, resulting in dissolution of these carbonate minerals and formation of dissolution pores and cracks. As the erosion continues, the rock will collapse to form breccia or karst breccia to be exact. When the dissolution cracks are highly mature, some irregular meshed cracks will appear to cut the rock into breccia. The gravels form a mosaic layout, and no obvious displacement occurs. The gravel content of karst breccia is higher than 90%. The high roundness of some breccia is attributed to not only river transportation but also dissolution. Karst breccia has a simple composition, varied shapes and poor roundness. The sub-rounded ones are outcomes of dissolution and have a poor sorting [9-10]. Some matrix features carbonate or dolomite, while some features weathered red soil materials.
2.2.2 Gypsum breccia. When gypsum (CaSO$_4$) in the gypsum rock formation is in the phreatic zone, it will be continuously eroded because of a high degree of dissolution, and migrate along with the phreatic water to form cavities. The roof or interlayer or breccia of the carbonatite in the gypsum rock formation collapses because the gravity stress losses the support below, sediments on the subsequent stratum autochthonously, and is cemented by Ca, Mg, or mud to form the gypsum breccia [11-12]. Gypsum breccia features a simple composition, an obvious angle, huge variance of sizes and a poor sorting. Because of being corroded by the underground water, angle of gypsum breccia is grounded, but shows no phenomenon of rounding and sorting. Gypsum breccia can be further divided into rubble gypsum breccia, mud and stone gypsum breccia, gravel gypsum breccia and hard-soil gypsum breccia [11]. The matrix features cement, which is made up of cryptocrystalline calcite, dolomite and mud.

2.2.3 Fault breccia. Under the effect of stress, the original rock is fragmented into breccia, which is cemented by clast or external materials. Generally speaking, the breccia with a clast content of higher than 30% is called fault breccia; otherwise, it is called fault mud (Sui et al., 2003). Fault breccia is usually monomineral with a simple composition. Formed by the autochthonous rock, it shows no obvious displacement. Angular ones and sub-angular ones dominate. There are few sub-rounded ones. The matrix is made up of clast and cement.

![Figure 6. The sketch of fault breccia under the microscope](image)

2.2.4 Fault-karst breccia. Fault-karst breccia is a new kind of fault rocks found by Sui et al. while studying Gongcheng-Limu fault zone. Under the effect of fault and karst collapse, the fault breccia and the karst collapse breccia are overlapped, which keeps spreading along the fault zone. Fault-karst breccia is the fault rock that on the spreading section. Different from the general fault breccia, breccia in fault-karst breccia includes both fault breccia and karst collapse breccia, and its cement also combines the effect of fault and karst collapse [13]. Fault-karst breccia is made up of rock fragments with features of the original rock. The angle of breccia is often ablated into a lenticular or elliptical shape because of the effect of stress. Some karst breccia is even corroded into an angular shape. Since fault-karst breccia is a
combination of fault breccia and karst breccia, the breccia feature a multi-stratum overlapped complex structure. The matrix is the breccia cement, which consists of grounded clast, rock powder, pressure solution materials and external materials.

![Figure 7](image1.png)

**Figure 7.** The Genetic mechanism of fault-karst breccia

![Figure 8](image2.png)

**Figure 8.** The sketch of fault-karst breccia under the microscope

2.2.5 *Fluid dynamic breccia.* Fluid dynamic breccia frequently described in literatures include crypto explosion breccia, fluidization breccia and hydrothermal solution breccia. First, there should be a favourable waterproof layer. During the rock-forming and compaction process of the high-porosity rock or under the effect of tectonic stress, the fluid going through rock pores will generate a fluid static pressure system, which will decrease the tensile strength of the rock to the lower limit. At the moment, if any stress is imposed on it, the water-containing layer restricted by the water-proof layer might burst all of sudden to form angular and tensile breccia or cataclasite [14]. The gravel has a simple composition, which is mainly the product of autochthonous rock fragmentation. The breccia is varied in shape, ranging from angular ones to sub-angular ones. The angle of some breccia is eroded by hydrothermal solution, thus forming a sub-angular shape. The deformation intensity of breccia is lower than that of
the surrounding rock. Besides, fluid dynamic breccia features a relatively concentrated layered, lenticular, irregular and consequent layout. Wang et al. (2000) divided fluid dynamic breccia into explosive breccia, fluidization breccia, and hydraulic pressure breccia [15].

2.2.6 Pressure solution compaction breccia. Due to the effect of pressure solution and compaction, the rock in the carbonatite area is cut into breccia by the suture line. Pressure solution compaction breccia consists of sedimentary clast and fossils under the effect of solution and compaction. After being separated by the thin clay layer and the micro-suture line, many gravel-sized sub-rounded or sub-angular grains appear [2]. The amount of matrix varies, and sometimes microlite is included in the matrix.

![Figure 9](image)

**Figure 9.** The sketch of pressure solution compaction breccia under the microscope

2.2.7 Glaciers breccia. Under the glacier environment, the mashed grains generate a new mineral surface. The clast with the new mineral surface reacts with the oxidized acid in the water, and the mineral is dissolved. In particularly, the dissolution of carbonate minerals is common to see. The process can result in re-sedimentation of CaCO$_3$ in the glacier system.

![Figure 10](image)

**Figure 10.** The sketch of glaciers breccia under the microscope
The synsedimentary carbonate breccia generated is glaciers breccia. Glaciers breccia has a complex composition. Some new and unstable components can usually be found in it. Besides, glaciers breccia has a poor sorting. The gravel content is lower than 50%, most of which features an angular shape. Some clast is found on the ground surface. On the surface, the “T-shaped” scratches can usually be found.

2.3 Breccia with unclear genesis

2.3.1 Leopard breccia. The porphyritic limestone and the dolomite with the breccia structure are formed by the porphyritic recrystallization and cementation. Meanwhile, the two is restricted by the distribution of organic materials. Leopard breccia is also regarded as a type of breccia which is made up of the autochthonous clast and segmented by the meshed joint. About genesis of leopard breccia, there are three prevailing ideas, namely genesis of gravity flow, genesis of uneven dolomitization, and tectonic genesis.

![Figure 11. The sketch of leopard breccia under the microscope](image)

3. Conclusions

This paper summarizes genetic types of carbonate breccia in West Hill, Beijing, and divides carbonate breccia into 3 general types and 15 sub-types. The three general types include sedimentary breccia, non-sedimentary breccia and breccia with unclear genesis. Among them, sedimentary breccia includes gravity flow breccia, avalanche breccia, reef front collapse breccia, storm breccia, seismite breccia and weathered residual breccia; non-sedimentary breccia includes karst breccia, gypsum breccia, fault breccia, fluid dynamic breccia, pressure solution compaction breccia and glaciers breccia; and breccia with unclear genesis mainly includes leopard breccia.

The genetic classification proposed in this paper also has its limitations. For example, not all types of carbonate breccia are covered by the genetic classification. The 14 types of carbonate breccia discussed in this paper are more commonly seen. Some types, which are not so commonly discussed, such as impact breccia formed by meteorolite, are not included in this paper. Besides, the issue of concept overlapping calls for further research.
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