Microstructural Characteristics of Saprolite with Different Weathering Degree

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***Abstract*—**Microstructural characteristics of saprolite with different weathering degree is obtained based on SEM images. A new index—plagioclase solution degree is proposed to evaluate the weathering degree of saprolite. Application in three sections of Hong Kong suggests that the new index is sensitive to saprolite and can identify weathering degree precisely.

***Keywords*—**microstructural characteristics, plagioclase solution degree, saprolite, weathering degree.

I. Introduction

GRANITE is widely distributed all over the world. In south China, its distribution area account for 30 to 40 percent in Fujian and Guangdong Provinces, 10 to 20 percent in Guangxi, Hunan and Jiangxi Provinces (Huang Zhenguo, 1996). These regions are tropical and subtropical zones, in favor of Al-enrichment. Large areas of saprolite spread there, with a depth of 20 to 60 meters. In Hong Kong, the saprolite is generally 20 to 40 meters deep, the deepest reaching to 60 meters (Irfan, 1994). Saprolite weathering is the primary geological environmental problem in these areas. Slide, debris avalanche and soil and water loss are all directly or indirectly related to it. The contradiction between geological environment and economic development is prominent, especially in Hong Kong. So, to propose a more accurate evaluation method of saprolite weathering is of great importance.

Through the study of saprolite weathering in HongKong, we find that many kinds of original minerals including albite which is sensitive to weathering still remain in saprolite, but in different kinds of forms. This can be used to identify the weathering degree of saprolite. Based on this knowledge, we have proposed a new weathering index—plagioclase solution degree to evaluate the weathering degree of saprolite.

II. Plagioclase Solution DegreE

Plagioclase, including albite, is not only one of the primary rock-forming minerals of granite, but also one of the most unstable and the most-likely-to-weather minerals. With the proceeding of chemical weathering, albite solutes continuously until totally disappearing from soil. Consequently, the solution state of albite can be considered to be a reflection of weathering degree.

Our observation indicates that in the weathering process the appearance of albite changes in the following two ways: 1) The shape of plagioclase changes from regular long prism-polygon form to irregular form; 2) Voids inside plagioclase grow larger (Fig. 1).

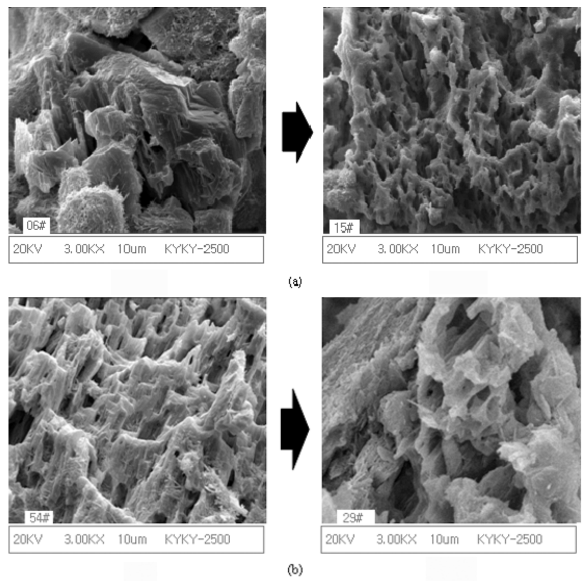

Fig. 1 Micro-morphologic changes of plagioclase due to weathering

(a) Shape of plagioclase transforming from regular (the left) to irregular (the right)

(b) Voids inside plagioclase changing from small(the left) to large(the right)

These two changes often occur at the same time. If we grasp the law of these changes, we can distinguish different weathering degree. In this paper, we analyze the change of internal voids of albite, and then make a subtly estimation on the weathering degree.

Of course, their area can characterize the development of the internal voids. We put forward the concept of “plagioclase solution degree” (N_f), and it is expressed as

$$N_f(\%) = \frac{\sum_{i=1}^{n} A(i)}{A(m)} \times 100\% \qquad (1)$$

Where $A(i)$ is the area of visible void inside the mineral tested, N is the number of visible void inside the mineral tested, $A(m)$ is the total area of the mineral tested.

Formula (1) is similar to the volume void degree of soil, but it measures the void degree of a single mineral rather than the void degree of the whole soil mass. The value of N_f ranges from 0 to 100: the larger N_f is, the more the voids inside the mineral tested is, the higher the solution degree and weathering degree is.

III. TESTING METHOD AND PROCESS

The mineral shape can be observed by SEM. The measurement of N_f is based on the albite image captured from SEM. To obtain a statistic result, at least 3 images should be taken from each sample. The analysis procedure is as follows:

(1) Choose a mineral sample and then draw its outline using a discernible close curve (Fig. 2a).

(2) Dye the background (the outside of the mineral sample) with a transitional color (grey scale) to stand out the sample (Fig. 2b).

(3) Binarize the object and mark all the voids inside the mineral with black color (Fig. 2c).

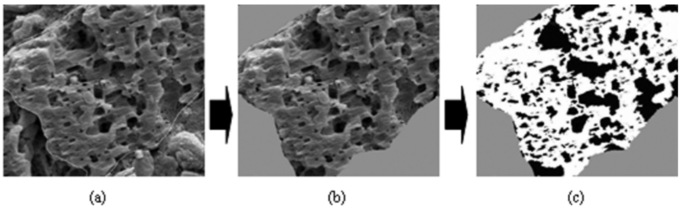

Fig. 2 Measurement method of plagioclase solution degree
(a) Enclosing the particle of plagioclase;
(b) Deleting backdrop;
(c) Binarizing the object (marking the inner voids).

(4) Measure the whole area of the mineral sample and the area of each void with MIPS (Micro-Structural Image Processing System (Hu, 1995)).

