Transitional relation exploration for typical loess geomorphologic types based on slope spectrum

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Abstract — **This research aims to explore the transitional relationships for typical loess geomorphologic types and their sub-types based on slope spectrum. Using the Chinese Geomorphologic Database at 1:1,000,000 scales, the distribution of the typical geomorphologic types, such as loess tableland, loess ridge, loess hill and their sub-types (such as loess terrace, complete tableland, residual tableland, beam tableland, oblique ridge and mao ridge) is acquired; then, based on SRTM (shuttle radar topography mission)-DEM data and topographic analysis methods, the slope spectrums are computed for the loess typical geomorphologic types; through analyzing the slope spectrum characteristics of the loess typical geomorphologic types, the transitional relationships are explored: (1) the loess tableland transits to the loess ridge, and then transits to the loess hill; (2) the transitional order among the subtypes of the typical geomorphologic types is: from loess terrace to complete tableland, to residual tableland, then to beam tableland, to oblique ridge, and then to mao ridge and finally to loess hill.**

INTRODUCTION

Slope spectrum, as a microscopic terrain index, can reveal the macro-geomorphologic features, which makes it a valuable topographic index in geomorphologic research [1]. Loess Plateau of China attracts world attention in geographic research because of its unique geomorphologic features. The slope spectrum index is applied in studying the loess geomorphology in many previous researches [2].

In previous researches, the loess geomorphology can be classified by using slope spectrum index. So the slope spectrum is an important topographic index in representing the characteristics of the loess geomorphologic types.

The achievement of the Chinese Geomorphologic Database (CGD) at 1:1,000,000 scales provides the distribution of the loess geomorphologic types; as to the slope spectrum index, it can be computed based on the digital elevation model (DEM) data, which is shuttle radar topography mission (SRTM) data in this research.

Hence, this research aims to analyze the characteristics of the slope spectrums of the typical loess geomorphologic types using CGD and SRTM-DEM data, and then explore the transitional relationships among the types and their sub-types based on the slope characteristics changing rules.

STUDY AREA AND DATA SOURCES

Study area

This research selects the Loess Plateau of China as the study area, and the transitional relationships among the typical loess geomorphology types and their subtypes are explored.

Located in the upper and middle reaches of Yellow River, Loess Plateau is in the west side of Taihang Mountain, the east side of Qinghai-Tibet Plateau, the north side of Qinling Mountain and the south side of Mongolia Plateau. Loess Plateau is one of the four largest plateaus in China, which distributes the widest and deepest loess in the world, so as to form the most typical loess geomorphology. Loess geomorphology has close relation with soil erosion, which is the one of the most serious problems for ecological and environmental safety in the Loess Plateau. So the research to the loess geomorphology has both scientific significance and economic importance.

Data sources

The main data sources used in this research are the CGD at 1:1,000,000 scales and the SRTM-DEM data.

The CGD data at 1:1,000,000 scales was achieved by using remote sensing visual interpretation and geographic information system methods from multi-source data, such as remote sensing images, SRTM3-DEM data, published geomorphologic maps, geologic data, and geographic base data and so on [3]. This data is the source data to compile the 1:1,000,000 set of geomorphologic atlas of China [4] and can be divided into seven layers: relief and altitude, genesis, sub-genesis, morphology, micro-morphology, slope and aspect, material and lithology [5]. In this research, the fourth layer — morphology and the fifth layer — micro-morphology are used to acquire the distribution of the typical loess geomorphologic types and their sub-types.

The SRTM-DEM data is the SRTM3-DEM data, which has 3″ spatial resolution (SRTM3) and is processed by the Consortium for Spatial Information of the Consultative Group for International Agricultural Research. It can provide continuous elevation surface information and wide coverage (60ºN–56ºS), so it has been used in many research fields. In this research, the SRTM3-DEM data is the 4th version data, and it is used to compute the slope spectrums for the typical loess geomorphologic types and their subtypes.

METHODOLOGY

Acquisition of the distribution of the typical loess geomorphologic types and their subtypes

The typical loess geomorphology types are loess tableland, loess ridge and loess hill. According to the CGD data, the distribution of the typical loess geomorphologic types is acquired. The areas of the three types are 6.52 × 10^4 km^2, 9.12× 10^4 km^2 and 1.91× 10^4 km^2.

The transitional rule among typical loess geomorphologic types is widely acknowledged as: from loess tableland to loess ridge and finally to loess hill [6]. Hence, in this research, the transitional rules of the subtypes of typical loess geomorphology are paid more attention.

