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# A CROSS CULTURE STUDY: IDENTIFYING LANDFORM PATTERNS OF AREAS PRONE TO POST-FIRE DEBRIS FLOWS IN COLORADO FRONT RANGE IN LIGHT FENG-SHUI



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## **Identifying Landform Patterns of Areas Prone to Post-fire Debris Flows in Colorado Front Range in Light Feng-shui**

### **Synopsis:**

Using feng-shui, Chinese geomancy, as a clue, the author identified landform patterns in field investigations in Colorado and compared them with geomorphic knowledge. This research found significant agreement between feng-shui principles and geomorphic concepts in identifying landform patterns of post-fire debris flow zones. In particular, dry washes play a significant role in generating debris flows. This cross-culture research could benefit site selection processes and evacuation strategies.

## **A CROSS-CULTURAL STUDY: IDENTIFYING LANDFORM PATTERNS OF AREAS PRONE TO POSTFIRE DEBRIS FLOWS IN COLORADO FRONT RANGE IN LIGHT OF *FENG-SHUI***

*This research attempts to explore the landform patterns apparent in the debris flow zones of the historic 2013 Colorado floods, using feng-shui as a clue. In feng-shui, Chinese geomancy, the form school, in particular, provides landform criteria used to select the favorable sites and to avoid risk areas. Debris flows involve the combined factors of landforms, climate, vegetation, soil, and postfire erosions. Increasing populations and frequent fires in the Colorado Front Range have changed the vulnerable mountain systems and increased debris sources and erosion. This research found significant agreement between feng-shui principles and geomorphic concepts in identifying landform patterns of debris flow zones. These patterns can be described in three areas: 1) the debris and runoff catchment; 2) the flow track that generates the speed and power of the debris flow as it proceeds downstream; and 3) the flow fan, the receiving area of the debris flow. In particular, dry washes and straight alignments, which feng-shui calls the "hidden arrow," play a significant role in generating debris flows. Moreover, Colorado high-impact zones often experience a fire before the debris flow. Mountain fires burn the forest and change the soil structure. When it rains heavily, runoff is mixed with debris, mud, and large timbers, leading to hillside erosions, significantly accelerating and intensifying the debris flow process. This cross-cultural research could benefit site selection processes, planning efforts, and mitigation strategies to avoid building in risk areas and aid in natural disaster evacuation in the Colorado Rocky Mountains and other high elevation areas.*

**Keywords:** *feng-shui, debris flow, landform patterns, straight dry wash, postfire debris flow sequence*

### 1 INTRODUCTION

Extreme climate patterns in recent decades have often led to natural disasters. A week of heavy rain, from September 9<sup>th</sup> to 15<sup>th</sup>, 2013, over complex mountain terrain and steep landforms caused historic floods in the Colorado Front Range. The violent power of the floods destroyed homes and infrastructure, wiped out small towns, rerouted water channels, and took several lives. Every high impact area involved debris flows, which washed into the water channels, damming them and causing the water to rise even further. These debris flows devastated communities that had already been impacted recently by fire. Homes built in debris flow impact zones demonstrate the lack of knowledge and limited warning systems concerning such hazards.

Debris flows are regarded as one of the most dangerous natural hazards [9] and are often referred to by the media as "mudslides," "mudflows," or "flash floods." It is different from a "spring runoff" flood, which usually involves water rising from spring snowmelt that runs over the bank and floods the land. Debris flows begin with a dense combination of mud and stone, which increase in solidity, concentration, and size when proceeding downstream and finally develop into a fast-moving debris flow [2]. During intense and heavy rain, a debris flow can gain great power, especially when originating at higher elevations. Debris flows can reach speeds of up to 100 mph, and the initial debris walls can be up to 30 feet tall [4]. There can be major and minor debris flow events. Major debris flows have often been recognized and mitigated by scientists and local governments [3]. The minor debris flows typically occur within local hills and can go unnoticed. All types of debris flows have the potential to be deadly.

Debris flows following wildfires are common. According to Wells, the surface soil on a burned slope is loosely compacted and easily wet-able. This water-repellent layer is formed by burned organic molecules that coat the soil particles and create a barrier for water to filter into the regolith. When it rains, pores between the loose soil begin to fill with water. The water in the pores puts downward pressure on the soil and causes a structural failure, excavating a rill. Surface water flows into the rill and runs downstream [18]. This “hydrophobic” layer in the ground – a kind of crust that repels water like glass [1] – accelerates the erosion process, often leading to a catastrophic disaster.

