Early identification and monitoring of hidden debris flow in low mountain red bed area based on InSAR and optical remote sensing technology——A case study of Wenjiagou debris flow in the Eastern New District of Chengdu

Jia Zihong¹,², Huang Xichao³, Wang Qingfang¹,², Yu Tianbin³, Wang Meng³, Jiang Yu³, Song Ban⁴ and Dong Jihong⁴

¹ Chengdu Institute of GEO-Environment Monitoring, ChengDu 610071, China
² Observation and Research Station of Chengdu geological disaster, Ministry of Natural Resources, ChengDu 610071, China
³ Sichuan Geological Survey, ChengDu 610081, China
⁴ Sichuan smart geological big data Co., Ltd, ChengDu 610081, China

845024355@qq.com

Abstract: Because of the typical geological environment and climate conditions, the number of debris flow geological disasters in low mountain red bed area is small, and most of them have high concealment. Identifying and monitoring debris flow under this kind of special disaster background has a certain significance for the prevention and control of geological disasters. Taking Wenjiagou debris flow in Danjing street, Eastern New District of Chengdu as an example, this paper uses InSAR technology and optical remote sensing technology to identify and monitor Wenjiagou debris flow by multi-period, multi-source and multi-means method. Combined with the geological environment conditions of red bed area, this paper comprehensively analyzes the causes and development characteristics of Wenjiagou debris flow. Research shows: 1) The debris flow in Wenjiagou is very hidden. The source of landslide in the early stage can be detected by using InSAR technology, which has certain deformation characteristics. 2) Using multi-period optical remote sensing images, the partial slope deformation can be identified in the study area, and the debris flow can be effectively identified in the early stage. 3) The provenance of Wenjiagou debris flow is mainly controlled by geological structure and stratum lithology. Finally, combined with the results of remote sensing interpretation and ground survey, the paper puts forward the targeted prevention and control suggestions of "Stable material source + Combination of blocking and drainage + Ecological restoration" for Wenjiagou debris flow, which has a certain guiding role for the development and planning of the Eastern New District of Chengdu.

Keywords: Debris flow, Early identification, Geological hazard, Low mountain red bed area
1. Introduction

On July 2, 2019, a large-scale rainfall occurred in Danjing Street area of the eastern New District of Chengdu, with the maximum daily rainfall of 166.7mm and the maximum hourly rainfall of 63.1mm. Due to continuous heavy rainfall, the slope on the left side of the rear of Wenjiagou sliding, resulting in about 19.45×10⁴m² of landslide accumulation, which blocked the gully, formed a 30-50m wide, 230m long and 5-10m thick debris flow gully along the gully. After the landslide occurred, the loose material sources in the gully posed a serious threat to the life and property safety of the villagers in Xinchang village of gully mouth down stream of Wenjiagou. The vegetation in Wenjiagou watershed is dense, and there is no sign of mountain sliding before the landslide, which is highly hidden and sudden. It is a typical hidden landslide in low mountain red bed area.

"Red beds" in China mainly refer to lacustrine, fluvial, fluvial lacustrine facies or piedmont proluvial continental clastic rocks of Triassic, Jurassic, Cretaceous and Cenozoic tertiary since Mesozoic[1]. The geological age of red bed formation is relatively short, and it experiences less crustal movement. The geomorphic types are mainly hills and low mountains, and the lithology mainly includes mudstone, sandstone, siltstone, clayey siltstone, claystone or argillaceous shale[2]. Under the action of internal and external geological forces, the rock mass is easy to be damaged and deteriorated, and the structure is broken. The mudstone and other soft rocks in the red bed are easy to soften and muddle when they meet with water, and forming a weak layer. The overall strength is low, and the saturated uniaxial compressive strength is generally less than 30 MPa[3]. Therefore, landslides and collapses are more developed in the red bed area, but debris flows are less developed[4].

