

Stochasticity controls and the central role of “internal variability” in soil erosion system

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Accurate prediction of soil loss rates remains a problem because erosion exhibits a non-unique behavior given the same rainfall/runoff forcing. The effects and causes of uncertainties in soil surface erodibility resulting in such a behavior have not been fully addressed from a mechanistic perspective in previous research. We use a large database of empirical data on soil loss and a comprehensive physical model of runoff –overland flow –erosion –transport processes that dynamically updates the mass and composition of soil substrate at the hydrologic-event scale to address reasons of unpredictability in soil erosion. We explain the role of micro-scale erodibility (referred to here as ‘geomorphic internal variability’) on geomorphic response, which acts as an intermediary between larger-scale forcings and soil loss response. Accounting for a possible range of internal variability illustrates the high sensitivity of erosion response to initial conditions of soil bed, resulting in extremely large uncertainties in short-term predictions. Furthermore, the reduction of geomorphic response variability at larger temporal scales is primarily attributed to a ‘compensation effect’ : temporal alternation of events that exhibit either ‘source-limited’ or ‘transport-limited’ regimes. We relate this reduction to a novel stochasticity index that reflects the degree of variability of intra- and inter-event hydrometeorologic conditions. A higher stochasticity index implies a larger reduction of soil loss variability (higher predictability) at the aggregated temporal scales with respect to the mean hydrologic forcing.

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Keywords: Soil erosion, Geomorphic Internal Variability, Geomorphic External Variability, Stochasticity index, Soil erosion variability

Mediation of sediment dynamic processes by vegetation within a rapidly developing saltmarsh

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Nowadays, the rapid reduction of coastal saltmarshes has become a worldwide problem and the practical needs of restoration and creation require the understandings of the basic physical mechanisms controlling the development of saltmarshes. The pioneer zone has been widely recognized to be the key of saltmarsh development. Generally, the pioneer zone is occupied by pioneer species in the form of dynamic patches or tussocks. The positive and negative feedbacks among vegetation, sediment dynamics and morphology determine the pattern and the rate of saltmarsh development, as a representative case for biomorphodynamic study.

In order to examine the processes and relevant mechanisms affecting the development of saltmarsh pioneer zones, observations over a timescale from vegetation patches to fully developed saltmarsh are in need. The Andong Shoal, located at the turbidity maximum zone of Hangzhou Bay, is a typical area of high sediment supply in the world. The saltmarshes, mainly covered by *Scirpus mariqueter*, are developing at a high rate and thus, it is possible to observe the development of saltmarsh pioneer zone within a relatively short period. Our study attempts to understand the feedbacks between vegetation and morphodynamics from vegetation patches to a fully developed saltmarsh in the pioneer zone of the Andong Shoal saltmarsh. *In situ* observations of sediment dynamics were carried out in two seasons, comparing the bare mudflat, the vegetation patch and the gap between two patches. Meanwhile, *in situ* biological investigations and geomorphological surveys were undertaken.

The preliminary results revealed that: 1) the tidal flat of the Andong Shoal received a large amount of sediments, resulting in a vertical accretion rate up to 50 cm a⁻¹; 2) due to the high sedimentation rate, the patches could convert into a fully developed saltmarsh at a seasonal scale; 3) the geomorphological surveys indicated that both vegetation patches and the gaps between them were depositional; 4) in the pioneer zone, the vegetation patches with diameters of several meters were able to reduce 36% of the flow speed in comparison with the adjacent bare mudflat, whilst the gaps between patches accelerated the flow speed to 157%, as such, a positive feedback occurred within the patches but the negative feedback within the gaps was suppressed by a high sediment input; 5) when the vegetation patches merged together to form a fully developed saltmarsh, the vegetation reduced 65% of flow speed in comparison the previous bare mudflat; and 6) the mean suspended sediment concentration increased after the patches merged together, and this pattern implied that the presence of vegetation patches was likely to be a more efficient sediment trap than the fully developed saltmarsh, in order to accelerate the vertical accretion which was crucial for the saltmarsh establishment.