When a fire burns vegetation from the mountainsides, it kills the groundcover and loosens debris. After two years even the roots have died. During heavy rains, the dead trees fall more quickly, levering out the soil and producing further debris. The dead timber washes into the debris flow, further generating power. Sometimes they can form a weapon, “shooting” anything in their path. Reneau and Dietrich’s geomorphic research indicates that in a debris flow, a large amount of heavy timber causes landslides and the destruction of property [10].

Colorado debris flow events involve a combination of factors. Many characteristics of the Rocky Mountain region, including steep slopes, exposed bedrock, thin soil, and shallow tree roots, provide abundant debris sources. Extreme mountain weather patterns are also an important factor. Intense thunderstorms with lightning can spark forest fires. The Chinook winds and the highest peak gusts in the nation can spread fire rapidly over thousands of acres. The increasing residential population, dense development, and frequency of fires in the mountains have changed the vulnerable systems on the steep hillsides, generating debris and accelerating erosion. These abundant debris sources can cause debris flow with consistent and intense rains.

This research method includes text studies of geomorphology and field investigations in the canyons of the Colorado Front Range, using *feng-shui* as a clue. *Feng-shui* is an ancient Chinese practice used to harmonize people with their environment. The author has lived in the Boulder mountain community for over 20 years and has experienced three evacuations for fires and once during the 2013 floods. As a professor and *feng-shui* consultant, the author uses a cross-cultural study with *feng-shui* in identifying landform patterns of debris flow zones.

## 2 USING *FENG-SHUI* AS A CLUE

Chinese populations have inhabited mountain regions for thousands of years. Today, about 1.3 billion people, as well as two-fifths of the cultivated land, are distributed in the mountainous areas of the country. China has a long tradition of recording debris flows that have destroyed villages and killed tens of thousands of people, dating from 186 BC to the current time [3]. These mountain disasters have been crucial in teaching people how to avoid residing at the areas prone to debris flows and adequately select favorable sites that are optimal for survival.

China’s survival experiences for over thousands of years are primarily summarized in the *feng-shui* practice. *Feng-shui* is practiced to select good timing, a suitable place, and supportive partners to sustain people’s lives and societies. *Feng-shui* has many schools; particularly prominent is the “form school,” which deals with landforms of special categories, including “mountains,” “hills,” “water,” “site,” and “orientation,” to select favorable sites and avoid disaster. *Feng-shui* methods practice on multi-scales, large to small, looking from mountain ranges to cities, as well as homes and even graveyards. When dealing with the increasing hazards in mountainous areas, some vernacular siting methods may provide wisdom. Adaptations to natural laws are directed towards enhancing life by promoting harmony between humans and nature [6].

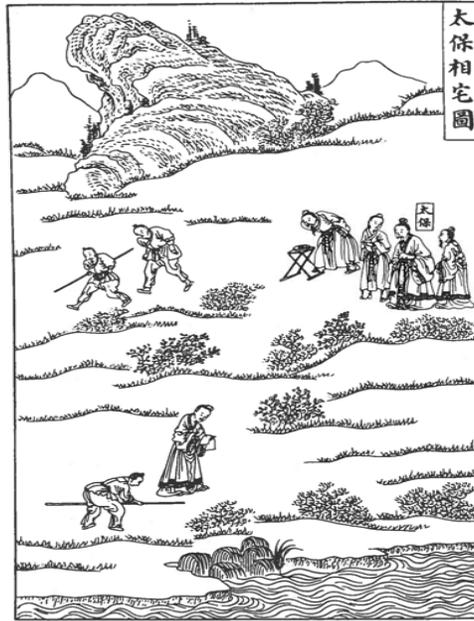


Figure 1: A late Qing Dynasty illustration of the practice of selecting a townsite, which is an excellent example of the *feng-shui* approach [5]. In this picture, the official is leading a group: a *feng-shui* master consulting his compass, another checking the *feng-shui* manual, and the workers analyzing the soil and water.

