CHARACTERISTICS COGNITION OF TYPICAL SURFACE GEOHAZARDS SCENE IN MINING AREAS AND REPRESENTATION OF GEO-INFOGRAPHICS SPECTRUM

ZHANG Jin*

Taiyuan University of Technology, 030024, Taiyuan, China, zhangjin@tyut.edu.cn

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ABSTRACT:

The concept of surface geohazards in mining area is put forward, and the surface geohazards in mining area are divided into three categories: first is surface subsidence fissures, collapse, second is instability of structures, slope deformation hazards (high and steep slopes, landslides and collapses) , debris flows (debris flows, tailings reservoir dam break), third is vegetation cover degradation and environmental and ecological damage in mining area. Author analyses the research status of spatio-temporal characteristics of surface geohazards in mining areas and the representation of geo-infographics Spectrum. Characteristics of typical surface geohazards scene in mining areas can be recognized using multi-resource spatial data, adopting abstract generalization, visualization and analysis of the various features and phenomena from four aspects: geographical environment, geological environment, engineering activity and geohazards. The field presentations of spatial morphological structure and geo-environmental conditions and spatio-temporal process in surface geohazards characteristic area are summarized as data fields, which express the shape, structure, location and distribution of geohazard bodies, action and physical fields which is all fields affected the data field and the coupled field which is scalar or vector field formed by the coupling of two or more fields. By using spatial location, semantic description, attribute characteristics, geometric shape, evolution process and the information of the relationship between features, taking into account the characteristics of object structure, distribution and coupling, the geohazard infographics spectrum is constructed and characterize the multi-field geo-infographics spectrum of surface geohazards in mining areas. It is a composite analysis method of time and space. A preliminary example of geo-infographics spectrum is given.

1. INTRODUCTION

Coal mining leads to geohazards such as subsidence and slope slippage of the mine ground, which affects a wide range and complicated in situation. Surface geohazards in mining areas mainly refer to hazards that occur on the surface of mining areas and pose threats and damage to safe production, life and property, ecological environment and natural resources of mines, such as the instability of stopes and landslides, and local abnormal movements in dumps. and slope slump, non-uniform subsidence and instability of structures, as well as large-scale ground fissures, subsidence, surface cover degradation in mining areas, and environmental and ecological pattern damage. The Surface geohazards in the mining area are divided into three categories: first is surface subsidence fissures, collapse, second is instability of structures, slope deformation hazards (high and steep slopes, landslides and collapses), debris flows (debris flows, tailings reservoir dam break), third is vegetation cover degradation and environmental and ecological damage in mining area. Most of the surface geohazards in mining areas are related to mining, but the formation and development vary greatly in the way and degree of hazards under different geological environmental conditions. On the other hand, different types of surface geohazards in mining areas have different material compositions and initial formation energy conditions, which are reflected in the movement state, movement speed, movement distance and other characteristics are very different (Zhang Jin, 2012)

The typical surface geohazards in mining areas are mainly ground subsidence and slope deformation hazards. The application of geosensor network, satellite remote sensing and unmanned aerial vehicle technology for monitoring and early warning of surface geohazards in mining areas is an important basic work to ensure safe production in mines. The better application results have been achieved, and a large number of long-sequence monitoring data has been accumulated. How to more effectively carry out satellite-ground collaborative monitoring, recognize and characterize disaster scene, identify early disaster anomaly information, and develop intelligent prediction services based on geoinfogaphics spectrum, spatio-temporal processes and monitoring data are urgently needed scientific and technological problem.

2. THE RESEARCH PROGRESS ON SPATIO-TEMPORAL CHARACTERISTICS OF SURFACE GEOHAZARDS IN MINING AREAS AND REPRESENTATION OF GEO-INFOGRAPHICS SPECTRUM

Through remote sensing images and digital terrain analysis, the terrain structure features such as elevation, slope, undulation, inclination, and empty surface of the slope are extracted, and the stability of the slope is analyzed, track length, density and other data, draw the slope joint track length statistical chart, joint distribution direction chart, rose joint statistical chart, etc., to obtain the dominant structural surface of the slope (Francioni M. et al., 2015).