Keywords: Saltmarsh, Vegetation patch, Sediment dynamics, Geomorphology, high sediment supply

Valley of the Gobi Lakesの上流に位置する、Olgoi盆地の古湖沼と流入河川 の古水理に関する考察

Consideration of paleolake and paleo-inflow in Olgoi basin, upstream of Valley of the Gobi Lakes, Mongolia.

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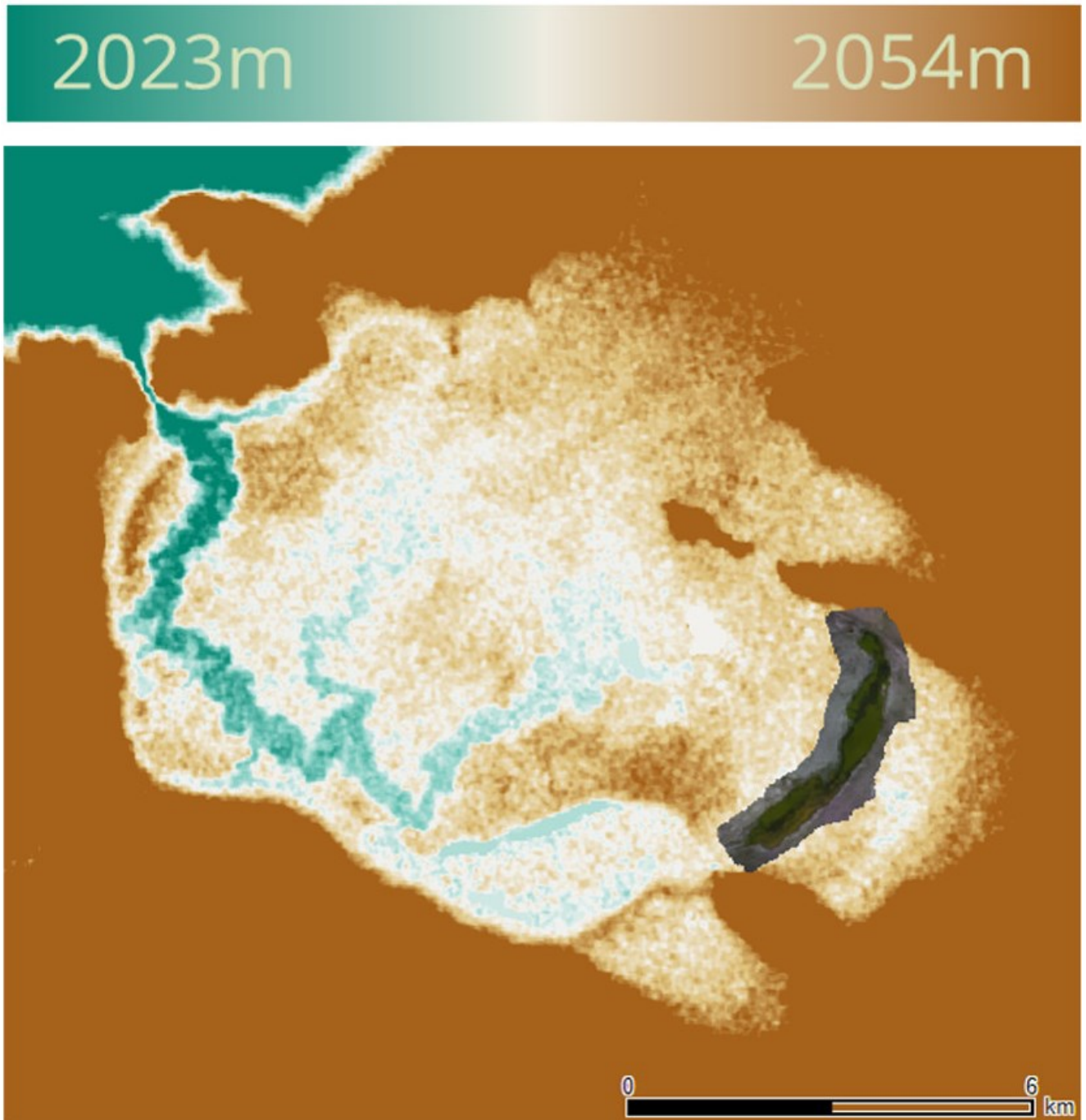
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Valley of the Gobi Lakes is between north Khangai Mountains and south Altai mountains in Bayankhongor Province, Mongolia. There are several closed lakes such as Böön Tsagaan Lake, Tsagaan Lake and Orog Lake in the valley. Previous geological studies indicated that there was once a large lake, but the geological history of this area has been still unclear. This study focuses on the basin including present Olgoi Lake upstream of Böön Tsagaan Lake flows. We found paleo shorelines in the east of the basin through a satellite image, and reconstructed Olgoi Paleolake, which was 70 times larger and 15 m deeper than present Olgoi Lake. We also numerically simulated the paleo-inflow with criteria regarding the shear stress necessary to transport the gravels measured in the field research. The calculation suggested two orders of magnitude larger discharge than the bankful discharge in the modern period estimated based on the present topography. Although this flow does not seem to occur under present precipitation there, this region should have experienced much wetter environment in the past whether the stream was caused by precipitation or melting of snow and/or glaciers.

