Summary of Information Monitoring Methods and Principles of Debris Flow Disasters

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Abstract. Debris flow is a sudden geological disaster, once it occurs, it will cause irreparable economic losses and casualties. In recent years, debris flow disaster control methods emerge in endlessly, among which monitoring and early warning method is the most effective and economic method. In this paper, through the analysis of the monitoring content of material source, water source, characteristics of debris flow mass and the comparison of the current monitoring technology and methods, which is conducive to the selection of monitoring methods for the prevention and control of actual geological disasters, which can avoid the waste of resources.

Key words: Debris flow; Monitoring and early warning; Disaster prevention and control

1. Research background

As one of the most catastrophic geological disasters in my country, debris flow has caused serious economic losses and casualties every year, posing a huge threat to social and economic development and the safety of human life and property (Cui Peng et al., 2000). The Chinese government attaches great importance to the study of debris flow and disaster prevention and mitigation, and has devoted a lot of human and financial resources to its risk analysis, monitoring and early warning, and disaster management. The Loess Plateau, as the main area where debris flows occur, has a unique combination of loess valley landforms and inter-valley landforms such as plateaus, beams, and maws. , making the Loess Plateau the region most severely affected by debris flow in my country (Guo Fuyun et al., 2015). At the same time, due to the high population pressure, the steep slope reclamation is very common in the mountainous area of Longnan, and the soil erosion is serious. Therefore, it is particularly important to carry out systematic monitoring and early warning research on debris flows in the Loess Plateau and the Longnan Mountains. At the same time, monitoring and early warning is an important means to reduce the damage of debris flow disasters, and it is also one of the most economical and effective means (Yuan Liqiang, 2014).

2. Debris flow monitoring

2.1 Monitoring content

Although the study of debris flow in my country started relatively late, due to the large amount of disasters and the wide range of disasters, the government and scientific and technological personnel have attached great importance to the monitoring of disaster reduction methods and have made great progress (Cui Peng et al., 2000). Debris flow monitoring is the leading means of debris flow research, which provides the basis for theoretical research, experimental research, mechanism analysis, physical process and mathematical simulation, and is also the basis for debris flow early warning. Usually debris flow monitoring includes monitoring of its formation conditions (solid material source, water supply source, etc.), monitoring of movement characteristics (dynamic elements of flow, dynamic elements, transport and scouring, etc.), monitoring of fluid characteristics (material composition and its physical and chemical properties, etc.) (Li Hongfu, 2015).

2.1.1 Debris flow solid matter source (source) monitoring

The source of solid matter of debris flow is the material basis for the formation of debris flow, and it is also the basis for studying the basic characteristics of debris flow. The Loess Plateau features thousands of ravines and ravines, and geological disasters such as landslides and collapses are prevalent, and the formed accumulations often provide sufficient material sources for debris flows in channels and slopes. Therefore, the monitoring of solid material sources should focus on the spatial distribution, scale, accumulation velocity and displacement of the deposits generated by unstable slopes on the slopes of the provenance area and in the trenches in the basin where the debris flow occurs. Displacement monitoring, etc.; for loose solid substances on the surface of the watershed, such as loose soil, construction waste and other artificial waste, its distribution range, reserves, accumulation speed, displacement and movable thickness should be monitored. Changes in physical properties under rainfall conditions or under thin-layer runoff conditions, such as the moisture content of loose soil and the change process of pore water pressure, etc. (Qiao Jianping, 2006; Yang Chenglin, et al., 2014).