Taking the mining subsidence disaster chain as an example, the evolution process of the disaster chain of subsidence is analyzed to verify the validity of the model (Yuanjue Chen and Jin Zhang, 2018). Space-time co-occurrence, instances of different object types subsets are spatially adjacent to each other in some time (or conform to a certain spatial relationship) (Jin Soung Yoo and

* Corresponding author

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Shashi Shekhar, 2006).The subset space of moving objects in a circle with a specific radius is the spatio-temporal co-occurrence pattern, which can be further subdivided into spatio-temporal co-location, spatio-temporal co-occurrence, spatio-temporal meeting, mobile clustering, etc. (Somayeh Dodge and Robert Weibel, 2008). spatio-temporal co-location pattern mining aims at discovering sets of events that frequently occur in nearby locations from spatial data, and is of great value for revealing the symbiosis between geographic phenomena. Due to the spatial heterogeneity, the spatiotemporal apposition pattern also has the characteristics of regional differentiation, and the analysis results at different spatial levels are different (Cai Jiannan et al., 2016).

The map representing the spatial information and the spectrum recording the temporal and spatial evolution are combined into one to form geo-infographics spectrum, which reflects the characteristics and dynamic changes of the object's morphological structure, mechanism, and constituent substances, and reveals the temporal and spatial change laws of regional geo-phenomena (Qi Qingwen and Chi Tianhe, 2001 and Liao Ke, 2002). The geo-infographics spectrum is a serial map for the phenomenon and process of geoscience in the field of geoscience. The geo-infographics spectrum realized through quantitative geoscience information (geoscience database) and geographic computing under the support of geographic information system. It is used to describe the law of harmonious coexistence between human and nature, invert its past, evaluate its current situation and even predict its future (Zhang Hongyan et al., 2020). The core of the geo-infographics spectrum is to discover the spatio-temporal knowledge and laws of geoscience, and to provide application services for social and economic construction. According to the research object, it is divided into symptom, diagnosis and realization geo-infographics spectrum according to function (LI Jun, 2001 and Yang Cunjian, 2020). Geoscience knowledge graph is a formalized graphical representation of geographic knowledge, with semantic features, so it is computable (Xu Jun et al., 2010). A geographic knowledge representation model covering three levels of geographic concepts, geographic entities, and geographic relationships is constructed to describe the basic composition and logical relationships of semantic units of geographic knowledge with different granularities (Zhang Xueying et al., 2020). A six-features representative model of geographic information is proposed, which covers spatial positioning, semantic description, attribute characteristics, geometric form, evolution process, and the relationship between features (LV Guonian et al., 2017). Knowledge graphs describe entities, concepts, events and their relationships, and can accurately and clearly express concepts and their complex semantic relationships. The Earth science knowledge graph is a graph representation and knowledge base of basic concepts, objects, phenomena, processes, standards, methods, etc. and their interrelationships in the field of earth sciences, providing a semantic basis for machine learning (Qi Hao et al., 2020).

The geohazard geo-infographics spectrum has attracted the attention of researchers. The formation conditions, development characteristics, geohazard-causing factors and geohazard precursors of different types of loess landslides in the loess area were deeply studied, and the loess landslides were classified into eleven types of disaster-causing models, and combined with their dynamic development and evolution process, various loess landslides were established. Landslide identification map and interpretation signs (Xu Qiang et al., 2020).

3. COGNITION OF THE CHARACTERISTICS OF TYPICAL SURFACE GEOHAZARDS IN MINING AREAS

The characteristics of typical surface geohazards in mining areas are recognized from four aspects: geographical environment characteristics, geological environment characteristics, engineering activity characteristics and disaster characteristics. The characteristics of geographical environment mainly focus on the geographical features, topography, surface cover and meteorology. The geological environment mainly focus on stratigraphic lithology, regional geological structure, hydrogeological conditions, etc. The engineering activities mainly focus on resource exploitation and disasters engineering characteristics such as prevention and control. The disaster characteristics mainly focus on the type, location, shape, structure, distribution, scale characteristics.