キーワード：ゴビの湖の谷、オルゴイ湖、古水理、写真測量、洪水解析、地理情報システム

Keywords: Valley of the Gobi Lakes, Olgoi Lake, Paleo hydrology, Photogrammetry, Fluid analysis, GIS



ウズベキスタン南西部，スルハンダリヤ地域の地形分類

Land classification in Surkhandarya region, southeastern Uzbekistan

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In the Surkhandarya river basin, southeastern Uzbekistan, there are many Buddhism temple excavations which were established after 1st century. The aim of this study is to clarify the distribution landforms and geomorphic environment in this area as a part of excavation of the Kara-Tepe Buddhism temple, which is one of the most important temples between 1st century and 3rd century.

The land classification map was created by interpretation of counter maps derived by Alos-2 data and satellite images of Google earth. Field surveys were also performed in September 2016 in southern part of the Surkhandarya valley.

The region consists of major five topographic regions: high mountain range, frontal mountain range, Surkhandarya valley floor, central hill, Amdarya river floodplain. The high mountain ranges are including the Hisor mountain range, which is the west extension of the Pamir, the Bobotag mountain range and Kohitangdog mountain range, whose elevation are up to about 4700m. The frontal mountain ranges are located on the front of the high mountain ranges facing the eastern and western fringe of the Surkhandarya valley. They consist of several rows of ranges whose elevation is up to about 1000m. The Surkhandarya valley floor is formed by the Surkhandarya River. That is consists of terraced flat surfaces, alluvial fans formed by tributaries flowing down through the frontal ranges, which includes dissected alluvial fans, the Surkhandarya flood plain. Although terraced flat surfaces are extended, the floodplain along the Surkhandarya is narrow. The central hill divides the terraced flat surface of the Surkhandarya valley. The hill is raised a couple of hundred meters from the terraces flat surface of the Surkhandarya valley and have five levels of backs. The Amdarya river floodplain is several tens of kilometers wide and eroding the lower ends of terraced flat surface of the Surkhandarya valley creating the boundary between Uzbekistan and Afganistan.

After formation of the Surkhandarya valley floor the central part of the valley floor and frontal zone of the high mountain ranges began to be uplifted and formed the central hill and frontal mountain ranges.

キーワード：地形分類、河成プロセス、隆起、スルハンダリヤ川、アムダリヤ川、ウズベキスタン

Keywords: land classification, fluvial process, uplift, Surkhandarya River, Amdarya River, Uzbekistan

Designing evacuation drills using GIS-based disaster prevention maps of cultural properties for Hanno City, Saitama Prefecture

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Serious disasters such as the Great East Japan Earthquake of 2011 and the Kinugawa floods of 2015 have highlighted the need for contingency plans to evacuate and rescue important cultural properties. Firstly, it is necessary to identify where and what types of Cultural Properties exist, and then, to know how to evacuate them from disasters. This study aims to identify the risk of damage to cultural properties and design appropriate means to evacuate them during landslide emergencies. Here, we focus on landslide disaster hazard mapping in Hanno City, Saitama prefecture using GIS. Potential landslide risk zones were identified using data provided by the National Land Numerical Information. Nine categories of Cultural Properties, including buildings and natural monuments etc., were mapped using GIS. Three regions: the Hanno City area, Agano area, East Agano area, were chosen for detailed investigation.

