

MASS WASTING IN SONG AREA OF THE HAWAL BASEMENT, NE NIGERIA

N. E. BASSEY

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ABSTRACT

A phenomenal mass waste incident was reported in Song area of Adamawa State in May 2003. The incident took place at a geomorphologic landmark called the Three Sisters Hills. The area is a metamorphic terrain, with Pan African granitoids occurring as intrusives. Basaltic flow is widespread with exposures along stream courses. Investigation reveals that the mass wasting is caused by a combination of lithological, structural, topographic, climatic and organic factors. Implications of the incident, and mitigation measures to avoid risks of loss of lives or property in the event of future occurrence are presented.

KEYWORDS: lithology, structure, faults, rock slide.

INTRODUCTION

In May 2003 a report was received from the office of the Chairman Caretaker Committee, Song Local Government in Adamawa State, by the Special Services Department of Government House Yola indicating that at about 2.00pm on Wednesday 21st May "one of the Three Sisters rocks at Song cracked from the top to the bottom" The report further stated that "the rock which produced a loud and frightening sound shocked the whole town" The Geology Department of the Federal University of Technology, Yola was subsequently engaged to investigate the incident. It was found that the "crack" was due to exfoliation, and "loud sound" was produced by the impact of a rock fall. A Report (dated 2003) titled "The investigation of the Three Sisters' Hills at Song, Song L.G.A., Adamawa State" on the incident had since been submitted to the appropriate government authorities. It is reported that a similar incident at the same site took place in 1993 (C. J. Dio personal communication.). Mass wasting is a hazardous geological phenomenon. Its effect could include destruction to buildings, supply lines, roads, farmlands and even loss of lives. Holmes (1981) enumerated some conditions which trigger mass wasting. These include:

- a) Lithological factors (unconsolidated or weak material or those which become slippery when wet).
- b) Structural factors (closely spaced joints or faults, crushed zones, shear zones, foliation planes).
- c) Topographic factors (steep slopes or vertical cliffs)
- d) Climatic factors (abundant precipitation and torrential rains).
- e) Organic factor (scarcity of vegetation).

Besides the above, human activities that involved ground vibrations (such as operation of heavy machinery and rock blasting during quarry operations or road construction) may serve as triggers to mass wasting. Examples of devastating mass wasting reported in Nigeria are hill slope wash and rock avalanche in Nandu area, Jema'a, in Kaduna State (Oluyide and Okunloja, 1993), and the rock avalanche of southeastern part of Imo state reported by Okagbue (1988).

This study is an attempt to present the Song mass wasting in the light of existing physiographic and field structural data. Recommendations to minimize its effects in the event of future occurrence are presented.

GEOGRAPHY

Location

Song and area lies between Longitudes 12° 35' E and 12° 40' E and Latitudes 9° 48' N and 9° 52' N (Fig.1). The Three Sisters' Hills are located along the Song – Gombi road behind the Local Government Secretariat. Near to the Three

Sisters' Hills in Song town are: a functional daily market, motor park, health clinic, secondary and primary schools etc. Several footpaths and cattle routes traverse the area. Song is the gateway to the northern cities in Adamawa state.

Climate

Like in most middle belt regions of Nigeria two main climatic seasons are experienced in the area, each about six months duration. The dry hot (with a short duration low temperature or hamathan period) and dusty season commences from November to April. The rainy season with moderate to high intensity precipitation commences from April and lasts till October. The peak period of the rains is July-September.