On the basis of hierarchical extraction of geo-environmental information such as features distribution, topography, surface coverage, geological conditions, and meteorology, it focuses on multi-dimensional geographic information such as location, shape, structure, semantics, content, and relationship, and images such as geometry, spectrum, and texture. Characteristic information, spatio-temporal process information, such as displacement, subsidence, object dynamics, disaster information such as disaster features, structure, distribution, development, process, etc. , in-depth understanding and perspective of surface geohazards in mining areas, and establishment of a cognitive model and content system for surface geohazards characteristics in mining areas to achieve multi-field information and multi-granularity analysis of characteristic areas and objects of ground hazards in mining areas. Research the dynamic pattern of the spatio-temporal process of the ground disaster objects in the mining area, and the spatio-temporal behavior and characteristics of the disaster objects. The spatial behavior, attribute behavior, relational behavior and composite behavior of spatiotemporal objects are formally expressed using complex networks and knowledge graphs. Establish a dynamic analysis and expression method for the spatio-temporal process, such as spatio-temporal co-location, spatio-temporal co-occurrence, and spatio-temporal meet of disaster objects.

Through feature quantification segmentation, division, index, pattern mining and situation graph generation for deformation types of stable, oscillating, multi-step, mutation, trend type, applying spatial positioning and semantic description, attribute characteristics, geometric shape, evolution process, information on the relationship between features, taking into account the characteristics of object structure, distribution, etc., to construct a geohazard geo-infographics spectrum, and to establish a location-morphological-attribute-semantic-structure-process-relational ground disaster multi-site representation model.

The spatial morphological structure and environment of the surface geohazards characteristic area is summarized as the basic field(data fields-the shape and structure of the disaster body, topographic field, monitoring data field, image information field, surface coverage field), and the action field, all fields that affect the basic field are called the action field(physics field: deformation field, geological structure field, geophysical field, stress field, rainfall field, temperature field, seepage field, etc.), and the coupled field, coupling of two or more fields is a coupled field. From multi-field information such as basic field, action field, and coupling field, perform feature quantification analysis for stable, oscillating, multi-step, sudden, and trending disaster stages and deformation curve types.

From the location, geometry, shape, structure, semantics, process, deformation, content, etc., we establish a cognitive model of surface geohazards in mining areas. Scene data, geographic feature, multi-field information and feature classification of surface geohazard in mining areas, see figure 1.

