Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

HGM02-01 Room:101B Time:May 26 11:00-11:15

Assessment of weathering grades for different chemical and geomechanical properties; A Sri Lankan case study

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Having a better understanding of the weathering grade of rock materials is highly beneficial in the perspective of civil engineering and geology. The classification of weathering grades can be performed based on the chemical, physical, mineralogical, textural and strength properties of rocks. Among those, the use of chemical components to classify weathering grades is not very promising for all types of rocks. Based on the mobility of elements various chemical indices for weathering grades have been formulated. Most of those indices are based on experiments of weathered acidic igneous rocks under humid and well drained environments. There are only a few indices formulated for sedimentary and metamorphic rocks, so the use of chemical weathering indices for the classification of weathered metamorphic rocks would not be convincing. However, the use of physical and strength properties for the assessment of weathering grades is comparatively convenient. A better variation of those properties with respect to weathering grades is resultant irrespective to rock type. Therefore, this study focuses on assessing weathering indices using physical, strength and chemical properties of a selected metamorphic rock and evaluating the correlation among the indices derived from those properties.

Fresh and weathered rocks of garnet-sillimanite gneiss were selected from the Samanalawewa Hydropower Project. Weathering grades were visually assessed initially, then confirmed with physical and strength properties using tests on dry density, water content, ignition loss, point load strength and slake durability. Whole rock geochemical data were used to calculate weathering indices.

Physical and strength properties show a marked difference with weathering grades. However, chemical indices are not very convincing. Silica-Titania, Product index and Ruxton ratio show a gradual variation with weathering grades. Mobiles index also shows an acceptable variation. However, the modified weathering potential index, which was formulated for metamorphic rocks, Parker index, which was formulated for all types of rocks, do not show a gradual variation with weathering grades. Chemical index of alteration and weathering (CIA and CIW) do not show a recognizable variation with weathering grades. Physical and strength properties show good correlation with most of chemical indices. In addition, most chemical weathering indices show good correlation with each other. The Lixiviation index is the one shows weak correlation with most of other chemical weathering indices. The failure of some indices in showing a good correlation can be accounted for the heterogeneity of garnet-sillimanite gneiss.

Keywords: Weathering grades, Rock weathering, Chemical weathering index

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HGM02-02 Room:101B Time:May 26 11:15-11:30

Spheroidal weathering process of granite porphyry with columnar joints to form corestones covered with rindlets

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In the southeast mountainous region of the Kii peninsula, Japan, granite porphyry shows typical spheroidal weathering, in which 0.4-1.5 m diameter of corestones are made with scale-like rindlets. The rindlets are made by the exfoliation of surface parts of a corestone by mineral-chemical alteration and crack propagation, of which processes were poorly known. We made field investigation and made analyses and measurements for mineralogy, chemistry and physical properties of rock samples and found that the oxidation of colored minerals and iron precipitation creates micro-cracks, which separates rindlets from a corestone.

Fresh granite porphyry has almost vertical columnar joints with 2-6 m intervals and is intersected near the ground surface by the sheeting joints. At the beginning of the spheroidal weathering, an oxidation front is made along joint surfaces to form a brown band. Brown bands were 2.5-5 cm thick and individual rindlets were 3.5-5 cm thick regardless of radius of corestones, which suggests that the rindlet separation occurs when a brown band thickness reaches about 5 cm. Thin-section observation and XRD analyses indicated that pyrite is depleted, chlorite is transformed into vermiculite, and iron(Ⅲ) hydroxides precipitate in the brown band. Microscopic observation of cut surfaces of rock samples impregnated with fluorescent resin showed that pores are filled with the precipitate and micro-cracks form subparallel to the oxidation front in the brown band. Cracks in the brown band or rindlets seem to converge at aggregates of iron(Ⅲ) hydroxides and vermiculite, and cracks form a network subparallel to the oxidation front with 0.5-2 cm interval at a maximum. In the brown band, P-wave velocities increased up to 10%, but tensile strengths with fracture surface parallel to the oxidation front decreased in the brown band than those of fresh rock. These physical property changes are due to pore filling and crack development in the brown band. The mass balance calculation using densities and Ti concentrations of rock samples did not detect rock volume changes in the brown band and the inner rindlets, but suggested that rock volumes increased by 20% in the outer rindlets and by 80% in the saprolite from the fresh rock. Mass balance calculation also suggested that chemical components are leached out in the brown band, the rindlets, and the saprolite in a consistent way. A corestone is thus getting smaller with the exfoliation of rindlets from brown bands, which gradually migrates inside the corestone by the oxygen diffusion, then rindlets are finally disintegrated into saprolite.

Keywords: spheroidal weathering, weathering rind, granite porphyry, crack, oxidation, P-wave velocity

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HGM02-03 Room:101B Time:May 26 11:30-11:45

Regarding to the arguing issue; Bioweathering vs Bioprotection in stone historical buildings

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The Angkor complex is the one of the greatest cultural heritages in the world. It is constructed in the early 12th century, designated as a world cultural heritage by UNESCO in 1992. The temples at the Angkor complex are mainly made of sandstone and laterite. However, due to the tropical climate, plants, lichens and various microorganisms are growing well on the rock surface. Black crusts are also easily found on the stone surface. Biological factors are considered as a damage factors for the heritage. The studies suggested that how it can be removed without destroying the substrate efficiently.