Relief

The Three Sisters' Hills occur isolated but are part of a group of hills located at the southern part of Hawal basement in NE Nigeria. Some of the hills occur as ridges like at the NE of the study area (Vande Sawim hills) and at Agurvula in the NW. Other hills are found at Mudore and Tapare. The lowest elevation ranges from 300 m to 333 m, while the highest peak lies at about 646 m above mean sea level. The elevation of the land surface generally increases northwards, with several of the hills marked by steep straight slopes caused by exfoliation and/or tectonism (Plate.2A). The Three Sisters' Hills occupy a surface area of approximately 1.5 km². They are highly and irregularly fractured, and have evolved through tectonism and exfoliation, with the screes and boulders accumulating at the foot of the hills. Fresh surfaces exposed by exfoliation are found on the slopes. The sizes of the disintegrated boulders/fragments vary, mostly measuring several metres in diameter and weighing several tonnes. Thick wooded vegetation grows on the screes/soils found at the foot of the hills. It is apparent that the tree roots penetrate through fracture and joint planes and have contributed to rock disintegration and weathering in the area. The study area generally has sparse tree growth but lush grassland especially in the rainy season.

Drainage

The area is well drained by a network of streams whose courses are obviously controlled largely by geologic structures. Most streams have straight channels and flow N-S, NW-SE, or NE-SW. The major streams in the area have their origin northwards and outside of the study area, where there are many hills. They then flow southwards along narrow channels. River Song follows a NNW-SSE course and flows through the central part of the area. This river and others to the east and west of it form essentially parallel to sub parallel drainage configuration (Fig.1).

