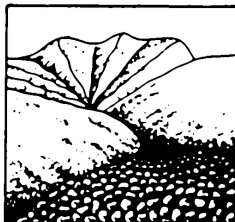


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СЕЛЕВЫЕ ПОТОКИ: катастрофы, риск, прогноз, защита

Пятигорск, Россия, 22-29 сентября 2008 г.



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Determination of the density of a debris flow by its deposition

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Определение плотности селя при отложении селевой массы

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Плотность селевых потоков - один из наиболее важных параметров, поскольку она используется для оценки и предотвращения селевой опасности. В этой статье проанализированы доли грубой фракции (> 2 мм) и тонких частиц (<0,05 мм) для установления связи с плотностью селевых потоков. Метод определения плотности был основан на соотношении долей этих фракций. Сравнение плотности образцов из идущего селя с плотностью образцов, отобранных в селевых отложениях, показало хорошую и умеренную корреляцию. Установленная зависимость также хорошо применима для нескольких последовательных волн селя в данном русле. Увеличение процента грубообломочных частиц в образцах отложений слабо когерентных селевых потоков было связано с сортировкой отложений. Чтобы внести поправку на повышенный процент грубой фракции в образцах отложений, необходимо не учитывать грубую фракцию (>5 мм). Анализ показал, что обрабатываемые образцы нескольких слабо когерентных селей имеют хорошую сопоставимость с плотностями, вычисленными с поправкой на распределение фракций и с улучшением методики исследований.

The density of debris flows is one of the most important parameters as it is used in hazard evaluation and prevention. In this paper, the percentages of coarse particles (>2mm) and fine particles (<0.05mm) were analysed to find their relationship with the density of debris flows, and consequently the method for determination of density of debris flows was developed. Comparing the measured densities of real-time samples and deposit samples of debris flows with the calculated densities by the percentages of coarse particles and fine particles, we have obtained consistent correspondence for strongly and moderately coherent debris flows. The correspondence is also good for the measured densities and calculated densities of real-time samples of weak coherent debris flows. Most percentages of coarse particles in the deposit samples of weak coherent debris flows were aggrandized due to deposit sorting of weak coherent debris flow. To correct the aggrandized percentage of coarse particles in deposit samples of weak coherent debris flow, we have to ignore the coarse part of >5mm. The measured densities of deposit samples of weak coherent debris flows are in good consistency with the densities calculated by the improved method of corrected particle distributions.

1 Introduction

The density of debris flows is one of the most important parameter of debris flows as it is used in the evaluation and prevention the hazards of debris flows. The density of living sample could be determined directly by measuring the volume and weight. But determination the density of deposit sample is much more difficult. Recently the research on determination density of debris flow by its deposition has a few progress, such as use the percentage of coarse particle: particle size >2 mm (Du et. al., 1987), or the D_{50} : the medium size of particle (IMDE, et. al., 1995), and the percentage of clay: particle size <0.005 mm (Chen et. al., 2003). But these methods have error as the different characteristics at different regions, in particular the error is quite large for the weak coherent debris flows. In this paper, the new method of determination the density of debris flow by the percentage of the coarse particle and fine particle was given by a few series of observation of debris flows. Comparing the measuring densities of deposit samples of debris flows with the calculating densities by the new method, it is good consistency.

2 Deposition and particle characteristics of debris flows

This study does not include mud flow and stone-water debris flow. There are many methods to classify debris flow, but the most popular method is classifying by density (Fei and Su, 2003). The debris flows were classified to strongly coherent, moderately coherent and weak coherent, and their density range are >2.0 g/cm³, 1.8-2.0 g/cm³ and 1.5-1.8 g/cm³, respectively (Fei and Su, 2003, Marr, et al., 2001). There is no deposit sorting for the strongly coherent debris flow, weak deposit sorting for the moderately coherent debris flow and deposit sorting for the weak coherent debris flow.

The particle size of debris flow has large range. The coarse particle are those >2 mm particle. In the strongly and moderately coherent debris flow, the concentration (the weight in per cubic meter) of <2 mm particle is almost the same. The fine particle are those <0.05 mm particle. In all kind of debris flows, the concentration (the weight in per cubic meter) of fine particle is almost the same (Fei and Su, 2003).