### 3 IDENTIFYING LANDFORM PATTERNS IN FIELD INVESTIGATIONS

For four months in 2014, the field investigations used *feng-shui* as a clue in examining the historic 2013 flood impact areas in the canyons along the Colorado Front Range, from mountain ranges to single sites. The fieldwork also included interviews with residents. Each of the high impact areas investigated in the mountains involved a debris flow event. These high impact zones and their surrounding landscape are the basis for this research. Though destructive, the historic 2013 flood in Colorado provides a unique opportunity for research on mountain flooding, demonstrating the evidence of impact zones.

According to geomorphic research, there are three main debris flow zones. The first zone is the debris catchment area, which provides an abundant debris source. The second is the debris flow track; these are the landforms that generate the speed and power of the debris flow as it proceeds downstream. The third zone is the debris flow fan, which is the receiving area of the debris flow [8, 9, 10]. These geomorphic concepts correspond significantly with *feng-shui* classifications. The debris catchment zone corresponds to *feng-shui's* "Mountain and Canyon" and "Hill"; the debris flow track corresponds to *feng-shui's* "Water"; the debris flow fan corresponds to *feng-shui's* "Site."

#### 3.1 Catchment collecting debris and runoff

##### 3.1.1 "Mountain and Canyon – Dragon"

According to the 16<sup>th</sup>-century *feng-shui* text by Shike Xu, in *feng-shui* practice, the first step of the field investigation is to figure out where the "dragon" comes from and to judge the nature of the "dragon." The "dragon" refers to a mountain range and canyons. The landforms of unfavorable mountains are described with five groups (Figure 2). First, the "dead dragon" is the mountain

without vegetation that has eroded and is covered in sand and broken rocks, which slide straight down the slope. Second, the "sick dragon" is the mountain whose surface is broken, forming a basin area. Third, the "violent dragon" refers to a narrow and dark canyon with steep slopes and many broken rocks. Fourth, the "ominous dragon" is the canyon whose plan takes the shape of a zigzag. Fifth, the "dead eel" mountain has a straight ridge, in *feng-shui* called a "hidden arrow," a straight alignment [11, 12]. In the author's field observations, all such canyons and mountains provided abundant debris sources, a crucial precondition for debris flows.



Figure 2: This *feng-shui* diagram illustrates the unfavorable mountains [11].

The "dead dragon" and the "sick dragon" often create the landform of a vast basin in the upper portion of the canyon. A dry wash or small creek originates from this high basin, rich in debris. The hillside where the dry wash passes through has a constant slope of 35%-45%. During torrential rains, the runoff with debris is washed into the narrow flow track and generates violent power as it proceeds downstream. When meeting a point where the slope suddenly drops more than 20%, the debris flow releases the debris onto the impact area, which has about a 5-10% slope. Geomorphic research by Reneau and Dietrech demonstrates that two-thirds of failures initiate within the basin. Therefore, an emphasis on both the basin and the flow tracks from upslope is significant in identifying the hazard [10].

A typical example of a basin case is in Chapel on the Rock, in Allenspark, Colorado. This site, which has about a 7% slope, received a heavy debris flow on the evening of September 12<sup>th</sup>, 2013. This site also experienced a fire in 2011. The debris flow buried roads in a layer of mud and tree chips over 100 feet wide and 6 feet high. This debris flow came from Mt. Meeker, five miles away. The flow was so violent that huge trees in its path were pulverized to woodchips by the time they reached the receiving area. The mountain's peak, high above the tree line, has a large basin area covered with broken rocks and sand and a constant 38% slope. In *feng-shui* practice, it fits the definition of a "sick dragon" and a "dead dragon." The small creek originates from a high elevation, and passes through a straight channel with steep slopes, generating a debris flow with heavy rain.

### 3.1.2 "Hills"

In *feng-shui*, "Hills" refers to the hills that the building site is located on or nearby. This category is discussed on a local scale. *Feng-shui* warns people not to build on the following unfavorable hills. *Feng-shui* master Xu Shike states that the "fire hill" has a steep slope and is shaped like the point of a flame, which is said to trigger fires [11]. The "dead eel" hill has a gradient slope and a straight ridge, a "hidden arrow" pattern. The "crab leg" hill has a zigzag plan view. The "pressuring hill" refers to a high hill in front of the site or house. The "broken flag" hills are full of debris and broken rocks. A hill less rugged and with even gradients may trigger floods [14].