Considering the distribution areas and situations of the typical loess geomorphology types, the loess tableland is divided into four subtypes: loess terrace, complete tableland, residual tableland and beam tableland; the loess ridge is divided into oblique ridge and mao ridge; and the loess hill is not divided further. From the CDG data, the distribution of the subtypes of the typical loess geomorphology can be acquired and shown in Figure 1.

Figure 1 shows the distribution of the typical loess geomorphology: loess table mainly distributes in the northern part of Xi'an City and eastern part of the Lanzhou City; besides, there exist spares distribution around Taiyuan City. Loess ridge has the greatest area, which mainly distributes in the eastern part of Lanzhou City and western part of Taiyuan City. Loess hill has the least area, which distributes in the western part of Taiyuan City, the northern part of Xi'an City, and around the Lanzhou City.

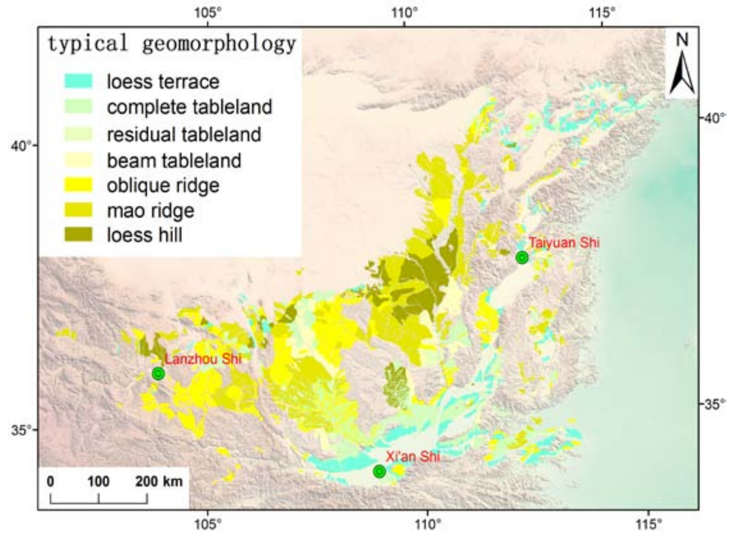


Figure 1. Typical loess geomorphology distribution in the Loess Plateau

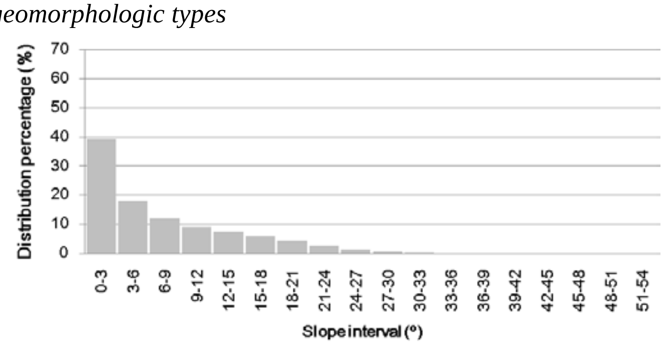
The acquisition of the distribution of the typical loess geomorphology provides the chance to compute the slope spectrum index for every type.

Slope spectrum computation for the typical loess geomorphologic types and their subtypes

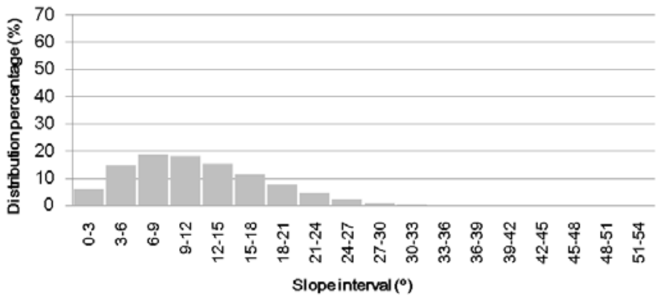
Based on SRTM3-DEM data and topographic analysis method, the slope is computed for the whole Loess Plateau; then, the slope is classified with the interval of 3°; overlapped with the classified slope data and the distribution data of typical loess geomorphologic types, the slope distribution status are acquired for all the types; through numerical statistics, the slope spectrum index is achieved for every type.