2.1.2 Monitoring of meteorological and hydrological conditions (water source)

The purpose of monitoring the meteorological and hydrological conditions of debris flow is to pay attention to the dynamic situation of water sources in the debris flow basin, because it is not only a necessary condition for the formation of debris flow, but also one of the main sources of power to induce its movement. There are various water source factors that induce debris flow, including atmospheric precipitation, surface runoff, melting water from ice and snow, dam break, and groundwater. For atmospheric precipitation, the main monitoring contents include rainfall, rainfall intensity and rainfall duration; for ice and snow meltwater, the main monitoring contents are the amount and duration of melting water; when there are lakes, reservoirs, etc. in the source area of debris flow, it is also necessary to assess the occurrence of leakage, Danger of dam failure.
Research statistics show that rainfall-type debris flows are the most widely distributed around the world, and the main monitoring contents include point rainfall monitoring in the basin (self-metering rain gauge observation), meteorological rainfall monitoring and radar rainfall monitoring. ① Rainfall monitoring. A certain amount of self-calculated rainfall is set in the provenance area, and real-time rainfall monitoring is carried out. Combined with the rainfall threshold data of previous debris flow occurrences, statistical analysis is carried out to establish the rainfall threshold forecast map of debris flow in the basin, and then the real-time rainfall and threshold line are calculated. Compare and issue disaster warnings. Due to the large differences in climatic conditions and geological backgrounds in different places, this method is often suitable for specific small and medium-sized debris flow basins. ②Meteorological and rainfall monitoring. Combined with the satellite cloud images in a certain area released by the national and local meteorological stations, mainly the location, movement, influence scope and changes of typhoons, so as to forecast and warn of precipitation according to the cloud type characteristics on the meteorological cloud map. ③ Radar rainfall monitoring. According to the echo structure characteristics of the electromagnetic waves emitted by the radar, the distribution and movement of the rain cloud clusters are detected, and the occurrence, distribution, movement of the rain area and the rainfall intensity in the next 24 hours and longer time are provided, and the rainfall amount set in combination with the regional channel is provided. The threshold standard is used for comprehensive judgment, and the early warning information of debris flow is released (Zhang Wanxi et al., 2012).

2.1.3 Monitoring the movement characteristics of debris flow

The movement characteristics of debris flow include dynamic elements and dynamic elements of debris flow. Monitoring of dynamic elements includes outbreak time, duration, process, type, flow pattern and velocity, flow rate, mud level, flow surface width, climbing height, number of bursts, changes in the vertical and horizontal slope of the trench bed, changes in transport, erosion and deposition, and monitoring of accumulation conditions, etc. , and sample and analyze, measure sediment transport rate, sediment transport or debris flow flow, total runoff, total solid runoff, etc. The monitoring contents of debris flow dynamic elements include debris flow hydrodynamic pressure, fluid impact force, rock impact force, and debris flow geoacoustic spectrum and amplitude (Wu et al., 2013).

2.1.4 Monitoring of fluid characteristics of debris flow

The main contents of debris flow fluid characteristic monitoring include debris flow material composition (mineral composition, chemical composition, etc.), structural characteristics (porosity, slurry microstructure, etc.), bulk, particle composition and fluid consistency, gravity (gravity density), soluble Physicochemical properties such as salt and its physicochemical properties (fluid bulk density, viscosity) (Zhang Wanxi et al., 2012).

3. Monitoring methods and their advantages and disadvantages

3.1 Monitoring technology

The monitoring of debris flow can integrate the monitoring technologies and means of mountain torrents and landslides. The current popular method is to set up sensors to sense the amplitude and frequency signals of debris flow in heavy rain, and then establish an early warning system through advanced transmission methods. Numerous scholars and research institutions at home and abroad have systematically studied the basic conditions and triggering factors of debris flow, put forward the basis for discriminating the occurrence of debris flow, carried out debris flow monitoring, and established a debris flow discrimination model. At present, the sudden debris flow monitoring technology popularized and applied in my country is mainly based on manual inspection and simple monitoring, including buried pile method, buried nail method, painting method, patch method, etc. These methods are relatively backward in technology, and in harsh conditions Climate conditions are extremely unstable and unreliable, and it is easy to miss opportunities for disaster forecasting. Therefore, the new debris flow early warning and monitoring system mainly uses advanced technology to monitor the on-site mud water level, rainfall and wired or wireless information transmission of video observation in real time, and uses the software platform to automatically monitor sudden debris flows online at all times, and at the same time conduct real-time on-site alarms. Improve the level of early warning and monitoring of debris flow (Han Rucai et al., 2004; Fang Hua, 2011).

