The influence of weathering on landslides in some granitic areas of Japan

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Landslides occurred in granitic rock areas are somehow affected by different weathering processes. However, only the climatic condition such as rainfall intensity was investigated well but weathering degrees are not quantified in the most of previous researchers. The present study describes weathering degrees by analyzing chemical and mineralogical properties, and considers their effects on landslides. Samples for analyses were collected sequentially from fresh to strongly weathered. Total 54 samples from Hiroshima (Hiroshima pref.), Nagiso (Nagano pref.), Yamaguchi (Yamaguchi pref.), Minakami (Gunma pref.), Iwakuni (Yamaguchi pref.), Yamada (Kagoshima pref.) and Ishigaki (Okinawa pref.) granitic areas were analyzed by using XRD (X-ray powder diffraction), Scanning Electron Microscope (SEM) and Energy Dispersive X-ray Spectrometry (EDS). As a result, typical weathering trends were observed by comparing both chemical and mineralogical data. The chemical changes like the concentration of K_2O, Na_2O, CaO, MgO, Al_2O_3, SiO_2, FeO changes and the presence of kaolinite, illite, smectite, vermiculite, chlorite along with quartz, k-feldspar, plagioclase, mica also showed the major causes of the formation of clay minerals.

Keywords: Granitic rocks, Weathering, Chemical and mineralogical properties, Clay minerals, Landslides

Temporal variation of filling processes of valley-head hollows in the Ohmatsuzawa Hills, Sendai, northeastern Japan

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A valley-head area is structured by several micro-landforms, each of which expresses hydro-geomorphic processes in evolution of hillslopes (Tamura 1974, 2008). Head hollows form from landslides, while subhollows develop from shallow landslides that have shorter recurrent intervals and smaller magnitudes than those for head hollow formation (Furuichi 1995, 2015). Filling or modifying of the scours or depressions constitutes another half of the evolution cycle, but its processes and timing appear to be not fully explored. Geomorphological knowledge on filling of the scours involves implications in geomorphic environment especially in terms of the climate change history. This paper presents field-based observation and analysis on filling processes of valley-head areas in relatively gentle, Neogene sedimentary-rock hills in northeastern Japan.

The Ohmatsuzawa Hills extend between the Naruse and Yoshida River lowlands, about 25 km north of Sendai. The hilltops align along the skyline below the level of 140 m a.s.l. and represent erosional surfaces with gravel beds (Akojima, 1971). The study area of the Showa Man-yo Forest Park is located in western part of the Ohmatsuzawa Hills. The highest and lowest elevations occur on the crest slope at 70 m a.s.l. and in the stream floodplain at 20 m a.s.l., respectively. The local basement is the Pliocene Miyatoko Tuff. Fluvial boulders of volcanic origin are found on some of the hilltops and less often on middle to lower parts of slopes. Eight valley-head areas form in the study area and micro-landforms of channel, subhollow, head hollow, upper sideslope and crest slope are identified and aligned in this order upstream.

Profiles of regolith in test pits and by the cone penetration test show layered structure. At channel heads, for instance, a gravel layer of 40-50 cm thick overlies the weathered (in-situ) Miyatoko Tuff at c.a. 80 cm deep and is occasionally covered by a buried humus layer of 10-20 cm thick. The gravels must have been transported (colluvium) given that patches of buried humus are found within the gravel layer. Spatial extent of the colluvial gravel layer is narrower than the area of head hollow but wider than subhollow. ^{14}C dating of a patch of buried humus within the colluvial gravel layer indicates an age of the middle of the Holocene and ages of a buried humus layer overlying the colluvial gravel layer are younger than the patch of buried humus.

It has been reported that shallow landslides can occur in (relatively steep) upper sideslopes once intensive rain and/or strong ground shake (earthquake) affect the slope stability and therefore evolution in valley-head areas is driven not only by continuous diffusional processes such as soil creep but also occasional mass-wasting (Tamura et al. 2002, 2011). In the preset study area, the colluvial gravels are sourced to the hilltop gravel deposits and were likely transported through shallow landslides occurred across the crest slope and (relatively gentle) upper sideslope. The time of the mass-wasting falls in the warmer (and probably wetter) period in the Holocene, suggesting forest fire and/or intensive rainfall may have caused the mass-wasting although earthquakes are known to induce landslides on convex slopes. The period of the mass-wasting was followed by a static period indicated by development of the buried humus.

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Keywords: head hollow, subhollow, mass-wasting, Holocene, climate change

Multi-proxy study of alluvial fan development during the Holocene in the Qu`Appelle Valley, Saskatchewan

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Sedimentation on alluvial fans is controlled by fluvial erosional processes occurring in upland drainage basins and slopes, as well as by the subsequent transport processes which deliver the sediments from the catchment area to the fan. Alluvial fan sediments may contain valuable information of climate change, anthropogenic influences and could function as an archive of landscape development. The deposits of the alluvial fans in the Qu’Appelle Valley, Saskatchewan comprise of weathered glacial till and glacial fluvial material transported from the upland drainage basin area. The purpose of this study is to establish a relative chronology of the alluvial fans in the Saskatchewan Prairies by exploring multiple proxies as well as to evaluate the weathering/leaching intensity of the modern upper catchment soil and the borehole core samples.