By collecting data and querying the literature, there have been many results in the research of landslides and collapse disasters in the red bed area. Due to the influence of typical stratum lithology and climate conditions, debris flow in red bed area is less developed and distributed, so the study also relatively few. At present, the research of red-bed debris flow mainly includes the study of formation conditions[4], the study of desert type[5], the study of erosion modulus[6], the study of slope-type debris flow[7], and the study of rainfall-induced conditions[8]. These studies mostly stay on the theoretical level, rarely used in production practice, and do not involve research on early identification. Therefore, the research on early identification of red-bed debris flow has great guiding significance for the mitigation and prevention of geological disasters.

Red bed area is not only facing such a serious threat of geological disasters, but also an important place for population gathering and human engineering activities. Because the debris flow in the red bed area is highly hidden and harmful, especially in the mountainous and hilly areas, once it occurs, it will seriously threaten the lives and property of the people. Therefore, how to improve the ability of early warning and prevention of debris flow is an urgent problem to be solved. Taking Wenjiagou debris flow in the Eastern New Area of Chengdu City as an example, the study on early identification and monitoring of hidden debris flow in low mountain red bed area has certain significance for disaster reduction.

2. Geological background of disaster in the study area

The study area is located in Danjing Street, Eastern New District, Chengdu, Sichuan Province. This area belongs to Southwest Sichuan Red bed distribution , the Middle part of the Longquan Mountains fault zone. There are red beds in southwestern Sichuan, and a large number of Cretaceous and Jurassic strata are exposed(Figure 1).

Wenjiagou debris flow is located in the northeast of Longquan mountain, which is a low mountain landform area. The highest point in the gully is the gully ridge on the northwest side of the basin, with an altitude of 840 m. The lowest point is at the mouth of the debris flow gully, with an altitude of 488 m, and a relative elevation difference of 352 m. The overall terrain is high in the northwest and low in the southeast.

The lithology of strata exposed in Wenjiagou debris flow basin mainly includes: Quaternary Holocene alluvium (Q₁h) and alluvial diluvium (Q₁a), Penglaizhen Formation (J₃p) and Suining Formation (J₃sn) of Upper Jurassic. The main fault of Wenjiagou debris flow is Ma'anshan fault. The
fault starts from Baiguoshu in the north, passes through Ma'anshan and Xinchang, and ends at Gaojiachang, extends roughly NE20° and it is 20 km long. The northern part of the fault occurs in the Suining Formation ($J_3^{sn}$), and the southern part is between the Suining Formation ($J_3^{sn}$) and the Penglaizhen Formation ($J_3^{p}$).

Figure 1. Southwest Sichuan Red bed distribution and study area location map

Near the mouth of the debris flow, the fault is well exposed. The hanging wall is composed of Suining Formation ($J_3^{sn}$) silty mudstone with siltstone, and the footwall is composed of Penglaizhen Formation ($J_3^{p}$) light purple gray medium thick layered sandstone. The fracture bandwidth is about 2m. It is mainly composed of compressive cleavage, cataclastic rock and breccia. The section occurrence is $305^\circ \pm 42^\circ$. The joint of Penglaizhen Formation ($J_3^{p}$) sandstone near the fault is developed, and the rock occurrence is basically the same as that of the fault.
3. Data and methodology

3.1. InSAR remote sensing recognition technology

3.1.1. Principle of InSAR Technology

By acquiring two SAR images covering the same area, InSAR technology obtains the surface elevation information according to the phase information of the same point\(^9\). According to data sources, SAR images can be divided into three categories: Spaceborne SAR data, Airborne SAR data and Ground-based SAR data. Among them, Spaceborne SAR is based on space vehicles such as satellites. It has the ability of all day, all-weather and large-scale monitoring. It has been widely used in deformation monitoring, DEM acquisition, ocean monitoring, disaster warning and other fields. It is the main platform of InSAR technology\(^{10}\).
The SAR data source used in this research is Spaceborne SAR data, and the InSAR data processing technology is Stacking-InSAR technology. The principle of Stacking-InSAR technology is briefly introduced below.