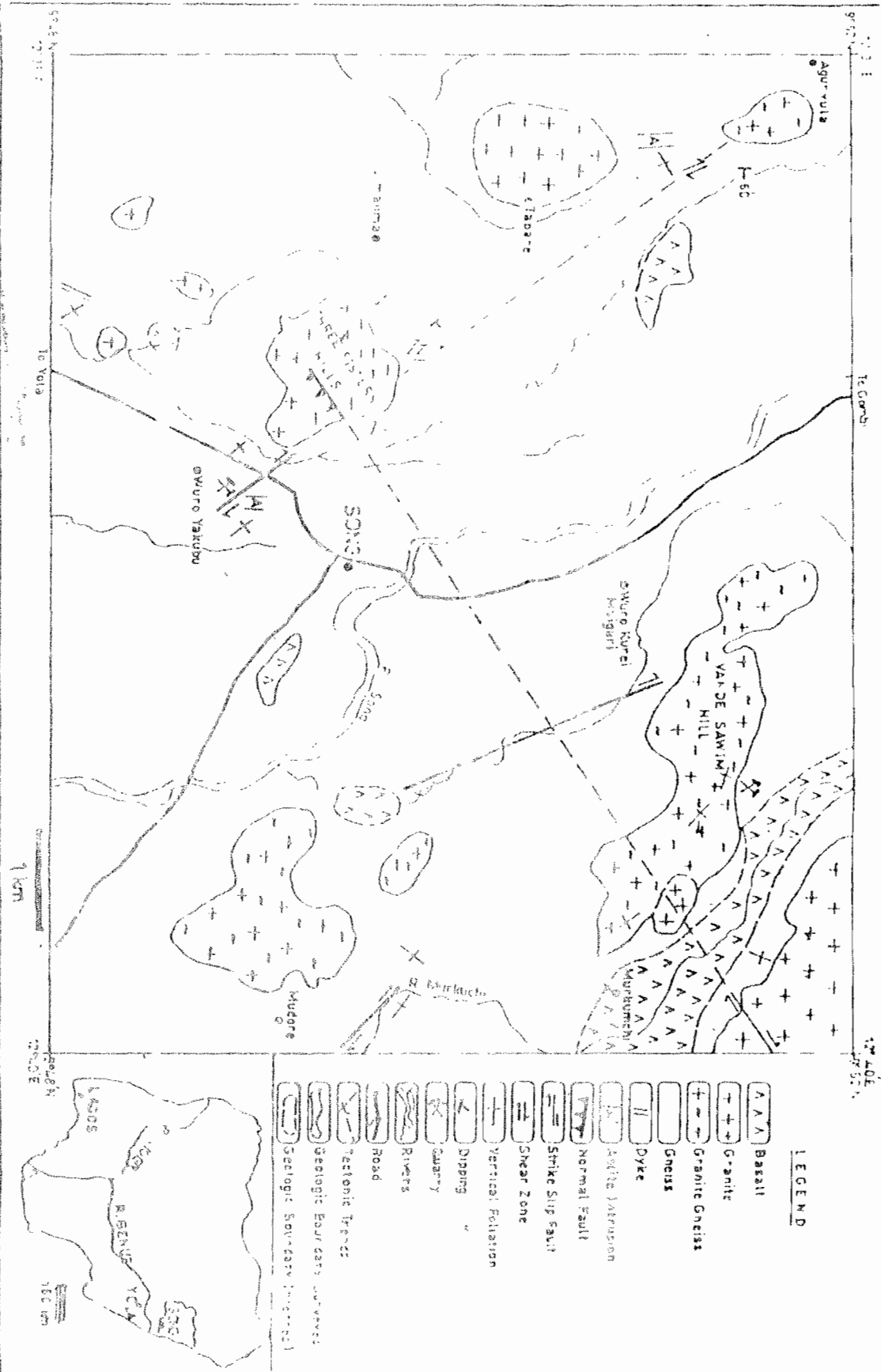


Fig. 1: Geological map of Song area, Nigeria showing the location of study area

GEOLOGY

Lithologies

The geology of the area has been presented by Adekeye and Ntekim (2004) and Bassey (2005). According to these authors, the major group of rocks found are gneisses, migmatites, and granites. Gneisses are the dominant rocks and are highly intruded by a series of granitic, pegmatitic and some basic intrusions. The gneissic rocks consist of varieties of predominantly granitic composition and textural variation. The rocks exhibit variable colour, due largely to the type and proportion of mafic or feldspar mineral content. The mafic minerals are mainly biotite and hornblende. The rocks exhibit

varying degrees of foliation trends (10°, 40°, 95°, 120°, and 160°) and dip (22° - 44°). Thirty seven foliation trends were measured in the field and their rose plot is shown in Fig. 2A. The main trend is 135° which is the NW-SE direction. The rocks have varying sizes, amount and orientation of feldspar porphyroblasts which range between 2 cm - 2.5 cm in width. The rocks are banded in some cases, while there are no such bands especially where biotite content is high. The rocks grade into migmatite gneisses in places. Petrologically, Song gneisses consist of granite gneisses, transition gneisses, porphyroblastic gneisses, agmitic and vein types

