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Emerging Roles of Engineering Geologist in Geotourism Industry: Some Case Studies from Malaysia

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Abstract: Malaysia now has four (4) UNESCO Global Geopark, eight (8) National Geoparks and five (5) Aspiring Geoparks. Some of the features of the National Geopark are karstic landscape with mining and quarrying as major economic activities, then and now. Kinta Valley National Geopark for example, has more than 50 limestone hills and almost 600 caves. Major geological hazards are landslides (mainly rock fall), subsidence (mainly sinkhole) and cave instability. The Department of Mineral and Geoscience Malaysia has published a Guideline on Development near Limestone Hill (Demarcation of Safety Zones in the Vicinity of Limestone Hills) in 2013. Safety of limestone cliffs are paramount important as several landslides and rockfall cases in the past has killed people and destroyed houses and other properties. Jerai Geopark which is one of the National Geoparks experienced large-scale multiple debris flow on 20 August 2021 where four (4) people killed and two (2) are still missing. Major attraction areas including chalets were destroyed completely and most of the downstream covered with debris flood and/or mud flood. This paper will discuss case studies from several geoparks including geological hazards mapping, characterization, analysis and modelling. This paper also proposes the inclusion of third component in geosite mapping which is preliminary geohazard identification and assessment. During geosite mapping exercise, the process of geohazard identification, georisk assessment and georisk control (GIGAGC) shall be conducted by qualified professional geologists. This process is based on Hazard Identification, Hazard Assessment and Risk Control (HIRARC) in HSE practice. Post-disaster and disaster preparedness activities including installation of Early Warning System (EWS), Community-Based Disaster Risk Management will also be presented.

Keywords:* *Geological hazards, Geopark, Geosite, Mitigation.

Introduction

Malaysia now has four (4) UNESCO Global Geopark, eight (8) National Geoparks and five (5) Aspiring Geoparks and almost five hundreds (500) identified geosites within and outside geoparks. Significant geological hazard incidents have been reported within or near to geopark territories such as rockfall, cave instability, debris flow, flood, earthquake, and tsunami. There were initiatives taken by government technical agencies including National Disaster Management Agency (NADMA), Department of Mineral and Geoscience Malaysia (JMG) and geopark's management - entity include installation of Early Warning System (EWS), Community-Based Disaster Risk Management (CBDRM) as well as engineering mitigation. However, all the initiatives were conducted under National Disaster Risk Management program by the Disaster Management Council not within the context of geosite development and geopark management. The Mineral and Geoscience Department (JMG) and the Ministry of Natural Resources and Sustainability have developed three (3) documents, i.e., Guideline on Geological Heritage Identification Survey, National Geopark Development Plan 2021-2030, and National Geopark Implementation Plan. Unfortunately, none of the documents touch on Disaster Risk Management (DRM).

This paper attempts to propose an approach to include DRM in geosite development and geopark management. The approach will adopt practices by the accepted industry practice by Health, Safety and Environment (HSE) practitioners worldwide. This step shall be included in geosite mapping exercise. Current geosite mapping components focus on geodiversity characterization and geosite boundary demarcation. This paper proposes to include the third component in geosite mapping which is preliminary geohazard identification and assessment. During geosite mapping exercise, the process of Geohazard Identification, Georisk Assessment and Georisk Control (GIGAGC) shall be conducted by professional geologists. This process is based on Hazard Identification, Hazard Assessment and Risk Control (HIRARC) in HSE practice. The product of GIGAGC is Geosite Safety Analysis (GSA), which is like Job Safety Analysis (JSA) in any project development.

Methodology

Typical geosite mapping includes identification, characterisation and valuation of geosite. Nonetheless, an extra process has been established/applied specifically for geohazard management.

- Develop preliminary engineering geological model by using Total Geological History approach, literature review, aerial imagery, expert advisory, etc.
- Define site-specific geology and identify sources of surface water and subsurface water including lithology, structures, weathering, process, water carrier.
- Refine engineering geological models dan develop failure hypotheses including mode, type, mechanism, etc. This will also include understanding the ground and possible incidents.
- Perform analysis such as kinematic, limit equilibrium method, etc.)
- Conclude your findings including recommendation (structural or non-structural control measures) in Geosite Development Plan

Geotechnology hardware and software can be used to support the analysis. All analysis and assessment must be in line with all guidelines published by the authorities.

Case studies

Our records showed that all geoparks in Malaysia have one or more of the following geological hazards:

- Debris flow
- Rock fall
- Cave instability
- Flood (induced by geological hazards)
- Earthquake
- Tsunami

Several case studies from various geoparks and geosites are presented in this paper.