キーワード：文化財、防災マップ、飯能市、地理情報システム

Keywords: cultural property, disaster prevention map, Hanno city, GIS

三陸海岸中・南部の津波常襲地域における地形特性・集落立地の再評価 Geomorphic Characteristics and Settlement Location along the Tsunami-hazardous mid-Sanriku Coast in Northeastern Japan

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三陸海岸の中・南部では、高位海成段丘が広い北部（宮古付近以北）とは対照的に、湾岸に小さな段丘状地形が点在するとされてきた。しかし、現実には段丘堆積物や旧汀線を確認できないものが多く、とくに花崗岩類から成る地域では、むしろ山麓緩斜面的な形状を示すところが少なくない。船越半島とその周辺山麓緩斜面を調査し、次のようなことが判明した。(1) 縦断勾配3~15度の緩斜面が、海拔70~90m付近で背後の急斜面から画然と区別される。なだらかな尾根状を呈する高位緩斜面と、その間から前面にかけて広がる、あまり開析されていない谷状の低位緩斜面とに分けられ、前者はさらに細分可能とみられる。(2) 高位緩斜面の地表下には、ほとんどの場合赤色土を発達させた深層風化花崗岩があり、風化角礫を含む層も一部に認められるのに対して、低位緩斜面は比較的新鮮な花崗岩角礫を主とする厚さ数m以下の堆積物で構成され、その基底は赤色風化断面を切っている。背後山地から続く開析谷の一部は土石流危険渓流に指定されている。(3) 低位面は、前面を完新世の海食崖に切られていることが多いが、延長が沖積層下底面に連続しているとみることができる。一方、上流山地内へは、多少開析された皿状の谷底面に連なる。これらの事実から、第四紀後期における山麓緩斜面の発達過程を論じることができる。

一方、このような位置、形態、構成物質の特徴をもつ地形には、半農半漁の集落が立地し、度々津波に襲われてきた。この地域の地形を「住民の目線」から捉えると次のようになる。1. 海食崖：農地や居住地を作りにくい上に、汀線へのアクセスも悪い。2. 河成・海成平野：三陸海岸の中では広く低平な土地が広がっており、海岸へのアクセスも良く、農地も作りやすい。反面、最も津波の被害を受けやすい地形で、津波来襲時には長い距離を移動しないと安全な場所まで到達できない。3. 山麓緩斜面：海成・河成平野と接しており、傾斜が緩く、表層物質はマサ土で時に角礫が混じる程度なので、人力による若干の地形改変で畑地や居住地を作り、維持することができる。その一部には古くから集落が立地し、また津波来襲時の避難先や被災後の集落の移転先として利用されてきた。

たとえば山田湾東岸の大浦では、明治以前から海に接した山麓緩斜面に小さな段を作って集落が立地し、一段上の宅地との間には道路とは別に階段が設けられていた所もある。船越湾北岸の地峡部の低地にあった船越は、明治津波で大きく被災した後、西側の山麓緩斜面に計画的な集落を作って全面的に移転した。同じく明治津波でほとんど壊滅した田の浜では、集落のあった船越湾岸小低地の背後に山麓緩斜面を一部改変して集落用地を造成しながら、ほとんど農地としてしか用いず、昭和津波の被災後ようやくそこを拡張して移転しながら、低地にも再び家屋が増え、チリ地震津波でも今回の津波でも被災した。

上にその一端を紹介した集落の立地・移転の歴史は、住民が、非日常的災害と日常生活・生業およびその時代的变化との関係で、地形のある側面を評価し、利用してきた結果である。その「住民の目線」に立った行動を、地形形成過程も含む「地形学の知見」に照らして再整理しておくことは、地形認識論、地形資源論、そして次の災害に備えた防災・減災論の展開に役立つであろう。

キーワード：山麓緩斜面、津波、人間活動

Keywords: piedmont gentle slopes, tsunami, human activity

The Experiment of Alluvial Fan Evolution Induced by Debris-Flow Tributary

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Rainfall events with high intensity cause many landslides, slope avalanches and debris flows in Taiwan. As a debris flow flows from a tributary to mainstream, an alluvial fan usually forms at the confluence. Villages and infrastructures adjacent to these alluvial fans are in high risk. The more understanding of the morphological processes of alluvial fans need to be explored for the disaster prevention.