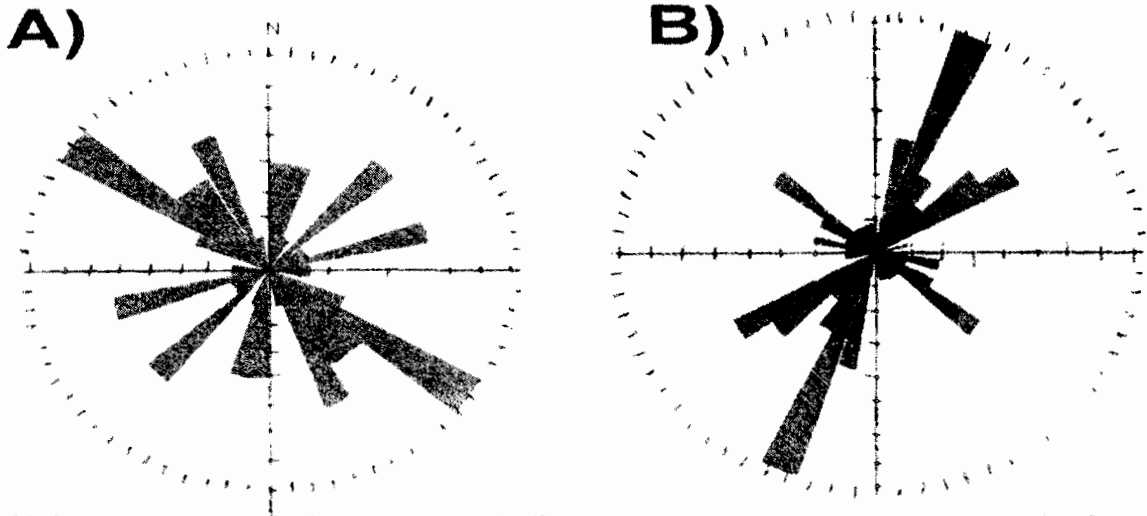


Fig. 2A: Rose diagram plot for foliation (n = 37, B); Rose diagram plot for dykes and veins (n = 41) in Song area

Granites occur as intrusives in the gneisses. They occur as bodies of considerable sizes with lithological variations including aplite and amphibolites. Plate 2B (top left) is a field photograph of part of an aplite intrusion in the area. Exposures of aplite and amphibolite are found in the abandoned quarries at Wuro Yakubu and Vande Sawim hill. The granites are generally coarse grained and compact, outcrops are found at

various locations including the Three Sisters' Hills. A medium grained variety is found at Tapere. There are numerous pegmatitic and aplitic veins criss-crossing the rock surface. The feldspar porphyroblasts which vary from pinkish microcline to whitish oligoclase are fairly well aligned to a N-S regional trend.



Plate 2a: Top, east view of Three Sisters' Hills showing mass wasting on the slopes, Bottom, rock fracturing and other mass wasting scenes on the Hills.

Basalt flows are superfluous in the area and are part of the Cameroon Volcanic Line outcropping in Nigeria (Fitton, 1980, 1982). Significant exposures are found along river channels especially River Murchumchi at the northeast of the

study area Plate 2B (top middle and right) are field photographs of basalt exposures along Murchumchi river channel. The basalts are generally vesicular in texture and the amygdaloidal variety is common



Plate 2B: Top left; part of an aplite intrusion at old Wuro Yakubu quarry. Middle and top right photographs show exposures of basalt along River Murchumchi channel. Bottom photographs show N-S and E-W trending fault planes in Song area.

Structure

Fourteen faults were observed during field mapping exercise. Only the major ones are shown for the purpose of clarity on the geological map of the area (Fig. 1). Two outcrops of fault planes in granites are shown in Plate 2B (bottom). The recognition of the faults was done following some criteria described by Billings (1972), and Hobbs et al. (1976). They

are discontinuities of structures (dykes or veins) across fault planes, presence of slickensides and lineation on the fault plane, and physiographic criteria such as presence of scarps and offsets of streams. The observed faults are either normal or strike slip faults. The types of faults and their structural characteristics are shown in Table 1

Table 1: Faults types and attitudes in Song area

S/No	Location	Strike	Dip	Plunge of lineation	Sense of movement	Type of faults
1	Three Sisters' hills slope	90°	79°	-	Vertical	Normal
2	NE granite hill	180°	65°W	-	Vertical	Normal
3	Vande Sawim hill	90°	90°	-	Vertical	Normal
4	Quarry north of Wuro Yakubu	110°	90°	30°W	Tateral (E-W)	Strip slip
5	"	132°	90°	30°W	Tateral (E-W)	Strip slip
6	"	128°	90°	20°SE	Tateral (NW -SE)	Strip slip
7	"	100°	75°S	40°W	Tateral (E -W)	Strip slip
8	"	130°	90°	65°SE	Tateral (NW -SE)	Strip slip
9	"	10°	56°W	-	Vertical	Normal
10	"	125°	70°	80°	Vertical	Normal
11	Along river channel east of Wuro	160°	-	50°SE	Tateral (NW -SE)	Strip slip
12	Kurei Maigari NE granite hill	40°	-	-	Tateral (NE -SW)	Strike slip
13	Top of Three Sisters hill	40°	-	-	Vertical	Normal
14	River course north of Mudore	140°	-	-	Lateral (NW - SE)	Strike slip