The smooth and steep hillside, with a constant 35-45% slope, can trigger flooding [15]. Often gullies, swales, or dry washes are located on a hill with a straight ridge. The narrow straight channel of a dry wash, a "hidden arrow," can initiate a debris flow with intense and constant rainfall. When the slope drops and reaches the area with a slope under 15%, the debris flow releases its debris onto the impact area. Though the debris flow is at the local hill scale, it can have a deadly impact. Geomorphic studies conducted by Reneau and Dietrich also indicate that debris flows generated from small tributaries, dry washes, swales, and side slopes are destructive [10].

A case of a local debris disaster can be seen at North Cedar Brook Road in Boulder, Colorado. Around midnight on September 12<sup>th</sup>, 2013 a debris flow came down through a straight dry wash and demolished a house on the hillside of the valley. This "hidden arrow" dry wash pointed directly to the back of the house from a hill with a 45% slope. Part of the upper floor of the house fell into the basement, even though the neighboring houses experienced no major damage. The North Cedar Brook Valley has been developed as a relatively dense neighborhood with large homes on the steep hillside. Such development causes erosion.

### 3.2 Debris flow track developing a debris flow: "Water"

According to the 17<sup>th</sup>-century *feng-shui* text by Jiusheng Ye (Figure 3), a straight stream or river with fast-moving water is evil, while the meandering one is favorable. This excludes the area at the lower part of a confluence, which is unfavorable [17]. *Feng-shui* also warns against building outside the curve of a river where the water flow changes direction sharply and aligns to the site. Such unfavorable water is known as the "water shooting heart" (Figure 4). Other unfavorable waters include the "water cutting feet," in which the water adjacent to the site cuts off pieces of the land during floods. The "mud water" means the water with mud washes luck away causing residents to lose their home and become vagrants. The "water pouring head" is a powerful flow from a higher elevation, which pours down on a site, identified as one of the vilest factors [14], known as a debris flow in geomorphic terms.

The "water shooting heart" at the confluence of two rivers can cause deadly disasters. Jamestown experienced the most substantial impact of the 2013 floods. The Little James Creek and the James Creek meet at the center of Jamestown. The Little James Creek passes through a deep canyon whose hillsides have a 25% slope. At midnight of September 13<sup>th</sup>, the creek collected vast amounts of debris through six miles of canyon. The mud on the creek bank is proof that the debris climbed several feet. James Creek caused a "water shooting heart," which knocked down a third of the house in the center of Jamestown. Like Jamestown, Drake also experienced a heavy impact. A "water shooting heart" from the southwest points to the site and the North Fork of the Big Thompson River passes through a canyon, whose slopes average 35%. During the 2013 floods, large amounts of debris were collected along the seven miles of a steep canyon.



Figure 3: This *feng-shui* diagram illustrates the unfavorable “Waters” [17].

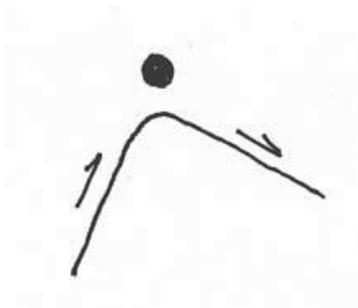


Figure 4: Diagram of “water shooting heart” (by Ping Xu).

As a debris flow track, the dry wash can trigger debris flow, particularly on a fire scar zone. The Big Elk Meadows neighborhood in Lyons was affected by a fire in 2002. The fire changed the structure of the soil and left a rich source of debris. During the 2013 floods, a house on the hillside was destroyed, the only thing left was the garage buried in mud. However, the neighboring houses on both sides received no damage. This is due to a dry wash directly pointing to the house and in 2013 generated a debris flow. This dry wash passes through a straight and narrow channel on a hillside with a 45% slope (Figure 5). The postfire debris flow sequence often leaves a straight track on the impacted land. Such tracks can be seen on Google Map data after the debris flow events. The straight tracks provide convincing evidence of *feng-shui*'s "hidden arrow" on the mountain landscape (Figure 6).



Figure 5: A debris flow passed through this straight gully and destroyed a house in Big Elk Meadows, Lyons (by Ping Xu, 2014).