Two borehole cores (AG850 cm and FN350 cm), which were taken from two Holocene alluvial fans located in the Qu’Appelle Valley in southern Saskatchewan (Kotowich and Hardenbicker, 2014) were used for this study. Core sediment sample collection ranged from 2-10cm based on sediment physical properties. The upper catchment areas of the AG and FN cores have been dominated by agricultural fields since 1890’s and natural prairies accompanied with recent agricultural practises, respectively. Modern surface samples from natural prairie grasslands, agricultural fields, tree groves, and sloughs were also collected from the upland catchments to examine soil properties. Elemental composition analysis using an Energy Dispersive X-ray Spectroscopy was carried out to obtain weathering/leaching intensity of the samples. The Beavers Index CaO/ZrO_2 molar ratio, the Parker Index [(Na)a /0.35]+[(Mg)a / 0.9]+[(K)a / 0.25]+[(Ca)a / 0.7])*100, the Product Index [SiO2/(TiO2+Fe2O3+SiO2+Al2O3)]*100 were focused to quantify the degree of weathering/leaching in semi-arid environment (Souri and Watanabe, 2011; 2013). Particle size distribution, pH, organic content, and radiocarbon dating were obtained for the borehole cores and the surface soils of the upper catchment areas. Features of foraminifera were observed by stereomicroscopy in sediment/soil samples.

The weathering index values showed fluctuations by depth in the borehole profiles, although there was an inverse relationship between Product Index and sample depth. Beavers Index and Parker Index performed a similar fluctuation in the profiles. Borehole samples with smaller Parker, Beaver and Product values also had a larger content of finer particles. Physical features seem to coincide with chemical features. The indexes obtained for the modern surface soil showed differences in land use or vegetation coverage; prairie grassland or agriculture field versus forest or slough, which suggest their behavior as leaching intensity indicators. Foraminifera were also found in modern soil samples from the upland drainage basin of both alluvial fans. Moreover, the presence and abundance of foraminifera varied in the borehole samples. This may suggest that they could be used in combination with weathering indexes as an environmental proxy for reconstructing the environmental history of the Qu’Appelle Valley.

Keywords: Alluvial Fan, Chronology, Canadian Prairies, Holocene environment

Lithological control on pothole formation in two tectonically active regions within the Deccan Volcanic Province, Maharashtra, India

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Recent studies have shown that the Deccan Upland region of the Deccan Plateau is constituted of different blocks with uplifts, mainly during the Quaternary times. Bedrock incision in streambeds has also been the focus of many recent studies worldwide. This paper talks about the difference in the morphology of potholes within two river channels from two distinct tectonically active regions. These two river channels were made up of distinct lithologies: Nighoj area- Mainly compound flows constituting of dominantly compact and vesicular basalts and Patan area- Mainly simple flows constituting dominantly of flow top breccia. The depth and diameters of potholes formed were measured in the field.
The studies indicate that the potholes formed in the compact and vesicular basalts have an average of 1:1 diameter to depth ratio; whereas in the flow top breccia potholes have an average ratio of 1:6. This indicates that the vertical incision controlling the depth and the lateral incision controlling the diameter of the potholes are nearly equal in compact, vesicular and amygdaloidal basalts, as seen at Nighoj, giving rise to potholes that are deep and have large diameters. At Patan, in the flow top breccia the vertical incision rate is much higher than the lateral incision, as the circular movement of the tools is hampered by the breccia fragments, obstructing the formation of eddies, giving rise to potholes that are small in diameter but have depths that are nearly six times that of the diameter.

Keywords: Deccan Plateau, Bedrock incision, Morphology of potholes, Diameter to depth ratio

Isolating lithologic controls on landscape morphology in the Guadalupe Mountains, Texas, USA

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Qualitatively, lithologic control on topography is apparent in many landscapes. This is perhaps most notably evident in dryland settings with horizontal stratigraphy, where the contrasting geomorphic expression of “cliff formers” and “slope formers” is common. However, in many geomorphic studies, lithologic contrasts are often acknowledged as important, but are otherwise ignored in attempts to determine tectonic forcing or climatic control. Tectonic inactivity and relatively little spatial variability in climate make the Guadalupe Mountains of Texas and New Mexico an ideal site to investigate the effects of lithology on topography. To determine the effects of lithology, we compared topographic metrics including topographic relief, slope and channel steepness index in different mapped lithologic units across the region. Steepness indices were calculated for approximately 1,050 channels in the Guadalupe Mountains and surrounding area using elevation data extracted from USGS 10m Digital Elevation Models. Individual steepness indices were fitted for distinctive segments along each longitudinal stream profile in order to capture the variability as streams cross potential lithologic contacts. These indices were then grouped per 23 discrete lithologic units, including abundant limestone and dolomite with some evaporites, sandstone, and shale.