One hundred and forty two shear zones were observed in the field and their strikes measured. A histogram of trends and distribution of the shear zones is presented in Fig.3. The histogram shows a bimodal plot with peaks along N-S direction (0-20°) and NW-SE (120°-140°). NW shearing is dominant (120° -160°) constituting approximately 31% While N-S shearing constitutes 19% of the observed shear zones

So NW-SE, and N-S shear deformations constitute 50% of all shear zones in the area. Shearing and faulting in the area are intimately related as some of the faults were initiated by shear deformation. Folds are found on the gneiss at the foot of Vande Sawim hill. Here open and tight folds affect the gneissose and granulose layering of the gneiss.

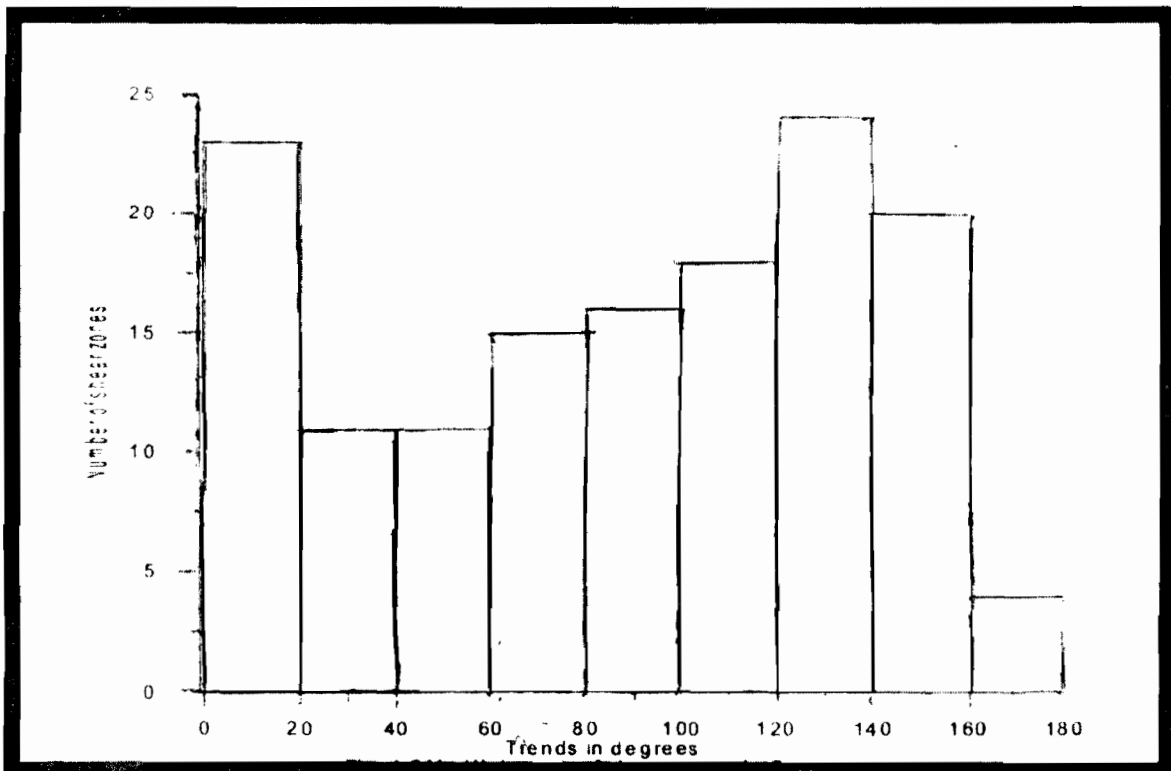


Fig. 3: Histogram of trends and distribution of shear zones in Song area (n = 142).