RESULTS

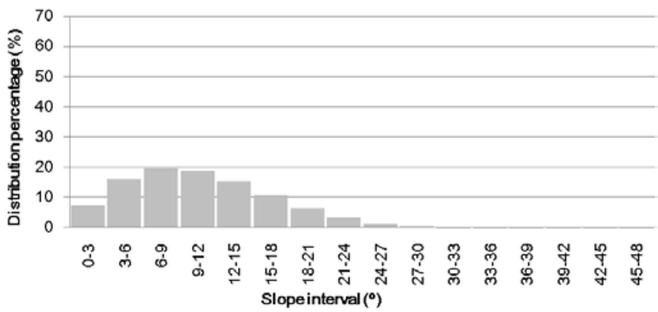
The slope spectrum analysis for the typical loess geomorphologic types



(a) loess tableland



(b) loess ridge



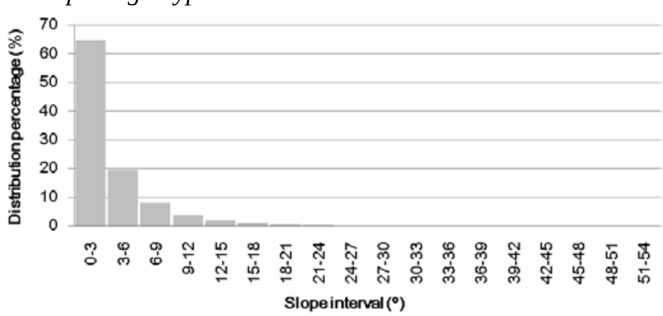
(c) loess hill

Figure 2. Slope spectrum of the typical loess geomorphologic types

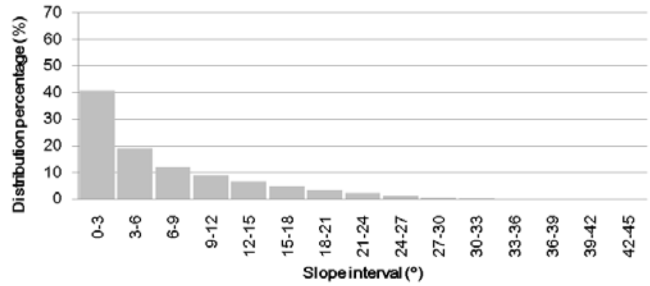
Based on the distribution data of the typical loess geomorphologic types and the slope spectrum computation method, the slope spectrum indexes for the typical loess geomorphologic types are acquired as shown in Figure 2:

Figure 2 shows: the slope spectrum index for the loess ridge is similar to that for the loess hill; the loess ridge is a little steeper than loess hill. As to the loess table, it is much more flatter than other two types. So it has distinct slope spectrum characteristics compared to it for other two typical geomorphologic types.

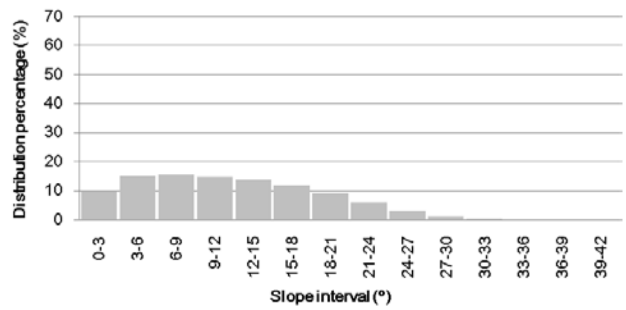
The slope spectrum analysis for the subtypes of typical loess geomorphologic types