A simplified laboratory experiment is conducted in this study to simulate the morphological process of alluvial fans formed by debris flows at the confluence. The tributary is set to be perpendicular to the mainstream with mobile bed. In fixed volume of debris flow, sediment concentration of debris flow is modified by the different water volume. In mainstream, discharge is altered in distinct amount to erode the accumulation of the debris flow at confluence. By using Particle Tracking Velocimetry (PTV) method, velocities of mainstream and tributary are measured. The impact of flows velocities at confluence can be observed to analyze.

During the process of deposition, the real-time morphological change is recorded by using images analysis. Cameras from different angles of views are used to monitor process. The Digital Terrain Model (DTM) is built to observe morphology elevation evolution through time by Digital Photogrammetry. The results show that experiments might reach a dynamic equilibrium elevation in late stage from an initial stage of elevation growth.

傾動隆起下での段丘形成の実験

Laboratory experiment of river terraces formation under tilting uplift

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河成段丘は過去の河床を記録しており、離水年代を示す。このことから、段丘から直接的に侵食速度を定量化することができる。段丘の形成は複雑で、一度の変動に対して複数の段丘が形成し、急激な変化がない一定の海水準の低下でも段丘が形成されることが確認されていることから、段丘から単純に古地形を再現することが難しく、精度よく再現する方法が確立されていない。

本研究では、時間経過の観察が可能なモデル実験を行い、一定の山側傾動隆起に対する段丘形成のタイミング、河川と段丘の縦断形、流路位置、段丘の高さと長さの時間変化、について調べることを目的としている。

水槽に標準砂とカオリナイトの量比を10.5:1で混合した砂を初期斜面1°で水槽に敷き詰め、スプリンクラーで霧状の雨を降らせることによって地形を発達させていくモデル実験を行った。河口側に設けた傾動モーターを用いて、河口をゆっくりと下げることによって相対的な山側傾動隆起を再現している。はじめの40分間は地形を発達させるために隆起をさせずに雨を降らせた。その後の試行は隆起をさせながら、雨を20分間降らせ、その後の地形をカメラで撮影する作業を繰り返し行った。写真測量から1mmメッシュDEMを作成した。

ある一つの流路に沿って8個の段丘(T1-T8)を観察することができた。河川と段丘の縦断形を作成すると、段丘は形成後隆起の影響を受けて勾配が時間経過で急になり、段丘縦断形は河川縦断形の下流に向かって収束して、先行研究の数値モデルと矛盾がない。河川の側方方向の移動変化が大きく、特に河川の下刻速度が高いときに段丘が形成されている。また、段丘の長さは河川の側方方向の移動が小さくなり、段丘と河床との高低差が短時間に大きくなるとその長さは変わらなくなる。段丘は形成後に短くなるばかりでなく、下流側にのびることがある。段丘面はすべてが同時面でないことがありうる。