Linear structures in the area are expressed by parallelism of some directional property of the rocks. These are found in the form of amphibolite boudins, quartzo-feldspathic boudins, rods, and striations on fault surfaces. These structures are observed in the gneiss close to Wuro Yakubu. Here ellipsoidal amphibolite boudins are found concordant with rock foliation direction along 150°.

Joints are expressed in all rock types, and the basalts exhibit columnar joints. Open, orthogonal and systematic joints are found at the east slope of the Three Sisters Hills. The study area has a density of 40-60 kilometres of fractures per square kilometre (Consulint Nigeria Ltd and Consulint International s.r.l., Rome, 1973).

Dykes and veins are common features in the area. To the north of the Three Sisters' Hills the gneissic rock is intruded by quartzo-feldspathic dykes and veins whose widths vary from 4 cm - 50 cm. Their strikes are concordant or discordant to rock foliation depending on the period of emplacement. The emplacements of the dykes in this place are fault controlled or their emplacements were guided by existing shear zones. At the quarry at Vande Sawim hill there are numerous criss - crossing dykes. Pegmatitic and aplitic dykes are found in places such as Murchumchi, Wuro Yakubu quarry, and south of Agurvula. The widths of the dykes vary from 5 to 15 m. Width of veins is about 4 cm. The rose plot of the trends of forty one dykes and veins is shown in Fig 2B. The dominant trend is in the NE-SW direction.

DISCUSSION

It is obvious from the account of what happened in Song that the factors enumerated by Holmes (1981) contributed to the mass wasting. This phenomenon is a combination of rock slide (involving a descending mass of rock which remains relatively coherent) and rock fall (involving a material falling freely or bouncing off a cliff).

The Three Sisters' Hills are a group of granitic plutons whose emplacement had been influenced by rock structure (foliation). The SE arm of the hills trend in the NW-SE direction (Fig.1). Granite by itself is a competent rock, but the area of occurrence of the hills has been subjected to tectonic deformations. At least two major tectonic trends pass through the Three Sisters' Hills (Fig.1), with the NE-SW trend terminating as a normal fault on the hills. The strike slip fault at Wuro Yakubu can be traced across Song - Gombi road, through the Three Sister's Hills extending as a shear zone to the NW of the study area. A third trend (N-S) could be inferred from the directions of N-S flowing stream in the vicinity of the hills. Some of the boulders are produced by mechanical fragmentation of the rocks.

The heavy rains that occur in the wet seasons serve to lubricate the contacts between boulders and rock surface, thus reducing friction between them and enhancing slide down the steep slopes under gravity. The reported case of mass wasting took place during a rainy month. Vegetation can hinder slide as their roots tend to consolidate soil. In the absence of vegetation the soil is easily eroded by rain water which carry down rock boulders. The occurrences of boulders on the hills constitute the lithological factor which enhance sliding.

CONCLUSION AND RECOMMENDATIONS

The rocks in the study area are highly fractured due mainly to tectonism. The tectonic trends are NW-SE, NE-SW, N-S, and E-W. These have produced faults, shear zones, joints, folds etc. Fracture planes provide favourable avenues for penetration and lubrication by rain water. With little or no vegetation present uphill to hinder erosion, the rain water erodes down slope the little soil that form. A combination of these factors cause mass wasting on the Three Sisters' Hills.

Due to its unpredictable nature and the colossal effects mass wasting cause to life and property, the following

recommendations are made and their implementation by Environmental Protection Agency is considered worthwhile.

Settlements should be sited far away from the foot of the hills. The Song Local Government secretariat building should be relocated. Hunting and bush burning should be regulated in the area, as bush burning which often accompanies hunting exposes the slope to severe denudation and exfoliation of underlying rocks. Operation of heavy vibrating machines in the vicinity of the hills should not be allowed to avoid triggering of rock falls. Quarrying of rocks in the vicinity of the hills should not resume as the operation involves rock blasting which creates shock waves and vibrations.

ACKNOWLEDGEMENT

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