We sampled Angkor sandstone covered by black crust at the Angkor Wat and Bayon temples, Angkor complex, and observed the section and the surface of the rock sample by using SEM. Surfaces of the samples are not polished in order to observe the original condition. The depth of the black crust is up to 1 mm. Many filamentous materials were found on the black crust. Average energy-dispersive X-ray spectroscopy data of the black crusts shows that over 70 % of the surface materials are compounds of carbon. And 15% of the mass are made of SiO_2. It seems that these materials are hyphae. The shape of the hypha is like a thread and its size is few μm in diameter and up to several centimeters in length. Black crusts are consisted of elements and compounds of carbon, Na, Mg, Al, Si, Cl, K, Ca, and Fe.

The answer of the controversy question “Do lichens on the historical building protect it or not?” is not fixed. It protects while weathers. It depends on the time scale and the surroundings. We have to focus on the timing of the lichen fall off. Under the lichen coverage, rocks may be protected. When the lichen fall off, it may have lower surface than lichen-free rock surface. Weathering is in progress and is a result of previous process under various facts, not only biological factors but wet-dry cycle, various salt and so on. This is the reason why it is hard to judge whether lichens should be removed or not. We have to check all the environmental data such as temperature, humidity, direction, insolation, rainfall frequency, human effect, weathering degree etc. and decide to remove or not. Therefore, field survey and evaluation standard are needed. Further research has to be continued to find out the better and proper way of conservation for the historical sites as Angkor monument.

Keywords: Angkor Wat, stone cultural heritage, conservation, lichen, biological weathering

Japan Geoscience Union Meeting 2015
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HGM02-04 Room:101B Time:May 26 11:45-12:00

Accumulation of radioactivity inside Yoshimi archeological heritage

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The Hundred Caves of Yoshimi is a cluster of ancient grave caves dug on the cliff made of tuffaceous sandstone located in Yoshimi town, Saitama. It was designated as a national historic site on March 7, 1923. Built between late 6th century and late 7th century, the caves were initially made for only the blood royal and other big powerful families but later used for large scale of underground munition factory. At present, the area is used for tourist attraction. Continuous survey has revealed that the caves are heavily affected by salt weathering, mostly by gypsum. However, seasonal changes have also been observed in salt formation. As part of that survey, accumulation of natural radioactivity, significantly anomalous than background level, has been observed inside some of the caves of Yoshimi. The survey has been carried out to all accessible caves and radioactivity was measured by Horiba Radi PA-1000 radiation monitor within 2-5 cm of the wall. Radioactivity was found to be as high as 0.119 micro sievert per hour in some of the walls which is more than twice of the natural radioactivity found at the entrance of the area. This amount is marginally higher than the radiation dose limits for general public. Having similar rock type in all the caves, the reason of such accumulation of radioactivity is lichen formation in the inside walls which is a known bio-accumulator of radioactivity. Though studied walls are still out of reach of tourists visiting Yoshimi caves, spreading of lichen to other walls might increase the radioactivity risk. Such accumulation of radioactivity also needs to be considered if other caves are opened for tourists in future. Specific source of radioactivity also needs to be investigated through detail survey.

Keywords: Natural Radioactivity, Yoshimi caves, Weathering, Lichen, Bio-accumulator, Radiation dose

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HGM02-05 Room:101B Time:May 26 14:15-14:30

Formation processes of block stream in Mt. Maneo, South Korea

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This study revealed that formation processes of slope deposits include block stream near Mt. Maneo, South Korea. Using a satellite image reading from Naver site (http://www.naver.com/) and a field survey, we studied the positional relationship between the Mt. Maneo block stream and its surrounding terrain, as well as the general shape of the block stream. The satellite image scale was about 1:5000, which had a resolution sufficient to identify the block stream. Next, we superimposed the interpreted satellite image on a 1:25000 topographic map, and read the contour lines over the location of the block stream. The plan view of the block stream on Mt. Maneo has a belt-like shape. The top end of the slope is the steepest, having an incline of around 20 degrees. On examining the contour lines crossing the block stream, the contour lines in the top section are found to be more or less straight and represent an even slope with no obvious ridges or valleys. In the central part of the block stream, the contour lines are convex in the upslope direction, indicating a wide valley. In the lower section of the block stream, the contour lines are convex in the downslope direction, indicating the presence of a ridge.

A cross-section of the block stream is visible in the central part of the out crop and can be split into two parts: a matrix of fine-grained materials on the northwestern side, and a matrix-free deposit on the other side. For the purpose of this study with respect to sedimentary facies, we counted the sections having matrix as part of the block stream. In the matrix-free deposit section, blocks with a larger diameter tend to be concentrated in the lower portion. The overall cross section has an upward convex shape.