Stacking InSAR\textsuperscript{[11]} technology was proposed by Sandwell & Price in 1998. The principle of this technology was to weighted average multiple unwrapping images in order to weaken spatially unrelated noise, including atmospheric effect, so as to obtain the deformation rate of the study area\textsuperscript{[12,13]}. Before stacking the unwrapping images, all SAR images are sampled to the same coordinate system and phase unwrapping is performed. Compared with D-InSAR technology, this technology can effectively reduce the influence of atmospheric delay error and DEM error. The basic assumption is that for N groups of interferograms, the atmospheric statistics are fixed. The estimated phase rate variance of each point in the image and variance formula is as follows\textsuperscript{[14]}:

\[
\text{ph. rate} = \frac{\sum_{i=1}^{N} \Delta t_i \varphi_i}{\sum_{i=1}^{N} \Delta t_i^2} = \text{var (ph. rate)} \approx \frac{\sum_{i=1}^{N} \left( \varphi_i - \frac{4\pi}{\lambda} \text{ph. rate} \Delta t_i \right)^2}{\Delta t_i^2}
\]

Where \(\text{ph. rate}\) is the average annual phase deformation rate, \(N\) is the number of interferograms participating in the weighted average calculation, \(\Delta t_i\) is the time baseline of the No \(i\) differential interferogram, and \(\varphi_i\) is the phase value of the No \(i\) differential interferogram. The basic idea of this algorithm is: because the atmospheric signal is random in time, assuming that the ground deformation is linear, when the phase superposition of \(N\) unwrapping interferograms is carried out, the linear signal of the surface increases by \(\sqrt{N}\) times, while the atmospheric phase error only increases by \(N\) times, so the influence of atmospheric phase is effectively suppressed. In addition, this method was once the only way to solve the random atmospheric influence in interferogram, and played an extremely important role in the application of geological disaster monitoring\textsuperscript{[15,16]}.

3.1.2. Stacking-InSAR Data Processing

In the study area, 88 issues of Sentinel-1A satellite data were selected for Stacking-InSAR processing, which resolution is \(5m \times 20m\), and the time span is from January 9, 2018 to December 24, 2020. At the same time, POD (Precise Orbit Ephemerides) data of Sentinel-1A satellite is used to assist Sentinel-1A data preprocessing and baseline error correction. And the AW3D 30 (ALOS Global Digital Surface Model ”ALOS World 3D - 30m”) data elevation model is used to eliminate the terrain phase in InSAR interferometry processing and to assist SAR image geocoding. The horizontal resolution of AW3D 30 DEM data is 30 meters (1 arcsec), and the elevation accuracy is 5 meters. It is one of the more accurate terrain data at present.