We first compared the datasets using the Kruskal-Wallis method for hypothesis testing and found that significant differences exist between the lithologic groups, suggesting potential correlation among channel steepness and lithology. To better evaluate the different rock units, we used published unit descriptions to develop a simple and a semi-quantitative ranking of relative rock erodibility. This ranking system assumes units with evaporates are softer and units limestone and dolomite are harder, with other units, including sandstone and shale in between. This ranking system also accounts for other factors such as relative bed thicknesses, as well as spatial heterogeneity and variety of rock type within a given unit. These objective ranks were correlated with average steepness indices for each of the 23 lithologic units, giving an R^2 value of approximately 0.44, suggesting that steepness provides some predictive ability in determining rock properties. Finally, we show that some of the variability in the relation between steepness and relative erodibility can be explained by effects of stratigraphic order.

Keywords: Geomorphology, Channel Steepness, Lithology, Digital Elevation Model, Topographic Relief, Rock Erodibility

The Role of Long Term Ecological Research in Understanding Dynamic Geomorphological Systems: Insights from Mountain Environments and Highland Watersheds

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This theoretical paper explores the new concept of integrating research on geomorphological processes and landscape ecology in order to understand dynamic and large geomorphic systems. Ever since the seminal work of Chorley (1962) that analyzed the essentially multivariate nature of geomorphic processes, whole landscape assemblages, heterogeneity, and evolutionary patterns; the idea of open systems is considered important in geomorphology. This approach was later fine- tuned by Thornes and Ferguson (1981: ‘systems of complex disorder’ approach) and Odoni and Lane (2011). A key ongoing debate within this paradigm is: whether concepts of ‘equilibrium’ and ‘equilibrium states’ as descriptors of geomorphic systems are inadequate and should be replaced with the concept of ‘systems in perpetual flux’ (Gregory and Lewin 2014). Another important question is on ‘universality’ versus ‘uniqueness’ of such system properties, with von Elverfeldt (2012) noting that such complex geomorphic systems could be ‘self-referential’. This paper invokes processes in mountain environments and highland watersheds—disturbance regimes in hillslopes, sediment transport in rivers, differential erosion and interplay with biotic and abiotic agents—to illustrate key points of this ongoing debate. Back in the 1970s, it was already asserted that reductive logic would fail to provide meaningful understanding of very complex systems due to the property of ‘synergy’ (Monod 1970). As for equilibrium in large geomorphic systems; Scheidegger (1983) contended with his ‘instability principle’, based on the study on the development of cirques, that the ‘equilibrium’ of geomorphic systems is inherently unstable. Those ideas resonate well with recent research on ‘emergence’ in landscape ecology; where it has been contended that Long Term Ecological Research (LTER) based on monitoring and accounting for change in a landscape over time is fundamental to understand complex system pathways, emergence, and resilience. 'Forward and backward loops' whereby the landscape undergoes periodic energy-buildup, storage, release, and reorganization phases (natural disturbance regime) is another key concept that has emerged from landscape ecological research. Recently, the sub-discipline ‘Biogeomorphology’ (Stallins 1996) has emerged to put the idea of the ‘landscape’ (with its often-chaotic patchwork of sub-components) as a fundamental unit for geomorphic system analysis; with empahsis on the key role of ‘ecological memory’ (i.e. how a set of abiotic and biotic factors is engaged in complex, at times recursive feedback between components) in describing processes. Through his 4R (Response, Resistance, Resilience, Recursion) concept, Philips (2011) has described how geomorphic systems co-evolve with climate, soil, ecosystems and other drivers. In mountain environments and highly active (dynamic) watersheds, abrupt threshold change has been noted for sediment transport and channel formation processes. Eaton et al. (2010) have observed that change- thresholds could be fundamentally ‘fuzzy’ and ‘overlapping’; posing yet more challenge for predictive science. While such developments could appear as erosive for the authority of geomorphology as a descriptor of land-formation, in reality they offer an exciting new vista for geomorphological research. Especially for highland watersheds, river geomorphologists’ long-standing preference for ‘stability’ (under which any change is an ‘anomaly’ and must be ‘normalized’) is increasingly untenable, in the light of recent advances in the understanding of active channel formation and mountain-river-plains interactions. By drawing on the seminal work of Stirling (2010) this paper proposes that understanding large and complex geomorphic

systems (or processes) need to switch to ‘recursive understanding’, and possibly abandon ‘predictive understanding’ which has functioned as a longstanding goal for geomorphologists.

Keywords: Dynamic and large geomorphic systems, Geomorphic processes, Equilibrium vs. Flux, Disturbance regimes, Highland watershed , LTER