We observed ground water flow and soil saturation by five tensiometers. All observation points were located at the top of block stream. Depth of the tensiometers were about 30cm. Tensiometers were inserted fine slope deposits at the upper part of the block stream. Observation period was Jul. 9, 2014 to Jul.14, 2014.We observed that slope deposits were rapidly saturated associating with rainfall event. Rain fall event was occurred in Jul. 13, 2014. Rainfall amount was 30mm/day. All tensiometers responded this rain fall event. Suction was decreased very rapidly at this rainfall event. This means that saturation of soil layer occurred at the head of block stream associating with rainfall event. Water was concentrated in the valley created by this landslide. We can recognize from observation of suction that the unsolidified weathered fine-grained material forming the landslide block was washed out by this water flow, leaving only the core stones behind.

We believe that the area of the Mt. Maneo block stream is an old landslide site. This could have been a deep seated landslide that reached the deep weathering layer of the upper section of Mt. Maneo, and it is thought that a large section of the landslide block consisted of core stones and weathered fine-grained material.

Keywords: Block stream, Form processes, Landslide, Hydrological survey, South Korea, Mt. Maneo

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HGM02-06 Room:101B Time:May 26 14:30-14:45

Roles of alluvial cones in sediment budget in the wide valley floor of the Kamikochi valley, central Japan

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The upper reaches of the River Azusa, flowing down in the Kamikochi valley in the Northern Japan Alps, central Japan, is surrounded by very steep mountain slopes and high mountains which elevation is higher than 2500m. There are many landslides on the steep mountain slopes, from which debris is supplied to the valleys of the tributaries of the upper River Azusa.

Alluvial cones are the most important features on the valley floor of the upper River Azusa. These are formed at each outlet of the tributaries. To clarify the roles of the alluvial cones in the sediment budgets of the upper Azusa basin, landforms of the alluvial cones were investigated and the sediment linkages between the tributaries and the main river were discussed.

Many debris flow lobes are distributed on the surfaces of the alluvial cones. This shows that the alluvial cones are formed by debris flow accumulation. Most of the alluvial cones have several levels of terraced surfaces. The cone of a tributary, Furuikezawa, has four levels of surfaces. Each surface is bordered by terrace cliffs of several meters high. While the most part of the lowest surface is covered with newly deposited gravels with pioneer trees younger than 70 years, the other surfaces are covered with mature forest, the age of some trees are hundreds of years, and dense forest floor vegetation. The channel of Furuikezawa directly connects with the lowest surface and the surface borders on the main river floodplain with dense riparian forest. The surface is not contact with the channel of the main river. The lower borders of the terraced surfaces are margined by terrace cliffs which stretch parallel with the direction of the valley of the River Azusa. Other alluvial cones in the Kamikochi Valley have such similar geomorphological characteristics.

These characteristics of the alluvial cone show the alternation of accumulation of debris flows on the cone surface and lateral erosion of the toe of the cones by the channel shift of the main river. The debris supplied from a tributary basin is stored as its alluvial cone deposits. When the channel of the River Azusa will be shifted to the alluvial cone, lateral erosion will occur at the lower end of it. As lowering of the base level the channel of the tributary begin downcutting and the alluvial cone surface becomes a terrace. Debris produced by the lateral erosion is transported downstream of the main stream.

During the time lag between debris supply to the cone and eroded away from the cone and transport downstream debris became easily breakable into fine materials.

Alluvial cones on a wide floodplain play important role on sediment transport link between mountain slope and valley floor. Produced debris from the mountain slopes is not transported directly downstream by the main river. That is an important factor in basin sediment budgets.

Keywords: debris transport process, alluvial cone, wide floodplain, sediment budget, Kamikochi, central Japan

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Geomorphological evolution of Hashirikotan barrier spits resulting from seismotectonics along the southern Kuril Trench

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An active barrier system is developed in the Nemuro Bay area along the Okhotsk Sea in eastern Hokkaido, Japan. This presently rare feature consists of a lagoon (the Furen-ko lagoon), a flood tidal delta, a barrier, and a tidal inlet that opens into the outer sea of Nemuro Bay and the Sea of Okhotsk. The Hashirikotan barrier spits are active in the northeastern part of the Furen-ko lagoon, and five spit branches (BS1˜BS5) can be observed clearly. Using geomorphological, sedimentological, and ground-penetrating radar methods, we analyzed Holocene sediments near the Furen-ko lowland. We dated them using radiocarbon and tephrochronological methods. The Furen-ko barrier system has been established since 5.5 ka. BS1, the youngest spit was formed after the 17th century, and BS2 was caused by the last seismic uplift in the 17th century. BS3 was uplifted in the 12˜13th century, and BS4 was caused by seismic uplift in the 9th century. These great earthquakes (Mw8.5˜9.1) have occurred at an approximate 500-year interval along the southern Kuril subduction zone. Coastal areas were raised by 1˜2 m during or just after the earthquakes due to postseismic displacement. Conversely, land subsidence has been ongoing at a rate of about 1.0 mm/year since the 17th century. We conclude that the geomorphological evolution of the Furen-ko barrier system has been controlled by the seismotectonics along the Kuril subduction zone.

Keywords: geomorphological evolution, Hashirikotan barrier spit, seismotectonics, southern Kuril trench, eastern Hokkaido, northern Japan