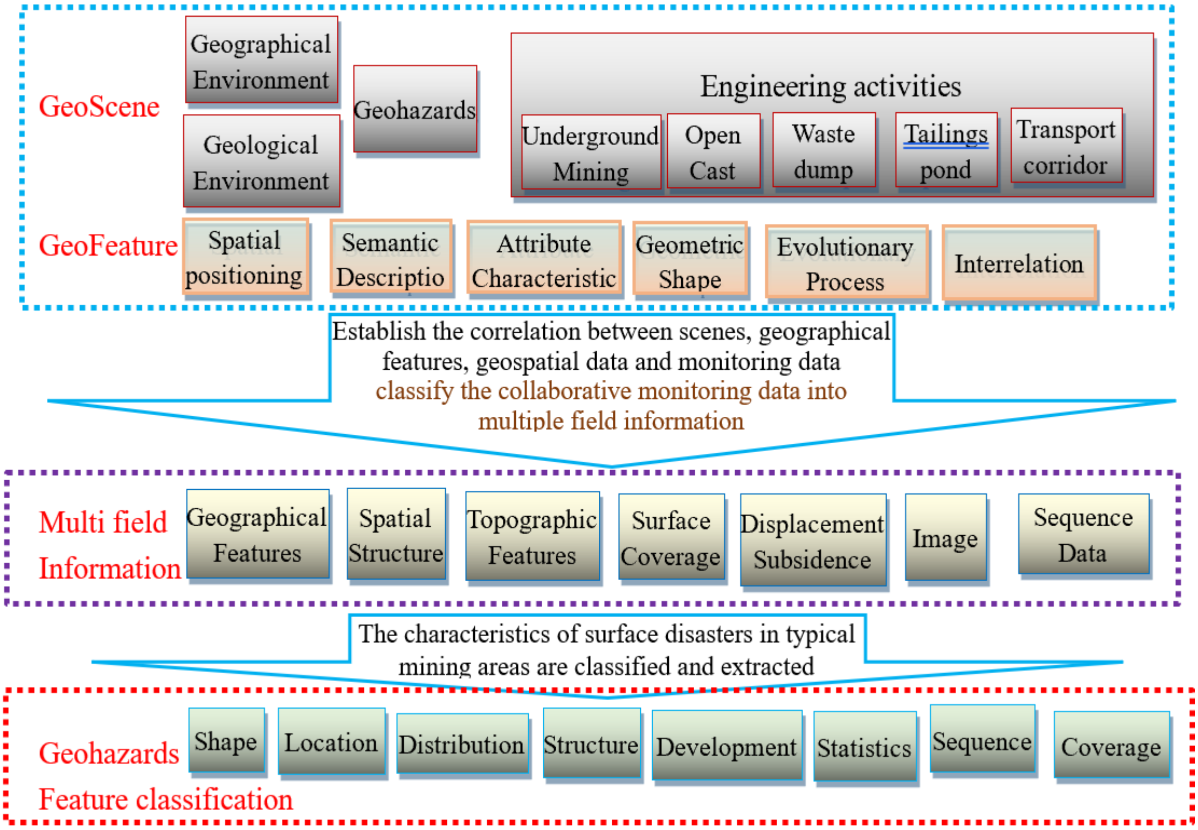

Figure 1. Scene data, geographic feature, multi-field information and feature classification of surface geohazard in mining areas

The dynamic analysis of the spatio-temporal evolution of the characteristic objects in the mining area is carried out to reveal the movement and evolution laws of the characteristic areas and point-line objects. Through the method of correlation analysis between objects-location-events and data fusion, multi-data collaborative analysis and pattern analysis are carried out to study the complexity, inheritance and temporal continuity of disaster objects' spatiotemporal behavior. Analyze the temporal and spatial variation characteristics of the interaction between ground disaster point features, edge features and surface features, and multi-field information, and analyze the interaction variation characteristics and mechanisms between features at different scales (mining area - mine - active area - key area).

According to the spatial proximity distance, the spatial proximity patterns in the time slot are calculated, and the set of spatial alignment patterns satisfying the threshold is obtained, the temporal frequency of each spatial alignment pattern is counted, the spatial and temporal co-occurrence patterns satisfying the temporal frequency threshold are found, and the geometry of the disaster object is extracted. Shape features, applying the method of pattern matrix, express and analyze the spatial-temporal co-location, spatial-temporal co-occurrence, spatial-temporal meet and spatial-temporal dynamic cluster analysis calculation of spatial objects. Analysis of temporal and spatial process of surface geohazards, see figure 2.

The spatio-temporal relationship between the initial equilibrium stage, the initial disturbance stage, the local failure stage, the unstable start stage, the progressive failure propagation transfer stage, and the overall sliding instability stage of typical surface geohazards in the mining area is analyzed. Study the gathering and dispersing process of the object, analyze its time series characteristics and evolution process, and construct indicators such as geographic flow aggregation degree, update frequency, and aggregation/diffusion flow direction. Express the disaster spatio-temporal process as a Bayesian network and a graph model, and analyze the interaction mechanism of geographic disaster object features through network system analysis methods, build a disaster object interaction model, and analyze the spatial behavior, attribute behavior, relationship behavior and formal expression of compound behavior. Apply knowledge graph, pattern mining, correlation analysis and other methods to analyze the disaster pattern process, and carry out spatial location, multi-field information and correlation analysis between disaster events.

