frontiers | Frontiers in Earth Science

EDITORIAL
published: 16 May 2022
doi: 10.3389/feart.2022.884610

Editorial: Multidisciplinary Loess Geohazard Investigations

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Keywords: loess, geohazards, multidisciplinary investigations, mitigations, China

Editorial on the Research Topic

Multidisciplinary Loess Geohazard Investigations

OPEN ACCESS

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Specialty section:
This article was submitted to Geohazards and Georisks, a section of the journal Frontiers in Earth Science

Received: *26 February 2022*
Accepted: *07 March 2022*
Published: *16 May 2022*

Citation:
Zhang F, Wang G, Allen MB and Xu Y (2022) Editorial: Multidisciplinary Loess Geohazard Investigations. Front. Earth Sci. 10:884610. doi: 10.3389/feart.2022.884610

INTRODUCTION

Loess geohazards are among the most catastrophic geological processes, causing severe casualties, serious economic losses, and massive eco-environment destructions. Because loess is a surficial loose deposit with exceptional water sensitivity and representative metastable structure, it is very prevalent to instability during wetting under loading. It has received particular attention to the loess behaviors and loess geohazards in the last few decades.

There are several research topics worth mentioning here. In 1988, a special issue titled "Loess geotechnology" was published in Engineering Geology (Lutenegger, 1988). In 2001, Derbyshire, (2001) gave a systematic summary of geological hazards in Chinese loess terrain. In 2018, Engineering Geology published another special issue titled "Loess engineering properties and loess geohazards" (Peng et al., 2018). Recently, loess geohazards research, for example, landslide, subsidence, and erosion, brought about a new focus on mega engineering projects in the Chinese Loess Plateau (CLP) (Li et al., 2014; Juang et al., 2019; Zhang et al., 2019; Hu et al., 2021). While the previous studies have improved the understanding of loess engineering properties and loess geohazards, they are inherently complex due to loess unique properites. So, further investigations will be needed to understand loess geohazards for hazard mitigation, especially with progress of climate changes and human activities.

This Research Topic aimed at widening the knowledges on the loess geohazards emphasizing interdisciplinary contributions. The issue currently includes 23 papers on the dynamic mechanism of loess geohazards, multi-scale analysis of loess mechanical behaviors, and new method of loess geohazards mitigation. The papers are from several fields across engineering geology, geotechnical engineering, geomorphology. All contributions to this Research Topic focus on one or more of the research areas highlighted above, evidenced below by reference to the designated areas' letters.

DYNAMICAL MECHANISM OF LOESS GEOHAZARDS

This thematic issue utilizes different techniques to investigate and analyze various types of loess geohazards, such as natural landslide, cave, and surficial erosion, and ground subsidence, check dam break, gully head incision related to the engineering projects. These contributions pay close attention to the evolution of the natural loess geohazards, aiming to understand their dynamical mechanisms and their relation with the engineering projects.

Concerning the natural loess geohazards, Ma et al. conducted flume tests aiming to understand the initiation mechanism of rainfall-triggered loess mudflows in the CLP. They found two global and local liquefaction failure models with the same retrogressive sliding close to the slope toe. Mao et al. used low-cost UAVs photogrammetry and terrestrial laser scanner (TLS) to produce the digital surface model (DSM) data for geomorphic change detection of the landslide. They provided also offered a novel perspective and technical scheme for evaluating unmanned aerial vehicle (UAV) data for geological hazard surveys. Geng et al. studied the interaction between animal burrowing and loess cave formation in the CLP by *in-situ* measurement and UAV image analysis. This field evidence shows that the formation and expansion of loess caves can dictate the distribution of active areas of biotic disturbance and that both biotic and abiotic processes exist in the distinct "topographic niches". Huang et al. analyzed the GNSS monitoring data using an adaptive sliding-window method, and the improved algorithm successfully extracte loess landslide deformation features on the Heifangtai, China. Chao et al. explained the failure mechanism of loss slope triggered by the Minxian-Zhangxian earthquake, and they speculated that this failure is cominbed effects ground water and ground shaking. Ma et al. reported piping-induced the break of the loess dam of a reservoir in the CLP. In addition, Lyu et al. performed a special focus on the landslide hazard that occurred in geoheritage.

In the loess geohazards arose from the engineering projects, through adopting a large-scale vibration table test, Deng et al. studied the seismic response of a water transmission pipeline across a fault zone. They observed that the dynamic responses are amplified significantly by the fault zone and the hanging wall and provided reasonable seismic design parameters for the detailed project. Zhu et al. used flume to mimic the failure models of the earthen check dam in the "Gully Land Consolidation" project. They found that water seepage triggered the progressive failure of the dam, leading to the slope slide and overtopping. Liu et al. evaluated the effectiveness of engineering measures in gully-head stabilization and loess-platform protection (GSLP) in the typical Dongzhiyuan area in the CLP.

MULTI-SCALE ANALYSIS OF LOESS MECHANICAL BEHAVIORS

This thematic section contains nine papers to the study of loess mechanical behaviors. They rely on experimental results with focus on the application in different loess geohazards and the analysis of well-constrained different loess strata.