Figure 6: In the 2014 satellite image the dashed line shows *feng-shui's* hidden arrow on the hillside pointing directly at the house that was destroyed [7]. The garage in the smaller circle was buried by debris.

### 3.3 Debris flow fan receiving the debris flow: "Site"

This research discovered that the highest impact areas often present the similarly combined unfavorable criteria as the following: 1) a site with a slope of 10% at the confluence of two rivers, 2) a small creek or dry wash, originating from a basin several miles away, which passes through a narrow, steep canyon, 3) a river that sharply turns and aligns the flow to the site, and 4) to the north of the site, a steep hill with an eroded and debris-ridden south-facing slope, having experienced a fire previous to the flood. During heavy rain, the small creek creates a debris flow, the river creates a "water shooting heart," and the slope of the hill to the north carries debris to the river, causing further flooding. Such landform patterns led to the most substantial impacts of the 2013 debris flow strikes in Jamestown and Drake, Colorado.

Jamestown was located in a narrow canyon and on a plain at the confluence of James Creek and Little James Creek. James Creek makes a sharp turn, and the flow aligns to the site, forming a "water shooting heart" pattern. Also, north of the town, there is a high hill. The soil on the southern slopes of this hill is dry and thin, with many rocks and little vegetation, providing a rich source of debris. After a fire in 2011, conditions on this hill have worsened. During the constant heavy rain in 2013, the debris was washed down directly to the center of Jamestown. Similarly, Drake was located at the confluence plain of the North Fork of the Big Thompson River. Large amounts of debris were collected along the seven miles of a steep canyon. The Big Thompson River also has

a sharp turn and aligns the flow to the site. The south side of the hill north to the town is an abundant debris source. Finally, the hill has also experienced fire previously.

### 3.4 "Orientation"

*Feng-shui* practice emphasizes "Orientation" as part of the site selection procedure. According to the author's field investigations, the debris flow events occur in the canyons open to the north, east, or southeast. In regard to the slopes, local debris flows occur on the slopes facing north, east, or southwest. Other research by Michael Clark in 1987 documented the debris flows primarily on slopes that face the northwest, north, northeast, and east. As a result, these slopes are shielded from direct solar insolation and would retain higher soil moisture levels from periods of rainfall [9].

## 4 CONCLUSIONS

Geomorphic studies indicate three debris flow zones: 1) the debris catchment area, which provides abundant debris source and corresponds to the *feng-shui* category of "Mountains and Canyons" and "Hills," specifically steep slope sides where debris flows are initiated, 2) the debris flow track, which corresponds to the *feng-shui* category of "Water," where these landforms generate the speed and power of the debris flow as it proceeds downstream, and 3) the third zone is the debris flow fan, coinciding with the *feng-shui* concept of "Site," which is the receiving area of the debris flow [8, 9, 10]. Per the author's field investigations of the 2013 Colorado flood impact areas, the *feng-shui* concept of the "hidden arrow," a straight alignment of the landform, is a significant pattern responsible for postfire debris flows.

Landform of debris flow zones	Debris and Runoff (Catchment Area)		Debris Flow Track (Developing Area)	Debris Flow Fan (Receiving Area)
Feng-shui Terms	"Dragon" Mountains and Canyons	"Hill" Slope sides and local hills	"Water" Water channel of river, creek and dry wash	"Site" Areas receiving debris flow impact
Feng-shui Hidden Arrows  Straight alignment of landforms	• "Dead Eel": mountain range is straight.	• Steep slopes (over 25%). • "Fire Hill": steep slope that comes to a point (like a flame) which can cause fire.	• "Hidden Arrow": straight dry wash on a hill behind the site. • "Water Shooting Heart": stream running toward site then away. • "Water Pouring Head": debris flow forms a straight alignment.	• When slope drops 25% on hillside, straight debris flow dumps debris, causing destruction. • Debris flow reaches low elevation plain of 10-15% slope and dumps debris, causing main disaster. • Site near confluence in lower portion of canyon: 1) "Water Shooting Heart": stream with debris sharply turns and directly attacks site. 2) Debris flow into river or lake dumps debris elevating water levels and causing floods.

Figure 7: *Feng-shui*'s "hidden arrow" straight alignment, appears as a significant landscape pattern in postfire debris flow zones (by Ping Xu).