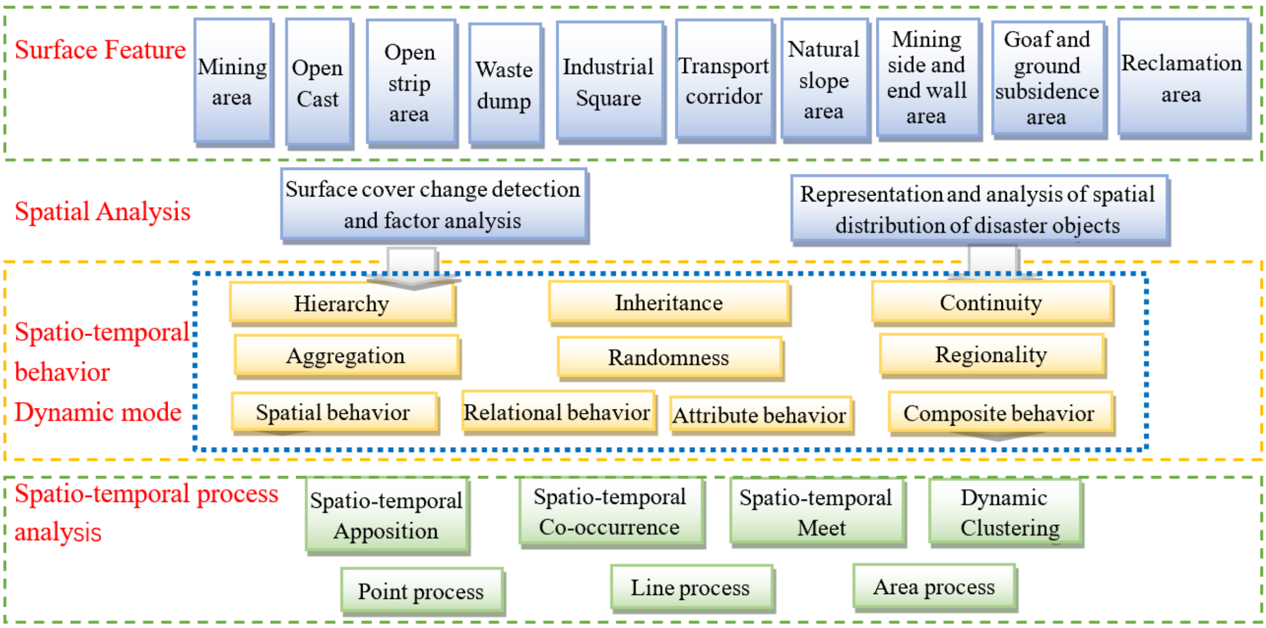

Fig. 2 Analysis of temporal and spatial process of surface geohazards

4. MULTI-FIELD GEO-INFOGRAPHICS SPECTRUM REPRESENTATION OF SURFACE GEOHAZARDS

Based on the established three-dimensional mine field model and multi-field information such as basic field, action field and coupling field, the time series development stages of stable, sudden change, multi-step, catastrophic and trend-type hazards and the types of deformation curves such as V-type, B-type, D-type, R-type and pendulum-type are quantitatively segmented, partitioned, index setting, pattern mining and geo-infographics spectrum situation generation.

Correlate the characteristic of surface geohazards object, multi-fields digital information can be used to build geo-infographics spectrum, through graphic thinking and abstract generalization, visualizes the spatial morphological structure and temporal-spatial changes analysis of the earth system and various features and phenomena. It is a temporal-spatial composite analysis method. The geo-infographics representing the spatial information of geosciences and the spectrum recording the temporal and spatial evolution are combined into geo-infographics spectrum, which reflects the characteristics and dynamic changes of the object's morphological structure, genesis mechanism, and constituent substances, and reveals the temporal and spatial change laws of regional geoscience phenomena. Characteristics of surface geohazards-disaster process-spatial distribution-geoscience information map , see figures 3.