(5) Calculate the total void degree inside the mineral with formula (1).

The test is completed on MIPS.

IV. APPLICATION

In order to evaluate the validity of this method – using void degree of mineral to identify the weathering degree of soil, samples at different depths are taken from the saprolite section of MA ON SAN in Hong Kong. This sampling section is located in a building site where slope protection is underway (Fig. 3).

Fig. 3 Photo of the site and section of samples from MA ON SAN.

The section is 3m high, almost perpendicular, and made of eluvial soil of weathering saprolite. From top to bottom, samples are taken at every 10 centimeter of the section with an Φ 8 centimeters steel ring. The steel ring is stroke into the slope by hammer. The samples are wrapped with three layers of plastic films, labeled with sampling depth. 22 samples are obtained in this way.

At least 3 SEM images of each albite sample are analyzed. The test results are shown in Fig. 4 and Fig. 5. Fig. 4 shows the change of plagioclase solution degree (N_f) of all samples with depth (H). Fig. 5 shows the average plagioclase solution degree of a certain depth. Representational SEM images are also presented in Fig. 5.

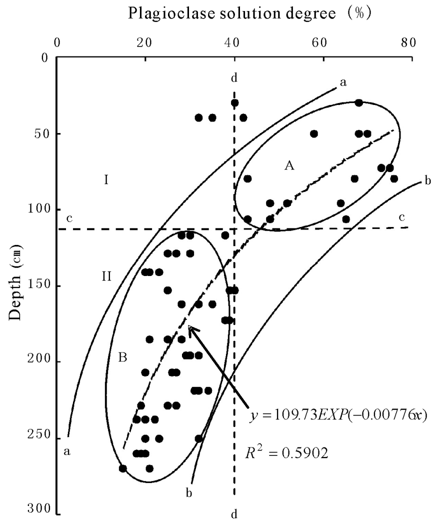

Fig. 4 Change of plagioclase solution degree with depth (Samples from MA ON SAN).

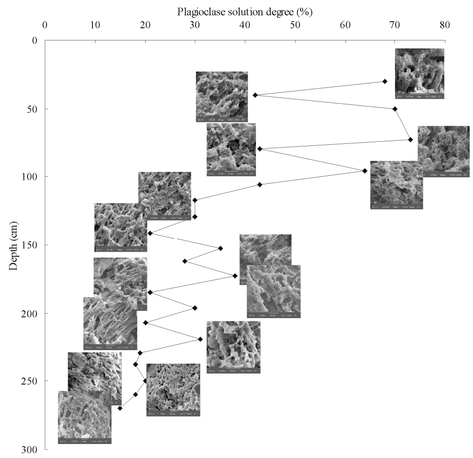

Fig. 5 Change of plagioclase solution degree with depth.

Test results prove that with the increase of depth (H), the plagioclase solution degree (N_f) decreases. The attenuation of N_f with depth is not linear but exponential. The law can be expressed as follows:

$$N_f = ae^{-bH}$$

Where a and b are parameters relating to the characteristics of soil, and can be obtained from test. The range of plagioclase solution degree is between a- a' and b- b'. As a whole, it accords with the exponential attenuation law mentioned above. From the whole fitting curve (the dashed figure), the value of *a* and *b* are 109.73 and –0.00776 respectively. From Fig. 4, we can see that the plagioclase solution degree can be divided into two groups, A and B, which reflect two soil groups with different solution degree. The depth boundary between A and B is line c- c'with a depth of 115cm. The corresponding solution degree boundary is about 40% (line d-d'). Based on these characteristics, we divided the saprolite of this section into two general types as listed in table 1.

Classes of solution degree	Depth (cm)	Range of solution degree (%)	Characteristics
I	< 115	14 ~ 40	Large void, irregular particles, good connectivity, roundness, loose
II	≥ 115	40 ~ 77	Small void, poor connectivity, clear profile, dense

Table 1. Classes the plagioclase solution degree and the description of its characteristics.

Using the same method, we also obtain the solution degree of Shi Xiawei section and Guan Tang section in Hong Kong. The test results are shown in Fig. 6.

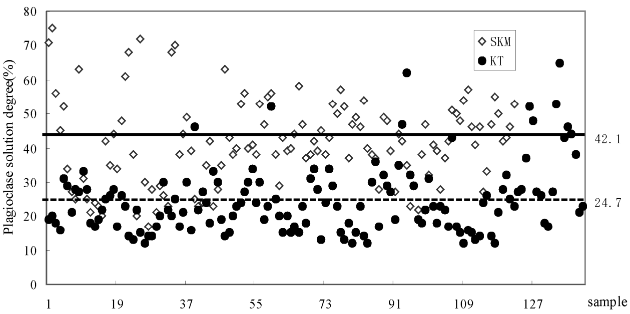

Fig. 6 Statistics of plagioclase solution degree.

We can see that, their plagioclase solution degree are between 15% and 65%, mostly between 15% and 45%. The plagioclase solution degree in Shi Xiawei is higher than that in Guan Tang: the mean value of the former is 42.1%, while the mean value of the latter is 24.7%. Thus it is reasonable that the stability of soil in Shi Xiawei is worse than that in Guan Tang.

V. Conclusions

It is important to evaluate the weathering degree of saprolite. Different geotechnical measures should be selected according to different weathering degree. Our studies in MA ON SAN, Shi Xiawei and Guan Tang sections of Hong Kong suggest that the plagioclase solution degree is a sensitive index that can accurately reflect the weathering degree of saprolite. However, as we all know, weathering depends on many factors. We don't expect that the plagioclase solution degree can be applied to all saprolite weathering areas, but its potential to characterize the weathering degree should be stressed and the introduction of SEM images seems to be able to open a new prospect to further refine the weathering degree.

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