3 Determination density by particle distribution of debris flows

The relationship of density with percentages of coarse particle and fine particle in living samples was analyzed. From the relationship of 10 different debris flow gullies in China, the density of debris flow could be determined by the percentages of coarse particle and fine particle of debris flow:

$$\gamma_D = P_{05}^{0.35} P_2 \gamma_V + \gamma_0 \quad (1)$$

In which γ_D = the density of debris flow; P_{05} = percentage of fine particle (<0.05 mm, in digit), P_2 = percentage of coarse particle (>2 mm, in digit), γ_V = the minimum density of strongly coherent debris flow, 2.0 g/cm³, γ_0 = the minimum density of debris flow, 1.5 g/cm³.

Fig.1 shows the measuring densities and densities calculated by Eq.1 in living samples. γ_C is the calculating data and γ_m is the measuring data. The data of living samples are from 10 different debris flow gullies in China. Fig.2 shows the measuring densities and densities calculated by Eq.1 in deposit samples. S.C.D.F., M.C.D.F. and W.C.D.F. are the strongly, moderately and weak coherent debris flow, respectively. The calculating densities are good consistency with the measuring densities except the densities of deposit samples of weak coherent debris flow.

4 Determination the density of deposit sample of weak coherent debris flow

The characteristics of deposit sorting of weak coherent debris flow make the coarse particle deposit around the upstream of fans, the fine particle deposit at the downstream of fans or flow into the main river. So all the deposit samples of weak coherent debris flow are not the full particle distribution: either too much coarse particle, or too much fine particle.

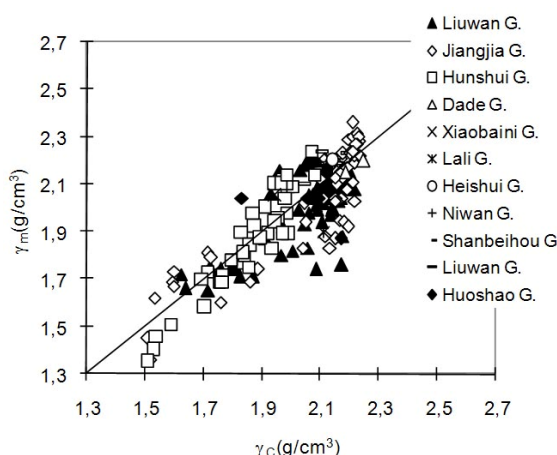


Fig.1. Comparing the calculating densities and measuring densities of living samples.

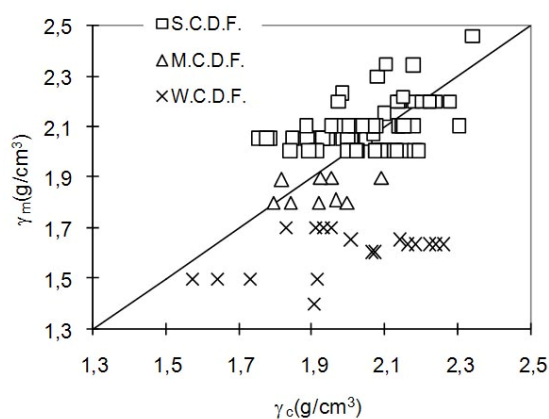


Fig.2. Comparing the calculating densities and measuring densities of deposit samples.

The main characteristics of deposit of weak coherent debris flow are line structure, imbricated structure and gravel supporting. These depositions structure happen at the upstream of fans and deposit samples are often taken around there. These deposit samples of weak coherent debris flow have much more coarse particle than they are. So the densities calculated by these particle distributions of samples are larger than the densities measured. Fig.3 shows the particle distributions of living and deposit samples of weak coherent debris flows. The percentages of >5 mm coarse particle in living samples are almost less than 10%. Only minority of deposit samples are similar with the living samples, and the less percentage of >5 mm coarse particle is, the better consistency of the measuring densities and calculating densities is. The majority of deposit samples have too much coarse particle and the percentages of >5 mm coarse particle are between 42.6–82 %. The more percentage of >5mm coarse particle is, the worse consistency of the measuring densities and calculating densities is. Most percentages of coarse particles are aggrandized as the deposit sorting of weak coherent debris flow. To correct the aggrandized percentage of coarse particle in the deposit samples of weak coherent debris flow, delete the coarse part of >5 mm is necessary. Although the part of >5 mm coarse particle is almost less than 10% (as in living samples), the corrected particle distributions are different with the real particle distributions. To get the reasonable calculating densities by deposit samples, the Eq.1 should be corrected for the weak coherent debris flow:

$$\gamma_D = P_{05}^{0.35} P_2 \gamma_V + \gamma_X \quad (2)$$

In which $\gamma_X = 1.4 \text{ g/cm}^3$, the particle distribution is the corrected distribution (<5 mm), and the percentages of coarse and fine particle are the corrected percentages.

Fig.4 shows the measuring densities and densities calculated of deposit samples by Eq.1 and Eq.2. The results of weak coherent debris flows calculated by Eq.1 are larger than their measuring densities, and some of them are too large. But the results calculated by Eq.2 and the corrected percentages are good consistency with their measuring densities.

5 Conclusions

1. The percentages of coarse particle and fine particle have relationship with the density of debris flow. For the strongly and moderately coherent debris flows, the densities calculated by the percentages of >2 mm coarse particle and <0.05 mm fine particle are good consistency with their measuring densities both in living and deposit samples. For the weak coherent debris flow, the calculating densities are good consistency with their measuring densities in living samples.

2. To correct the aggrandized percentage of coarse particle in the deposit samples of weak coherent debris flow, delete the coarse part of >5 mm is necessary. For the weak coherent debris flow, the densities calculated by the corrected equation and corrected percentages are good consistency with their measuring densities of deposit samples.

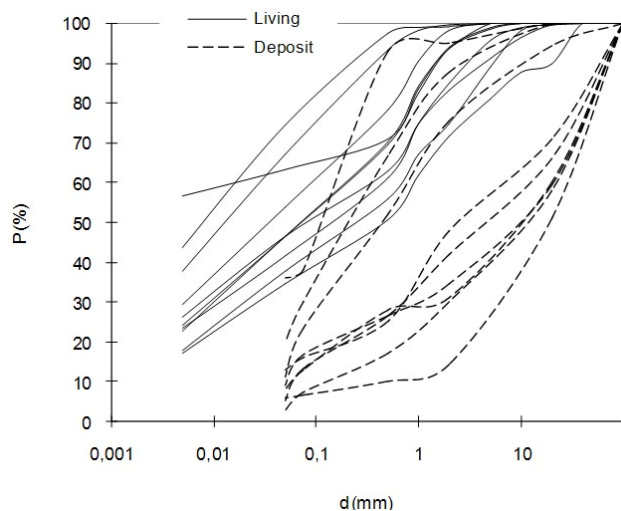


Fig. 3. Particle distributions of weak coherent debris flows.

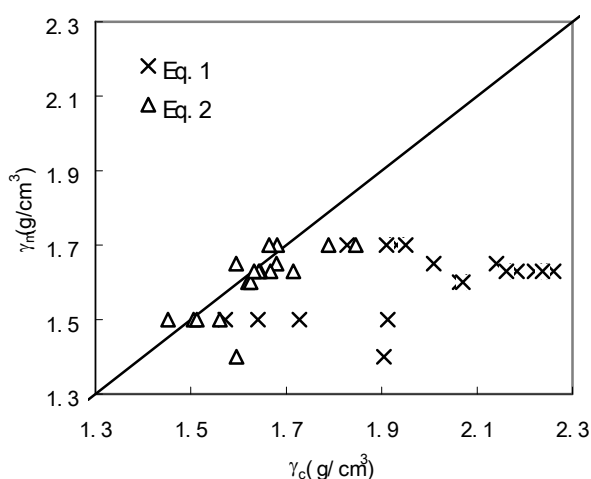


Fig. 4. Comparing the calculating densities and measuring densities of weak coherent debris flows by Eq.1 and Eq.2 of deposit samples.

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