A multi-dimensional feature-based surface geohazard data perception model integrating time, space, semantics and relationships is constructed to realize multi-field information multi-granularity parsing and location-based information aggregation method in disaster feature area. The automatic location information discovery and matching, location semantics association and spatial behavior inference are accomplished. The spatial behavior inference under different location semantics is supported to reveal coal mining. It provides precise information support for the impact of the surface and the mechanism of dynamic change. Analyze the terrain features of the geohazard area, extract the slope, slope aspect, roughness and terrain feature lines, form slope units, divide the slope entity area, extract the free surface of the slope body, and form a terrain feature dataset.

According to the geohazard object category, the features are extracted respectively. The block features such as spectrum, texture and shape of the image feature block are calculated, and the block feature object information table of the image is established. For landslide hazards, extract the morphological features of landslide walls, landslide steps, landslide drums, closed depressions, landslide tongues, and landslide cracks; for land subsidence hazards, extract the subsidence area range, subsidence ground morphology, etc.

Calculate the mutual information between image feature blocks and image categories. According to the amount of mutual information, the fast features of the image are extracted. Extract brightness value, band variance, feature point line and edge, texture homogeneity and correlation, etc., and perform feature analysis on pixels, objects, and scenes. Use directional associations to describe the nature (intensity, length or extent) of spatial associations in a certain direction, extract structural features, build quantitative parameter tables, and feature datasets of disaster areas and objects.

Extract structured event knowledge from the geohazard geo-infographics spectrum. From the aspects of data abstraction, concept description, classification, clustering, correlation analysis, association modeling, change and deviation analysis, etc., design the principle of mining surface geohazard classification based on geographic semantics, establish a semantic classification system of geohazard geo-infographics spectrum, and associate knowledge discovery methods and sequential pattern knowledge discovery methods, etc., perform semantic classification and analysis.