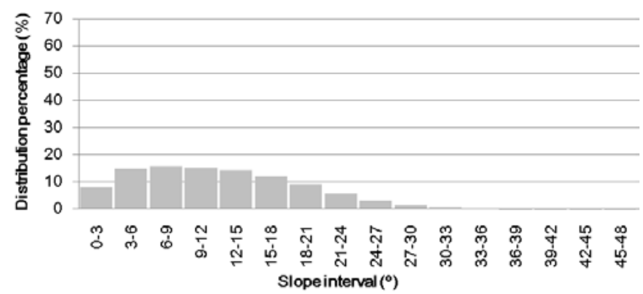
(a) loess terrace



(b) complete tableland



(c) residual tableland



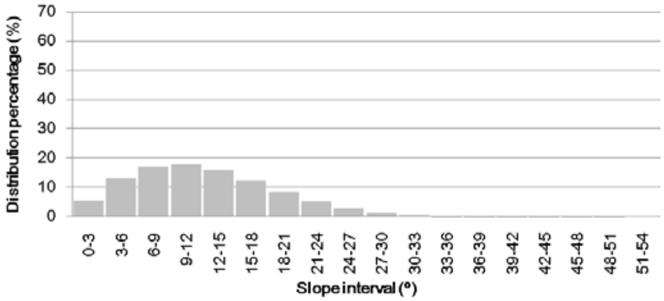
(d) beam tableland

Figure 3. Slope spectrum for the subtypes of the loess tableand

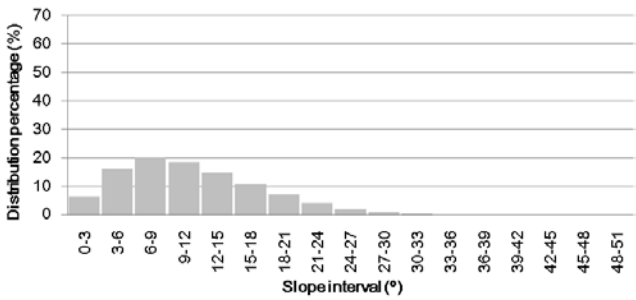
The slope spectrum for the subtypes of the loess tableland is computed as shown in Figure 3:

Figure 3 shows: the loess tableland is divided into 4 subtypes: loess terrace, complete tableland, residual tableland and beam tableland. The loess terrace is the most flattest one; and then the complete tableland, which is similar to the loess tableland; the residual tableland and beam tableland are steep, the slope spectrums for which are similar to that for the loess ridge, especially for the beam tableland.

Figure 4 gives the slope spectrum distribution for the subtypes of the loess ridge. From Figure 4 we can see: the loess ridge is divided into 2 subtypes: oblique ridge and mao ridge; the slope spectrum characteristics for the two subtypes are similar; compared to oblique ridge, the slope for the mao ridge is more similar to that for the loess hill.



(a) oblique ridge



(b) mao ridge

Figure 4. Slope spectrum for the subtypes of the loess ridge

Transitional relationship exploration for the typical loess geomorphologic types

From the slope spectrum characteristics analysis for the typical loess geomorphologic types and their subtypes, the transitional relationship is achieved as shown in Figure 5:

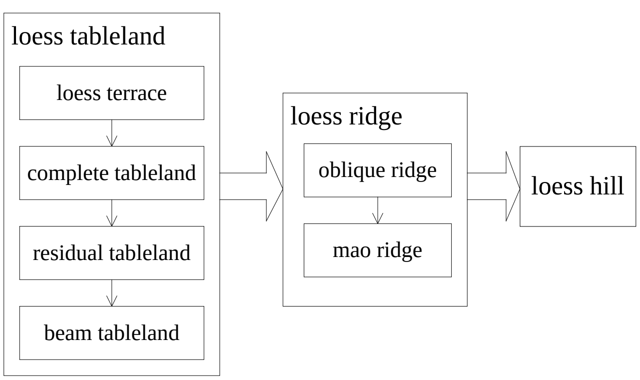


Figure 5. Transitional relationship among typical loess geomorphology

Figure 5 shows: for the loess tableland, the transitional order of the subtypes is: from loess terrace to complete tableland, to residual tableland and beam tableland; for the loess ridge, it is: from oblique to mao ridge; so the beam tableland is the closest subtype to the loess ridge, and the mao ridge is the closest subtype to the loess hill.

DISCUSSIONS

Innovations

This research explores the transitional relationships among the typical loess geomorphologic types and their sub-types based on the slope spectrum index, which gives a way to further study the loess geomorphology.

limitations

Slope spectrum is an important topographic index, but acquiring the transitional relationships only using the slope spectrum perhaps is not enough.

CONCLUSIONS

The transitional relationships among the typical loess geomorphologic types and their sub-types are achieved as the following: for the typical loess geomorphologic types, from loess tableland to loess ridge and finally to loess hill. For the subtypes of the loess tableland, from loess terrace to complete terrace, and then to the residual tableland and finally to beam tableland; as to the loess ridge, from oblique ridge to mao ridge.

ACKNOWLEDGMENT

This research was supported by the National Natural Science Foundation of China (41301469, 41171332) and the National Science Technology Basic Special Project (2011FY110400-2), the strategic plan project of science and technology of Institute of Geographic Sciences and Natural Resources Research (2012ZD009), the National Science Technology Support Plan Project (2012BAH28B01-03). We would like to express our gratitude to the editors and anonymous reviewers for processing our manuscript.

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