Here the mechanical creep behaviors of the loess samples gained particular concerns. Li et al. studied the creep behavior of intact loess (Q_3) followed unloading paths experimentally, and proposed a modified Burgers model to compare the test data. Their results elucidate the possible mechanisms of the progressive failure of loess slopes due to excavation in high-fill projects. Liu et al. conducted the experimental study on the creep characteristics of saturated loess (Q_2), and used the Burgers model to mimic the experimental test data and *in-situ* monitoring deformation. They present two models of the brittle shear failure and progressive failure, which contribute to explaining the flow failure of the deep-buried loess tunnel along with the ground collapse above the tunnel.

The other seven papers discuss the effect of micro-and macro-structures on the shear and compression behaviors of the loess samples. Dong et al. studied the angle of repose of the loess (Q_3) using the fixed funnel methods. They analyze the different mechanisms in four kinds of microscopic contact structures and suggest speculating the formation process of the loess slope system. Zhu et al. developed an empirical shear model of the interface between the loess (Q_3) and red clay based on a series of modified direct shearing experiments. Their results suggest that the mechanical properties of the geological interface have a significant influence on the failure of loess landslides developed on the tertiary Hipparion red clay. Zhang et al. examined the compression behavior of undisturbed and compacted loess (Q_3) using a modified oedometer by controlling total suction and injected solutions. They illustrate that undisturbed loess has more slight changes in void ratio than compacted loess, which guides the mega land creation project in Lanzhou New Area. Gu et al. studied the effect of sulfate on the aggregation of clay particles in loess (Q_3), and analyzed the relation between microstructure and mechanical properties. Rong et al. and Guan et al. studied the tensile strength of loess (Q_2), stiff and soft rocks using five different test methods. They found that the inner hole fracturing and horizontal compression tests have distinct advantages. Liu et al. examined the effect of shear velocity and water content on residual strengths of slip zone taken from Middle Pleistocene loess (Q_2) using a drained ring shear apparatus, and compared the strength differences in the single-stage and multi-stage shear tests.

Almost all these contributions try to use microstructures to explain loess mechanical behaviors. There is no doubt that there is an inherent link between macroscopic properties and microscopic characteristics. Nevertheless, building this kind of quantitative relation is vital to the physical mechanism of loess mechanical behaviors.

STABILIZED METHODS OF LOESS GEOHAZARDS MITIGATION

The loess performance improved through various stabilization methods are the study subjects of the three papers, aiming to develop new strategies for different loess geohazards mitigation. Kong et al. analyzed the geotechnical and physicochemical changes in loess (Q_3) caused by nano-SiO_2 pile migration. These authors find that loess preformation improvement is a physical structure modification rather than chemical stabilization leading to an increase in collapse resistance. Zhang et al. developed a cross-linked polymer soil stabilizer for loess hillslope conservation on the CLP. The results from indoor tests and field practices show that the stabilizer effectively improves the stability of the loess slope and, consequently decreases soil erosion and vegetation growth. Wang et al. studied the mesoscopic characteristics and performance evaluation of loess (Q_3) treated by different improvement technologies. The results present that chemical additive (i.e., fly ash and cement) and compound improvement methods (dynamic compaction + chemical additive) are more efficient than physically dynamic compaction methods to eliminate the earthquake subsidence.

All three contributions also used the multi-scale viewpoint to analyze the changes in the mechanical properties and microstructures of those treated loess samples. Still, there is also lacking bridging multi-scale linkages. In addition, these suggested stabilized methods still need to be verified for more comprehensive practical application.

PERSPECTIVES

In conclusion, this Research Topic provided multidisciplinary loess geohazard Investigations, focusing on relevant geological engineering, geotechnical engineering, geomorphology. Emphasizing the research on the nature, state, behavior of loess could contribute to the future mitigation of the loess geohazards. Nevertheless, incredible challenges on the loess geohazard need more attention following the abrupt extreme weather and the mega engineering project. Then, the following aspects are provided as references for loess geohazard mitigation.

1) Bridging multi-scale analysis to better understand the progress mechanisms of the loess geohazards. Here, microscopic characteristics benefit to explain the physical mechanisms, while mesoscopic or/and macroscopic behaviors prefer to predict the dynamical processes.
2) Building multiple physical field observation systems of loess geohazards to accurately early warning and precisely real-time forecast. Here, the combination of mechanism-driven and data-driven models should be given further attention to local and regional case studies.
3) Seeking eco-friendly and cost-effectively remediation materials and technologies for loess performance improvement and loess geohazard mitigation. Here, this probably requires more attention to the assessment framework in embodied energy and carbon dioxide emissions of ground improvement works to green, low-carbon, and sustainable development.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

This study was supported by the National Natural Science Foundation of China (No. 41927806), and the Fundamental Research Funds for the Central Universities (No. lzujbky-2021-ct04), and Education Science and Technology Innovation Project of Gansu Province (grant no. 2021A-008).

ACKNOWLEDGMENTS

We deeply thank all the authors and reviewers who have participated in this Research Topic.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.