| Table 1. Statistics of Sentinel-1A data sources |
|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Date: y/m/d     | 2018/1/9       | 2018/1/21      | 2018/2/2       | 2018/2/14      | 2018/2/26      | 2018/3/10      | 2018/3/22      | 2018/4/3       |
|                 | 2018/4/15      | 2018/4/27      | 2018/5/9       | 2018/5/21      | 2018/6/2       | 2018/6/14      | 2018/6/26      | 2018/7/8       |
|                 | 2018/7/20      | 2018/8/1       | 2018/8/13      | 2018/8/6       | 2018/8/9       | 2018/8/18      | 2018/8/30      | 2018/10/12     | 2018/10/24     |
|                 | 2018/11/5      | 2018/11/17     | 2018/11/29     | 2018/12/11     | 2018/12/23     | 2019/1/4       | 2019/1/16      | 2019/1/28      | 2019/2/9       |
|                 | 2019/2/9       | 2019/2/21      | 2019/3/5       | 2019/3/29      | 2019/4/10      | 2019/4/22      | 2019/5/4       | 2019/5/16      | 2019/5/28      |
|                 | 2019/5/28      | 2019/6/9       | 2019/6/21      | 2019/7/3       | 2019/7/15      | 2019/7/27      | 2019/8/8       | 2019/8/20      | 2019/9/1       |
|                 | 2019/9/1       | 2019/9/13      | 2019/9/25      | 2019/10/7      | 2019/10/19     | 2019/10/31     | 2019/11/12     | 2019/11/24     | 2019/12/6      |
|                 | 2019/12/6      | 2019/12/30     | 2020/1/11      | 2020/1/23      | 2020/2/4       | 2020/2/16      | 2020/2/28      | 2020/3/11      | 2020/3/23      |
|                 | 2020/3/23      | 2020/4/4       | 2020/4/16      | 2020/4/28      | 2020/5/10      | 2020/5/22      | 2020/6/3       | 2020/6/15      | 2020/6/27      |
|                 | 2020/6/27      | 2020/7/9       | 2020/7/21      | 2020/8/2       | 2020/8/14      | 2020/8/26      | 2020/9/7       | 2020/9/19      | 2020/10/1      |
|                 | 2020/10/1      | 2020/10/13     | 2020/10/25     | 2020/11/6      | 2020/11/18     | 2020/11/30     | 2020/12/12     | 2020/12/24     |
During Stacking-InSAR data processing, in order to consider the coherence of SAR data and increase the number of observations, the time baseline should be no more than 48 days and the vertical baseline should be no more than 150m according to the InSAR data processing specification. A total of 200 differential interference pairs are generated, that is, 200 interference maps are generated. At the same time, the annual average deformation rate map of Wenjiagou watershed during the monitoring period is obtained based on Stacking-InSAR technology.

3.2. Optical remote sensing recognition technology

3.2.1. Selection of multi period and multi source optical remote sensing data

Remote sensing data sources have an important influence on remote sensing interpretation. Different data sources have different characteristics. According to the characteristics of the work area, selecting a reasonable data source can maximize the advantages of remote sensing technology. The selection of data source mainly considers the following aspects: A. The data phase and quality must meet the requirements of interpretation. B. The data source with corresponding resolution should be selected for different precision interpretation. C. According to the characteristics of the interpretation content, choose a reasonable type of data source.

Through the analysis of the characteristics and application scope of various satellite data, combined with the characteristics of the study area, the early remote sensing identification of Wenjiagou debris flow hazards selects optical satellite images with resolution better than 1 meter, such as GF-2 and BJ-2. At the same time, the early high-precision historical image and recent UAV aerial image data in the basin were also collected (Table 2).

| Satellite data type | Spectral characteristics | Resolving power | Data time |
|---------------------|--------------------------|-----------------|-----------|
| Google Earth        | RGB3 band synthetic image| Panchromatic 0.5m | 2016/06/07 |
| Google Earth        | RGB3 band synthetic image| Panchromatic 0.5m | 2017/12/30 |
| BJ-2                | RGB3 band synthetic image| Panchromatic 0.8m, Multispectral 3.2m | 2018/04/09 |
| Google Earth        | RGB3 band synthetic image| Panchromatic 0.5m | 2019/01/04 |
| GF-2                | RGB3 band synthetic image| Panchromatic 0.8m, Multispectral 3.2m | 2020/02/06 |
| UAV image           | synthetic image          | 0.2m            | 2020/07/27 |

3.2.2. Image processing and making of optical remote sensing data

Optical satellite remote sensing image processing mainly includes orthorectification, data fusion, geometric correction, tone matching, image mosaic and various enhancement processing functions. The main workflow of optical satellite remote sensing image processing is shown in Figure 4.

Remote sensing data processing mainly includes orthorectification, fusion processing, geometric correction, land registration and mosaic, image enhancement processing, etc. Remote sensing data can be registered into a unified geographic coordinate system for use with other data. In order to enhance the information of geological disasters and regional geological environment background, various enhancement processing technologies are used to process the remote sensing data.