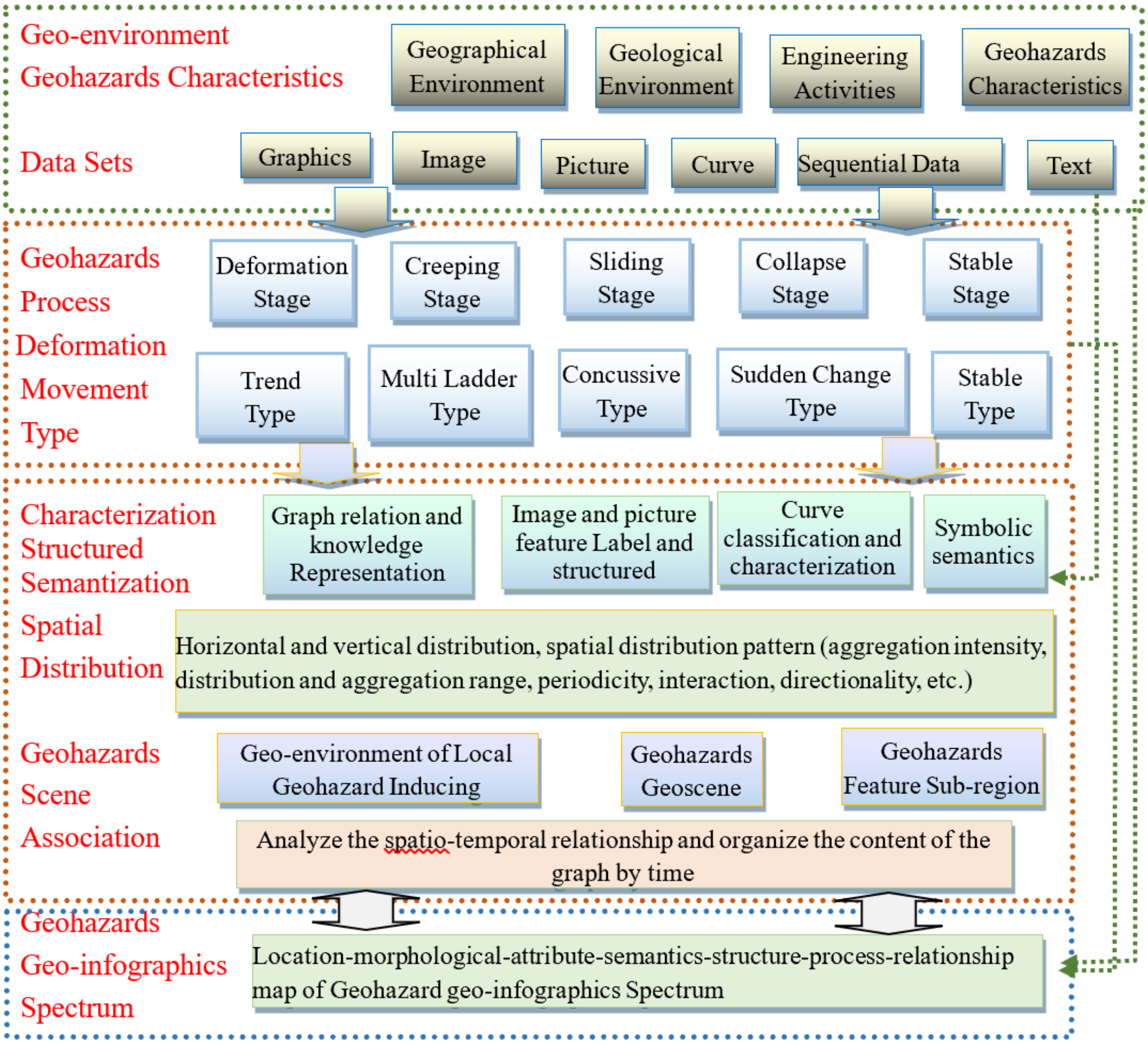

Fig. 3 Characteristics of surface geohazards-disaster process-spatial distribution-geoscience information map

5. EXAMPLES OF GEOHAZARD GEO-INFORGRAPHICS SPECTRUM

From the dimensions of spatial morphological characteristics, spectral characteristics, texture characteristics, terrain characteristics, deformation characteristics, structural characteristics, geological environment characteristics, mining characteristics, time series characteristics, disaster chain characteristics, etc. and geographic grid-based geoscience disaster-pregnancy environment model expression. Applying spatial positioning, semantic description, attribute features, geometric form, evolution process, and interrelationship information of features, taking into account the characteristics of object structure, distribution, coupling, etc., a geo-infographics spectrum is constructed. Representation of multi-field Geo-infographics Spectrum of Surface Geohazards in mining areas see figure 4.

6. CONCLUSIONS

The cognition and representation of geohazard using geo-infographics spectrum have important significance and role in monitoring and early warning of mine surface geohazard and ensuring safe production. The spatial morphological structure and environment of the surface geohazard area is generalized as the basic field and action field and coupling field. Correlate the characteristic of surface geohazards object, multi-fields digital information can be used to build geo-infographics spectrum, through graphic thinking and abstract generalization, visualizes the spatial morphological structure and temporal-spatial changes analysis of the earth system and various features and phenomena. By using spatial location, semantic description, attribute characteristics, geometric shape, evolution process and the information of the relationship between features, taking into account the characteristics of object structure, distribution and coupling, the geohazard infographics spectrum is constructed and characterize surface geohazards in mining areas. It is a composite analysis method of time and space. The spatial positioning, semantic description, attribute characteristics, geometric shape, evolution process and relationship information of features, the characteristics of object structure, distribution are the main information of geo-infographics spectrum.