Current initiatives

There are initiatives by the public technical agencies including:

- Community-Based Disaster Risk Management (CBDRM)
- Early Warning System (EWS),
- Continuous drills at areas prone to disaster.

Certain guidelines have also been established for general development and can be applied to the development of geoparks or geosites.

Recommendations

Based on experiences with geohazards assessment of several geoparks or geosites for development in Malaysia, the process of Geosite Safety Assessment had been device and shall be used for future works.

Nevertheless, all critical sites shall be assessed again using common engineering geological approach for mitigation purposes upon completion of geosite mapping. Additional steps including Geosite Safety Analysis (GSA) were developed for non-technical decision makers for ease of decision-making processes.

The following tables showed the analysis process where it will start with Geosite Safety Analysis (GSA) in Table 1 follow with Geohazards Identification, Georisk Analysis and Georick Control (GIGAGC) in Table 2. Table 3 showed Geohazards Risk Rating Matrix GRRM) while Table 4 showed the Geotrail Difficulty Level. All these will help the decision maker with several limitations to the geosite such as carrying capacity, age limit, type of visitors, etc.

Table 1, Geosite Safety Analysis.

Geosite Safety Analysis

Location	Type of Hazard	Consequence/Impact	Risk Rating	Proposed Control Measure
Cave Entrance	Rockfall	Death, hospitalization, injury, bleeding	Very High	Rockfall protection, fencing
Pit Stop 4	Rockfall Slipper walkaway	Death, hospitalization, injury, bleeding	Low to Medium	Proper walkaway
Sungai Tikus	Rock fall Slippery walkaway	Death, hospitalization, injury, bleeding	High	Fencing, guarded walkaway

Table 2, Geohazards Identification, Georisk Analysis and Georisk Control (GIRARC).

Hazards Identification, Risk Analysis and Risk Control

Hazard Category	Type of Hazard	Consequence/Impact	Risk Rating	Proposed Control Measure
Geological Hazard	- Landslide - Rockfall - Debris Flow - Flood	Death, hospitalization, injury, bleeding	Very Low to Very High	Structural/engineering: Netting, protection, removal, fencing Non-structural: Community engagement, training,
Biological Hazard	- Poisonous reptiles - Carnivorous animal	Death, hospitalization, injury, bleeding	Ditto	Structural/engineering: Protection, fencing Non-structural: Community engagement, training, personal protective equipment, scheduling
Atmospheric Hazard	- Haze - Noise	Death, hospitalization, sickness	Ditto	Non-structural: Community engagement, training, mask, personal protective equipment, scheduling

Table 3, Geohazards Risk Rating Matrix.

Geohazard Rating	E Very High	Very significant potential for geohazard	E1	E2	E3	E4	E5
	D High	Significant potential for geohazard	D1	D2	D3	D4	D5
	C Medium	Minor possibility of geohazard	C1	C2	C3	C4	C5
	B Low	Geohazard problems are unlikely to be present	B1	B2	B3	B4	B5
	A Very Low	No indicators for geohazard were identified	A1	A2	A3	A4	A5

Risk Rating	Description	Action Required
Low	Risk is tolerable. No immediate action is required, but regular monitoring should be carried out to ensure risk remains controlled.	Original DOA to be maintained
Medium	Risk is tolerable if mitigation measures are applied. Regular monitoring and control measures are needed.	Pipeline leave-in-place with remediation
High	Risk is tolerable if strong mitigation measures are implemented and closely monitored. Immediate action is necessary.	Pipeline leave-in-place with remediation
Very High	Risk is not tolerable. Immediate action and closely monitored is required.	Pipeline to be removed

Table 4, Geotrail Difficulty Level.

GEOTRAIL DIFFICULTY LEVEL

CLASS	LIMITATION/DIFFICULTY	VISITORS LEVEL	PPE REQUIREMENT
1 (Very Easy)		All Level	Normal attire
2 (Easy)			
3 (Medium)		Adult/Public	
4 (Difficult)			Helmet and special shoe required
5 (Extremely Difficult)	Slippery, High Cliff,	Trained Person/Researcher	Complete PPE

Conclusions

In conclusion, there is an emerging role of engineering geologist must play in geotourism industry from the very beginning stage of geosites identification to geopark declaration to the management and maintenance of geopark or geosite.

Engineering geologists must actively promote the safety aspect of geotourism industry which has always been neglected by the tourism practitioners as their focus only to commercialize the geosite.

Simple method for Geosite Safety Assessment was devised to categorize the safety component of geosite and for ease of decision-making process by non-technical personnel.

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