In order to meet the needs of this research work, according to the spectral characteristics of each band of remote sensing image, different band combinations are selected, and the digital image is processed by computer according to a certain mathematical model, that is, the digital image is processed by computer according to a certain image processing function, so as to enhance and extract geological disasters and their environmental geological information. In order to improve the quality of remote sensing image, multi-source, multi-resolution remote sensing data fusion processing and multi-function information extraction are carried out, and the geological disasters and their development environment information needed for this study are extracted to the maximum extent.
4. Early recognition results of InSAR and optical remote sensing technology

4.1. InSAR interferogram interpretation

Through the analysis and interpretation of Stacking-InSAR interferogram, and interpreting suspected deformation areas within the basin. It is found that most of the suspected deformation areas are affected by vegetation, resulting in poor correlation. The suspected deformation areas interpreted by the interferogram should be combined with the subsequent InSAR deformation rate map and optical image for comprehensive interpretation and analysis. The suspected deformation area of the study area according to the interference diagram is shown in Figure 5.
Figure 5. Suspected deformation area of typical Stacking-InSAR interferogram

4.2. InSAR deformation rate graph interpretation

By analyzing the Stacking-InSAR deformation rate map, 14 deformation regions are obtained, and the deformation rate ranges are greater than 10 mm/y and less than 100 mm/y. These 14 InSAR deformation areas have a certain deformation scale, but from the geological point of view, whether the InSAR deformation area is a disaster or not needs to be comprehensively analyzed by combining optical remote sensing and field investigation. Through interpretation analysis, the graphic interpretation results of Stacking-InSAR deformation rate are shown in Figure 6, and the specific deformation information of interpretation deformation area is shown in Table 3.

Table 3 Stacking-InSAR interpretation deformation area in study area

| No. | Longitude   | Latitude   | Area (m²) | Rate of deformation (mm/y) |
|-----|-------------|------------|-----------|---------------------------|
| ID01| 104° 13’17.836”  | 30° 20’54.525”  | 27844.04   | -71~49                   |
| ID02| 104° 13’19.715”  | 30° 21’1.152”  | 13668.21   | -88~55                   |
| ID03| 104° 13’24.809”  | 30° 20’56.575”  | 17897.04   | -97~55                   |
| ID04| 104° 13’24.950”  | 30° 20’48.962”  | 5374.94    | 15~28                    |
| ID05| 104° 13’28.698”  | 30° 20’43.950”  | 14137.35   | 10~29                    |
| ID06| 104° 13’34.538”  | 30° 20’30.976”  | 29228.79   | -76~35                   |
| ID07| 104° 13’19.206”  | 30° 21’7.371”   | 29167.01   | 12~46                    |
| ID08| 104° 13’40.625”  | 30° 21’0.989”   | 8889.99    | 10~19                    |
| ID09| 104° 13’49.587”  | 30° 20’57.877”  | 14887.00   | 10~15                    |
| ID10| 104° 13’49.465”  | 30° 20’46.556”  | 16228.04   | -60~26                   |
| ID11| 104° 14’1.578”   | 30° 20’49.494”  | 30675.08   | -70~30                   |
| ID12| 104° 13’44.954”  | 30° 20’31.737”  | 8060.47    | -58~46                   |
| ID13| 104° 14’9.187”   | 30° 20’42.477”  | 3754.75    | 10~31                    |
| ID14| 104° 14’8.952”   | 30° 20’46.093”  | 7381.50    | 10~16                    |
4.3. Optics dynamic interpretation of typical provenance

Wenjiagou debris flow occurred on July 2, 2019, and its main source is the H05 landslide at the source of the gully. Based on this landslide, the multi-phase optical remote sensing dynamic analysis was carried out.

The Google Earth historical image on June 7, 2016 failed to find obvious slope deformation of H05 in the gully. The vegetation in the gully is dense. There is a local collapse deformation body in the middle and lower part of the gully. The image is light yellow and the degree of deformation is weak.

The Google Earth historical image on December 30, 2017 shows that there are two local collapses in the H05 landslide area, which are gray and white in image and medium in deformation degree. There is a local collapse deformation body in the middle and lower part of the gully, which is light white in image and medium in deformation degree.
BJ-2 image on April 9, 2018 shows that there are three signs of local collapse deformation on the gully source slope in the middle and rear part of the gully. The image is grayish and white, and the deformation tensile crack is formed by the collapse body, and the shape is broken line. There is a local collapse deformation body in the middle and lower part of the gully, which is light white in image and medium in deformation degree.