According to *feng-shui*, evil energy follows a straight alignment, known as a "hidden arrow." Previously, the author thought this idea was only a cultural phenomenon. Westerners often view it as superstition [5]. However, this research on the impact areas of the historic 2013 Colorado floods provides a better comprehension of the "hidden arrow" concept. The "hidden arrow" straight alignment appears not only in debris flow impact zones but also as a major pattern in the landscape prone to postfire debris flow (Figure 7).

*Feng-shui* practice first looks at the larger scale, mountains and canyons. The "dead eel mountain" should be avoided because the range forms a straight line, a "hidden arrow." *Feng-shui* practice then examines the detailed scale of the hill, where people should avoid steep slopes over 25%, as they can trigger fast runoff. *Feng-shui* principles also indicate that even gradients on a hillside can cause floods since a smooth slope readily forms straight gullies. The "fire hill" rises to a straight sharp point, similar to a flame. Its straight edge can attract lightning and cause fire.

In *feng-shui*, the straight channels of rivers, creeks, and dry washes, the debris flow tracks, also trigger debris flow strikes. When the flow track sharply changes direction, there is potential for disaster, which is called the "water shooting heart." A straight dry wash is the most dangerous "hidden arrow" if it is on a hill behind the site. The dry wash triggers a debris flow, known as the "water pouring head."

Finally, debris flow fan sites are often located on gentle slopes of 10-15%. During debris flow events, the confluence of two flow tracks can receive heavy damage from both a "water pouring head" and a "water shooting heart." Often these areas also have local hills with steep slopes, which have experienced fire recently. When the debris flows from these hills dam the rivers, it causes even more flooding.

Often on a slope affected by the fire-debris flow sequence, a straight track is visible on the impacted land. According to the author's field investigations, a local debris flow can act like an "arrow" and directly "shoot" the property, damaging up to one acre of land. These landform patterns can be seen in Google Maps data shortly after debris events. This debris flow data has great value for designers, planners, and property owners as it can prevent structures from being built in front of a "hidden arrow," or straight dry wash. The creation of debris flow disaster maps with "hidden arrow" overlays could help mitigate the destruction of these events.

An important issue that Colorado, in particular, must consider is the presence of massive timbers and dead trees. These timbers can be torn out of the riverbank and carried by a debris flow, adding to the volume and power of the flow. These timbers can also act as "weapons," impaling obstacles in their way. The flows are often so violent that the massive timbers are pulverized to woodchips by the time they reach the debris flow fan. This dangerous characteristic is distinct to Colorado debris flows and similar high elevation areas.

The significant correspondence of *feng-shui* criteria to geomorphic concepts indicates that *feng-shui* is not only a valid method, but it can also be used to expand our knowledge of site selection and to establish mitigation strategies for natural disasters. Moreover, the practice of *feng-shui* emphasizes horizontal-spatial analysis of landforms and their impacts on the multi-landform criteria for a spatial union, including mountains, hills, water, and orientation. The spatial analysis of *feng-shui* encompasses the larger scale of mountain ranges to the smaller scale of sites. In the 2013 Colorado floods debris flows often originated from miles away. Landscape research and design with larger scale considerations will be crucial to avoiding future failures [19, 20].

In this research, *feng-shui* principles, alongside a comparison of geomorphic knowledge, are used as a clue to identify landform patterns. This approach would enrich methods by integrating vernacular experiences with contemporary site selection processes. As in the application of *feng-*

*shui*, visiting a site, seeing the landscape, and understanding the spatial relationships of landforms is integral in the contemporary practice and education of environmental design. Vernacular methods have tremendous value for sustaining civilizations [16]. Ancient people survived by adopting natural laws based on thousands of years of experience [6]. Insight into folk knowledge would not only help rethink vernacular practices but would also enhance our methods and knowledge in creating sustainable environments.

This research uses the cross-cultural study to identify landform patterns of the areas susceptible to debris flow. The criteria of these patterns would predict impact zones. As a result, this research and its ongoing work would benefit the government, planners, architects, landscapers, developers, and the general public to improve site selection processes, planning efforts, and mitigation strategies to avoid building in risk areas and aid in natural disaster evacuation in the Colorado Rocky Mountains and other high elevation areas.

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