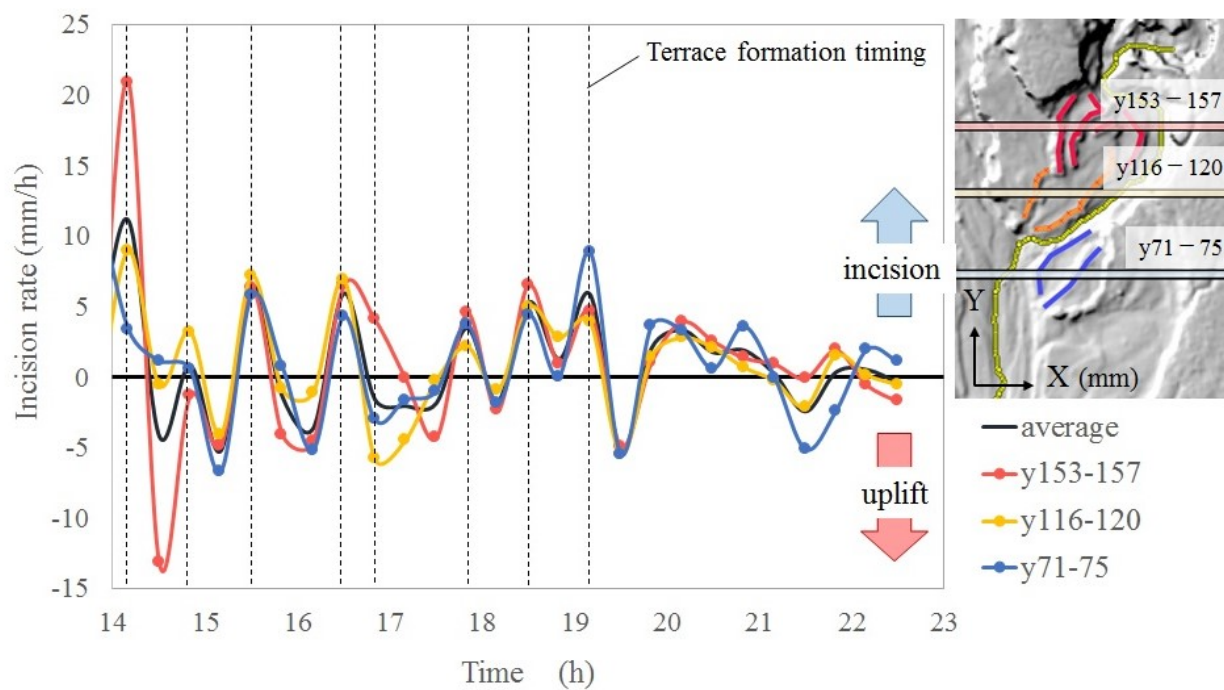
隆起だけでなく、河川の側方方向の移動や下刻速度が段丘形成、形成後の存在の仕方に影響していると考えられる。一定の傾動隆起下の実験で、下刻側刻が自発的に振動していることが数値的に確かめられた。

先行研究で示されている蛇行切断による内因的段丘形成以外に、河川の自発的な侵食速度の振動でも段丘が形成されうることが示唆されている。河床変動は氷期間氷期の土砂生産が原因であるとしている先行研究があるが、気候的外力がなくとも河床が変動しうることをこの実験から示唆できる。

キーワード：段丘、形成

Keywords: terrace, formation

Incision rate measured during 20 min terms



Geometry and dynamics of braided channels and bars under experimental density currents

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Submarine channels convey turbidity currents, whose deposits are key hydrocarbon reservoirs and indirect records of continental denudation. Submarine channel patterns resemble those of their subaerial counterparts, but controls on the form and dynamics of submarine channels and associated deposits remain comparatively uncertain. Existing laboratory experiments show that braided channels can develop under similarly high flow width-to-depth ratios for both subaerial and submarine conditions. We conducted a new set of experiments with net-depositional density currents to (1) further test the conditions for channel formation; (2) test the response of channel and bar geometry to changes in the ratio of water-to-sediment flux, inlet conditions, and submarine versus subaerial conditions; and (3) quantify the relative timescales of channel lateral migration, abandonment, and aggradation. We generated density currents within a freshwater basin using saline inflows that transported plastic sediment as bedload across a platform 2 m long and 1 m wide. We find that across a 2.7-fold range in the ratio of water-to-sediment flux, submarine braided channels consistently develop, are more pronounced upstream, and can transition to zones of sheet flow downstream. We measured topographic statistics directly, and using a reduced-complexity flow model. The topographic analysis showed that braiding index is higher for subaerial than for submarine conditions with other variables fixed. For a representative submarine experiment, channel lateral motion decorrelated in double the time to move laterally one channel width, and one-third the time to aggrade one channel depth. We propose a new stratigraphic model for submarine braided channels, wherein sand bodies are more laterally connected and less vertically persistent compared to those formed by submarine meandering channels. These results suggest that channel pattern is a key variable for predicting stratigraphic architecture in submarine environments.

Keywords: Geomorphology, Sedimentology, Submarine channels, Braided rivers, Turbidity currents