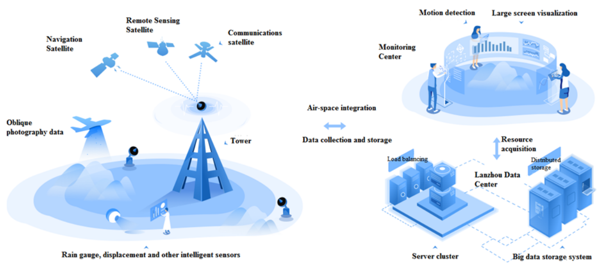

Figure 1. Air-space-earth integrated data acquisition and storage system

Figure 1 shows that the monitoring method of debris flow has developed from the simple and simple real-time monitoring in the past to a modern monitoring method integrating automation, real-time, remote and accurate (Xu Liang et al., 2012). Debris flow monitoring methods at home and abroad mainly include: surface displacement monitoring method, close-range photogrammetry method (Xu Wei et al., 2020), global positioning system (GPS) method, remote sensing (RS) and geographic information system (GIS) combined method, groundwater level monitoring method, inclinometer method, interferometric synthetic aperture radar (INSAR) method, wireless sensor network (WSN) method, geoacoustic monitoring technology method, microseismic monitoring method, ultrasonic method to implement monitoring to realize real-time monitoring and monitoring of geological hazards such as landslides and debris flows.

The air-space-ground monitoring system mainly includes InSAR monitoring (Li Xiaoen et al., 2021), UAV aerial survey and 3D modeling technology, and surface deformation monitoring (Gong Bo et al., 2020). The geological big data analysis system is based on the management and analysis of geological data based on cloud computing and big data technology. It conducts unified management of geological-related data resources, service resources and application resources, and provides it to the terminal layer in the form of services to improve information products. and quality of service.

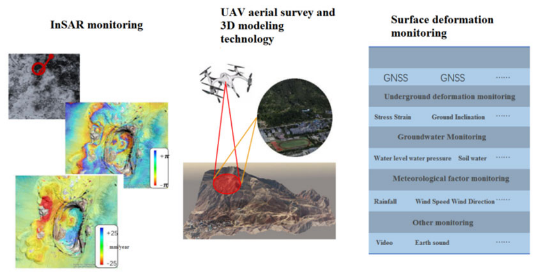

Figure 2. Monitoring content of air-space-ground integration

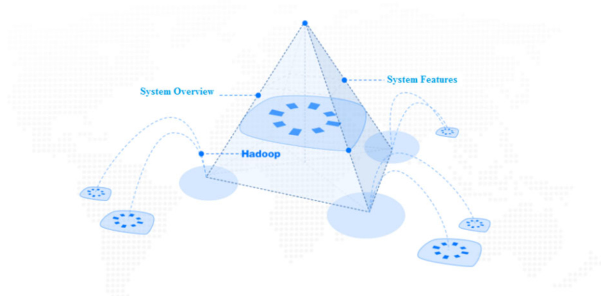

Figure 3. Geological big data analysis system

4. Conclusions

At present, the technology and methods of debris flow monitoring and early warning at home and abroad are not very different, and manual monitoring is mainly used. At the same time, various professional monitoring equipment is becoming more and more routine, and a large number of early warning models are born; It was soon applied to the field of debris flow monitoring, such as 3S technology, three-dimensional laser scanning, interferometric synthetic aperture radar (In-SAR), and microseismic monitoring methods (Tan Wanpei, 1996; Zhong Dunlun, 2011; Li Ming, 2015). In order to further improve the success rate of monitoring and early warning such as debris flow, the current directions that still need to be worked on are as follows:

(1) Establish a mechanical model of movable solid matter (different from traditional loose solid matter) in the source area of debris flow, and calculate the total amount and distribution of solid matter that may move under different hydrodynamic (rainfall) effects.

