論 文 の 内 容 の 要 旨

論文題目　Morphometric analysis of drainage basins in the Western Arabian Peninsula in relation to geomorphic processes and lithologic control

（アラビア半島西部の流域地形の計測と解析－地形プロセスと岩質との関連）

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The Arabian Peninsula has a very long geological history, extending back to the Precambrian. The Tertiary Red Sea-Gulf of the Suez rift system is a prime example of active continental rifting and breakup. The uplift of the western margin of the Arabian Plate and the opening of the Red Sea led to the formation of well-developed mountain escarpments with the highest elevations over 3000 m. The resultant escarpments have been subjected to natural processes to form steep drainage systems in the Western Arabian Peninsula. Although the Peninsula has been studied from a geological perspective in relation to oil production, plate tectonics and eolian systems such as sand dunes, the steep mountainous drainage basins have received much less attention. The geomorphological studies exist regarding the Western Arabian Peninsula have mostly been carried out by petroleum geologists whose main interest is not geomorphology itself. Fluvial processes and landscape development there are poorly understood, in spite of some practical hydrological studies related to water availability. Considering the lack of comprehensive geomorphological research on the steep drainage basins in the mountainous terrain of the Western Arabian Peninsula, this study aims morphological quantification and comparisons of 36 drainage basins and their 1046 sub-basins.

A total of 21 morphometric parameters were extracted from the ASTER GDEM using geographic information systems (GIS) and multivariate statistical analyses were conducted to classify the basins and discuss the potential factors affecting drainage-basin form and development. Principal component analysis (PCA) and hierarchical cluster analysis (CA) were used to identify the variance distinguishing the morphometric parameters. Three major principal components (PC1 to PC3) were found to explain 73% of total variance. PC1 strongly reflects basin dimensions and drainage texture; their positive correlations indicate enhanced erosion in large basins as well as limited stream incision in small basins under an arid climate. PC2 mainly reflects the effect of bedrock geology, suggesting that volcanic rocks tend to produce more elongated and less eroded immature basins than crystalline rocks. PC3 mainly reflects the basin relief, slope and the length of each stream segment which may indicate the effect of mass wasting on stream development.

The erosional processes and depositional environment in the study area are analyzed from the alluvial fans at the mouth of the drainage basins. The commonly used power law expressions for the fan area–basin area relation and the fan slope–basin area relation were applied to examine the area and slope of alluvial fans and source areas. The analysis shows the size of the alluvial fans tends to be large but it corresponds well to their large source basins. The fan slope is steep and variable, reflecting that fans formed in the arid climate is less organized than those in humid regions.

This study as also evaluated the spatial controls on basin hypsometry by assessing factors that might influence the distribution of hypsometric integrals (*HI*). From the main basins defined, three sets of sub-basins were derived for each Strahler order ranging from 4 to 6. Then *HI* versus distance were plotted for each basin order for further analysis. Results reveal that basin hypsometry is independent of spatial variation and spatial scale. Furthermore, *HI* and hypsometric curves were analysed in terms of lithologic control on landforms. The result suggests that basin hypsometry is sensitive to lithological variation in the study area. At the largest scale, the *HI* values can be divided into two populations. More evenly distributed erosion in crystalline rocks and relatively uneven erosion in volcanic rocks are suggested from the results.

Longitudinal river profiles for the main channels of the 36 major basins were extracted from the DEM and the steepness and concavity indices were plotted using MathWorks Matlab codes. High steepness and low concavity in volcanic rocks and a

reverse trend in crystalline rocks confirms the observation from the results of basin hypsometric analysis. For the first time in this region, knickzone analysis was conducted by using changing rate of river gradient at different scales; a total stream length of 5121 km was analysed and 325 knickzones were identified and interpreted. Knickzone frequency and knickzone density vary according to bedrock types. The effect of faults on knickzone abundance found weaker in relation to. The investigation suggests a coupled climatic and bedrock control for the origin of knickzones.