![Figure 9. Image of BJ-2 on April 9, 2018](image)

The Google Earth historical image on January 4, 2019 shows that the deformation of the slope at the gully source is intensified, and the three landslides in H05 landslide area are gray and white on the image, with strong deformation; There are two local collapse deformation bodies in the middle and lower part of the gully, which are light white in image and medium in deformation degree.

The satellite image of GF-2 on February 6, 2020 shows that the slope deformation mass at the gully source completely disintegrates and forms H05 landslide deformation mass. The image is bright white, and the landslide accumulation mass accumulates in the gully and becomes the source of debris flow. In the middle and lower part of the gully, the landslide accumulation body can be seen rushing out, and the image is yellowish brown, and the shape is irregular long strip.

![Figure 11. Image of GF-2 on February 6, 2020](image)

The UAV image on July 27, 2020 shows that the landslide mass at the gully source accumulates along the gully, part of which is washed out and accumulates along the gully, and cracks develop on the left rear edge of the landslide, which may slide again. The debris flow deposits in the middle and lower part of the gully, and the bright white retaining dam can be seen near the gully mouth.

According to the on-site investigation, in the afternoon of July 2, 2019, affected by continuous heavy rainfall, the slope deformation body at the source of Wenjiagou sliding, inducing landslide, about $20 \times 10^4 \text{m}^3$ loose accumulation body is gathered in Wenjiagou gully. Debris flow is formed under the action of water erosion and washes out along the gully. It accumulates about 180m along the gully, and changes the channel at the elevation of 577m. The formed water rock flow rushes out to the
gully mouth, and a large number of debris flow deposits do not rush out to the downstream gully, forming about 20000m³ debris flow deposits.

4.4. Optical remote sensing interpretation of debris flow

According to the multi-phase dynamic analysis results of H05 landslide, based on the UAV image on July 27, 2020 and the site investigation results, the optical remote sensing interpretation of Wenjiagou debris flow is carried out. The provenance types developed in the basin mainly include landslide provenance, collapse provenance and channel accumulation provenance. There are 16 provenances (5 landslide provenances, 7 collapse provenances and 4 channel accumulation provenances) interpreted and investigated, with a total area of $17 \times 10^4$m². According to the site investigation and empirical formula, the total amount of material source in the basin is about $66.66 \times 10^4$m³, the dynamic source is about $18.43 \times 10^4$m³. The provenance is mainly distributed in the middle of the basin, and the distribution is scattered.
According to the investigation and analysis of the shape of Wenjiagou gully, the development of branch gully and its channel, the variation characteristics of longitudinal gradient of gully bed, the loose material source and activity characteristics in the gully. The debris flow in Wenjiagou gully can be divided into material source area, circulation area and accumulation area. Among them, the ditch bottom elevation is above 540m to the trailing edge watershed is the source area, the ditch bottom elevation 505 to 540m is the circulation area, and the ditch bottom elevation 488–505m is the accumulation area. At present, the accumulation fan is not obvious, mainly from the original Danjing township government office building to the Jiangxi River, and the dike is built on both sides of the channel.

5. Suggestions on engineering treatment and prevention measures

Combined with the development characteristics of Wenjiagou debris flow, the susceptibility and risk of debris flow were evaluated. According to the quantitative comprehensive evaluation method, the susceptibility of debris flow in Wenjiagou is identified. The score of the susceptibility of debris flow in Wenjiagou is 94, which is the susceptibility of debris flow. Combined with the multiphase optical images, the activity of debris flow in the valley is judged by the area-elevation curve (Strahler curve) and its integral (Strahler integral) which represent the geomorphic development period. The elevation-area integral value of Wenjiagou debris flow basin is 0.352, which indicates that the development of Wenjiagou debris flow basin is in the prime of life, and the probability of debris flow breaking out in the valley is higher. In the study, the geological hazard risk analysis method is used to analyze the composition of the debris flow risk index in the study area. The risk index of Wenjiagou debris flow is 2.63, and the risk level is moderate. In this study, the single gully debris flow evaluation method is used to evaluate the risk degree of Wenjiagou debris flow. The risk degree of Wenjiagou debris flow is 0.406, which belongs to moderate risk.