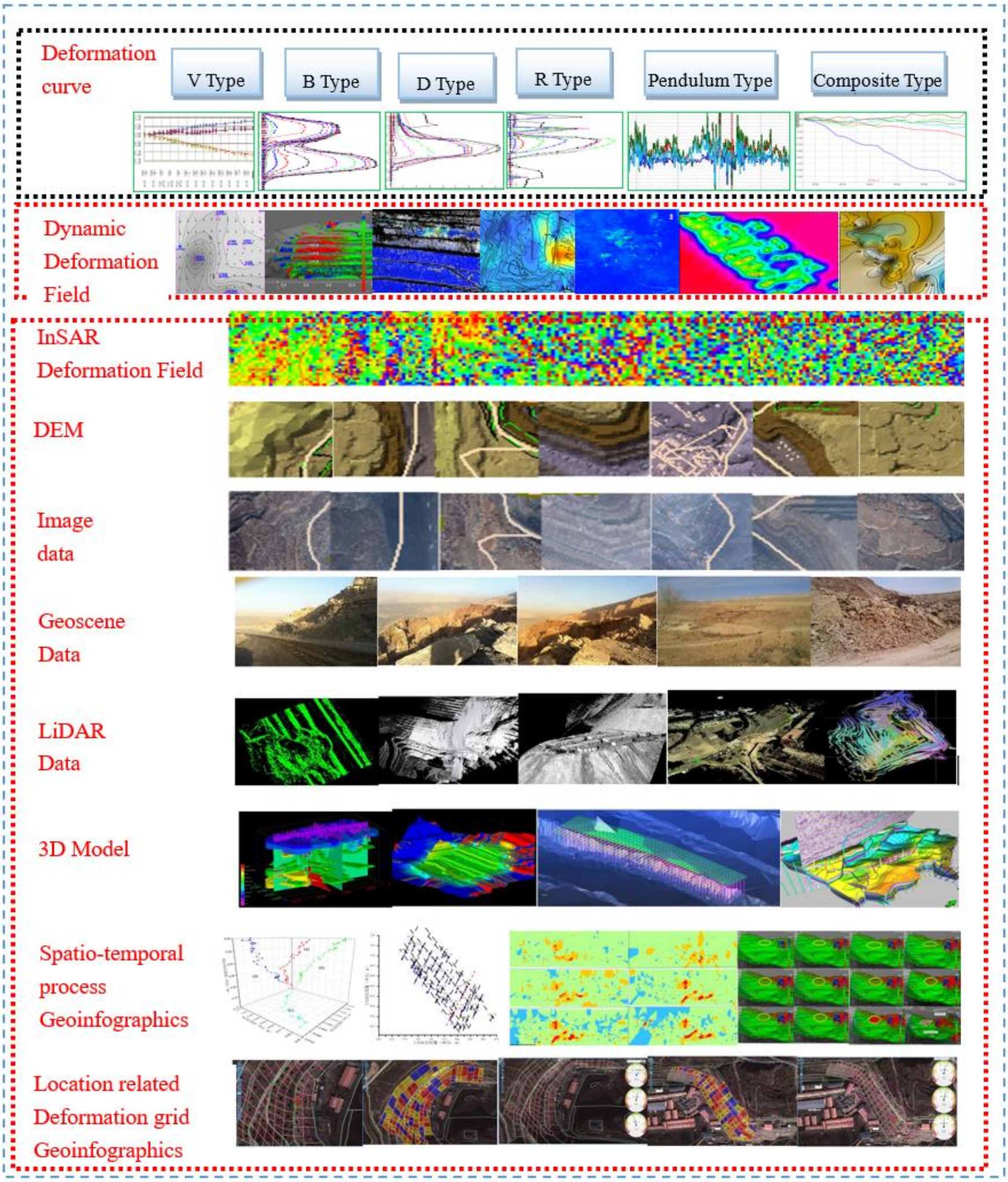

Fig. 4 Representation of multi-field Geo-infographics Spectrum of Surface Geohazards in mining areas

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