(2) Grasp the process of precipitation, the area of precipitation and the amount of precipitation from the space of the watershed, and use the distributed hydrological model to calculate and analyze the movable solid matter in the source area of the debris flow and the precise rainfall process. range of hazards.

(3) Establish an automatic monitoring and early warning system for debris flow, and establish a three-dimensional monitoring network for the surface and deep underground during the data collection stage. Surface deformation monitoring (landslide body deformation direction, deformation speed, deformation range, rainfall, etc.); underground monitoring (underground water content, soil temperature and humidity, water level changes) and external environmental changes such as seismic activity,

etc., to practice building a set of landslide stability Sexual health intelligent diagnosis system. Layer-by-layer early warning of debris flow before, during, and after the occurrence of debris flow can ensure accurate debris flow early warning information, provide local residents with sufficient time to avoid disasters, and minimize disaster losses.

(4) Monitoring and early warning technology based on multidisciplinary cross-disciplinary use of intelligent sensing technology, GNSS technology, Internet of Things technology, cloud computing technology, and big data technology (Liu Hanlong et al., 2021) combined with professional geological disaster monitoring equipment to build real-time monitoring, early warning A comprehensive solution for forecasting, information management, and auxiliary decision-making, which is widely used in real-time online automatic monitoring of key geological hazards such as landslides, debris flows, collapses, ground subsidence, ground subsidence and ground fissures. It can realize real-time analysis of geological disaster monitoring data and real-time release of early warning information, which fundamentally solves the problems of single monitoring space, primitive monitoring methods and lack of monitoring parameters. From shallow surface monitoring to multi-space, multi-level, and multi-variable monitoring in four dimensions of space, sky and ground, and underground, geological disaster monitoring has entered a new era of sky-sky-ground-underground three-dimensional and all-weather monitoring.

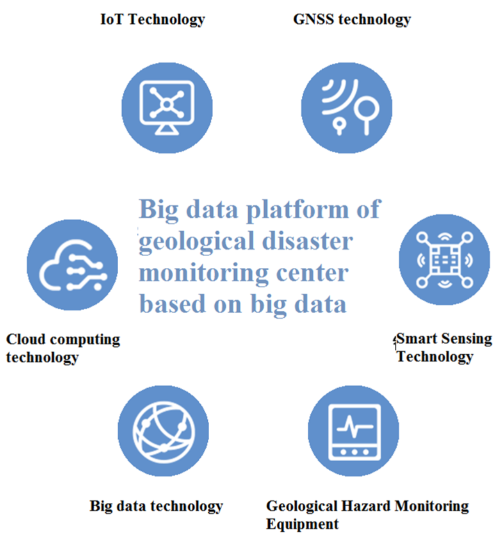

Figure 4. Big data platform of geological disaster monitoring center based on big data

Geological disaster monitoring and early warning is a multi-disciplinary interdisciplinary technology integrating geological disaster investigation, monitoring scheme design, instrument layout, early warning and forecasting technology. Its main task is to monitor the temporal and spatial evolution information and inducing factors of geological disasters, obtain continuous spatial deformation data to the greatest extent, and make early warnings in time. Conventional monitoring methods and technologies tend to mature, and equipment accuracy and equipment performance have been greatly improved. Therefore, only by giving full play to the multi-disciplinary monitoring and early warning methods, the comprehensive discrimination ability of geological disaster monitoring and early warning can be strengthened, and the further development of geological disaster monitoring and early warning can be promoted.

All in all, in the preliminary work of preventing and controlling debris flow disasters, according to the situation on site, the distribution monitoring of provenance, water source, and the movement characteristics and fluid characteristics of debris flow can be carried out respectively. By comparing the advantages and disadvantages of each monitoring method and choosing a reasonable monitoring method, large-scale debris flow disasters can be avoided in time, the impact of debris flow disasters on surrounding residents is reduced, and the safety of people's lives and properties can be effectively guaranteed.

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