According to the above calculation results, considering that Wenjiagou is a seasonal dry gully, there is only running water in rainy season, which belongs to medium-sized debris flow. The vegetation coverage of the basin is good, and there is no debris flow before 2019. There are a large number of landslide, collapse and gully accumulation sources in the middle of the basin, but the H05 landslide is the main source of debris flow. The slope at the back of the branch trench where the landslide was located was steep and the provenance distribution was relatively concentrated. Therefore, the provenance of the landslide in this area should be stabilized. At the same time, a large number of gully accumulation sources are distributed in the downstream of the gully. Once the upper part of the gully forms debris flow, the lower part of the gully will participate in debris flow activities. The downstream section of the main ditch is relatively wide and gentle with good blocking conditions. Therefore, it is suggested to adopt the governance idea of "Stabilizing material source + Combination of blocking and drainage + Later ecological restoration". The specific proposal is as follows:

5.1. Stabilizing material source + Combination of blocking and drainage

The main treatment measures are: Retaining dam + Check dam + Drainage channel + Solid source project.

1）The main source of debris flow is the branch gully where the H05 landslide is located in the debris flow basin, which may slide again. It is suggested that the source fixation project should be carried out in this area.

2）The main gully in the middle part of the debris flow basin is wide and has the conditions to build a retaining dam. It is suggested to build a retaining dam in the middle and lower part of the gully to block the debris flow in the branch gully, and build a retaining dam in the open part of the lower part of the main gully.

3）The ditch channel of the debris flow is narrow, and some are heavily silted. The houses on both sides are densely constructed and it is difficult to be wide. It is suggested that the gully should be raised and cleaned.

5.2. Later ecological restoration
Vegetation was restored by planting grass and trees on the bare mountain in landslide and gully provenance area.

Figure 16. Layout plan of proposed treatment project

6. Conclusion

Taking Wenjiagou debris flow in the Eastern New Area of Chengdu City as an example, the paper studies the early identification of hidden debris flow geological disasters in low mountain red bed area, and discusses the deformation characteristics of Wenjiagou debris flow by using InSAR technology and optical remote sensing technology. The main achievements are as follows:

1）The deformation monitoring of Wenjiagou debris flow is carried out by using Stacking-InSAR technology. 14 InSAR deformation areas are interpreted, and their deformation rate ranges are greater than 10 mm / y and less than 100 mm / y.

2）The dynamic monitoring of H05 landslide, the main material source of Wenjiagou debris flow was carried out by using multi-stage optical remote sensing images. It was found that the landslide began to deform continuously in 2017 and disintegrated in the rainy season in 2019, becoming the material source of debris flow.

3）According to the deformation characteristics of H05 landslide, based on the UAV image and field investigation in 2020, 16 provenances (5 landslide provenances, 7 collapse provenances and 4 gully provenances) of Wenjiagou debris flow were interpreted, with a total area of $17 \times 10^4$ m$^2$. According to the field investigation and empirical formula, the total amount of material source in the basin is about $66.66 \times 10^4$ m$^3$, the dynamic reserve is about $18.43 \times 10^4$ m$^3$. Among them, H05 landslide is the main source and controlling source of debris flow, which is mainly controlled by stratum lithology and geological structure.

4）As the material sources of landslide in Wenjiagou are mainly distributed in the middle and upper reaches of the landslide, the material sources are relatively concentrated, and the material sources of the gully are distributed in the wide and gentle flow area of the gully. There are many
material sources involved in the debris flow activities in the gully. Therefore, it is suggested to adopt the management idea of "Stabilizing the material sources + Combination of blocking and drainage + Later ecological restoration".

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