

Identification of Metal Mineral Concentrate Content in Artisanal Gold Mining Tailings Using Gravity Method with Shaking Table

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Article Information	ABSTRACT
Article History Received : March 17, 2025 Revised : April 03, 2025 Published : April 12, 2025	Artisanal gold mining in the Kahayan River Basin (DAS Kahayan), Ramang Village, produces tailings that contain metallic minerals such as zircon (Zr), yet their management remains suboptimal. This study aims to identify the zircon content in the concentrate resulting from shaking table separation and to analyze the geological and hydrological factors influencing its distribution. The results show that zircon content in the tailings ranges from 0,002% to 0,112%. The highest concentration was found in the upstream area (Z1), while the lowest was in the downstream area (X1), indicating that river flow direction and tidal influences play a role in zircon particle distribution. The zircon identified is genetically linked to the weathering of granite rocks, particularly the Kapur Granite Formation and Sepauk Tonalite in the upstream region. These findings indicate that current small-scale gold mining practices remain inefficient, allowing zircon to be discarded in tailings. This study emphasizes the importance of improved tailings management through efficient containment systems, the potential for reprocessing, and continuous environmental monitoring to enhance resource utilization and reduce the ecological impact of traditional mining.
Keywords: <i>Artisanal gold mining; Shaking table; Mineral distribution; Geological and hydrological; Kahayan River Basin.</i>	

INTRODUCTION

Indonesia possesses abundant natural resources, particularly gold and other metallic minerals. A small portion of the population residing near the Kahayan River engages in artisanal gold mining, which generates waste products (tailings). Quartz is the primary mineral constituent of the tailings, constituting over 90% of their composition. Other minerals include cassiterite, monazite, tourmaline, ilmenite, zircon, clay, and iron oxides or hematite (Irvani & Artasari, 2018).

Tailing found in river basin areas is usually mixed with alluvial deposits (Redmann, 2018). Tailing is a waste material from ore processing that is deposited in lowland areas, where erosion processes cause tailing piles to become stretches of degraded land, preventing any plant species from growing in the area and affecting river conditions. The large amount of tailing produced alters the morphology, physical, and chemical properties of the soil, as well as the vegetation that grows on it (Sengupta, 2021).

These deposits are formed as river water (during floods) carries coarse material to the riverbanks, where it is then deposited. At the highest water level, these natural levees become elevated, distinguishing the floodplain from the river. Levee deposits consist of clay and silt particles (Alwi & Jati, 2019). The distribution of trace metals in alluvial sediments depends on

their natural background concentration and the dynamics of contemporary deposition and erosion processes, particularly those caused by flooding (Falkowska & Falkowski, 2015). The determination of depositional environments can change based on the interpretation of river flow under tidal conditions, including oblique accretion, overbank, and sand bar formation (Prasetya, 2019).

The geological map indicates that the study area is located within an alluvial formation containing quartz sand, gravel, and boulders derived from metamorphic rocks, loose quartzite, and granite rocks. In some areas, sandy mud and clay contain lignite and limonite. Zircon has been found in the Alluvial and Dahor Formations on the island of Kalimantan. Genetically, these minerals were deposited along with gold grains in alluvial deposits, and in some areas of West Kalimantan, they were deposited together with tin (Geological Agency, Ministry of Energy and Mineral Resources, 2015).

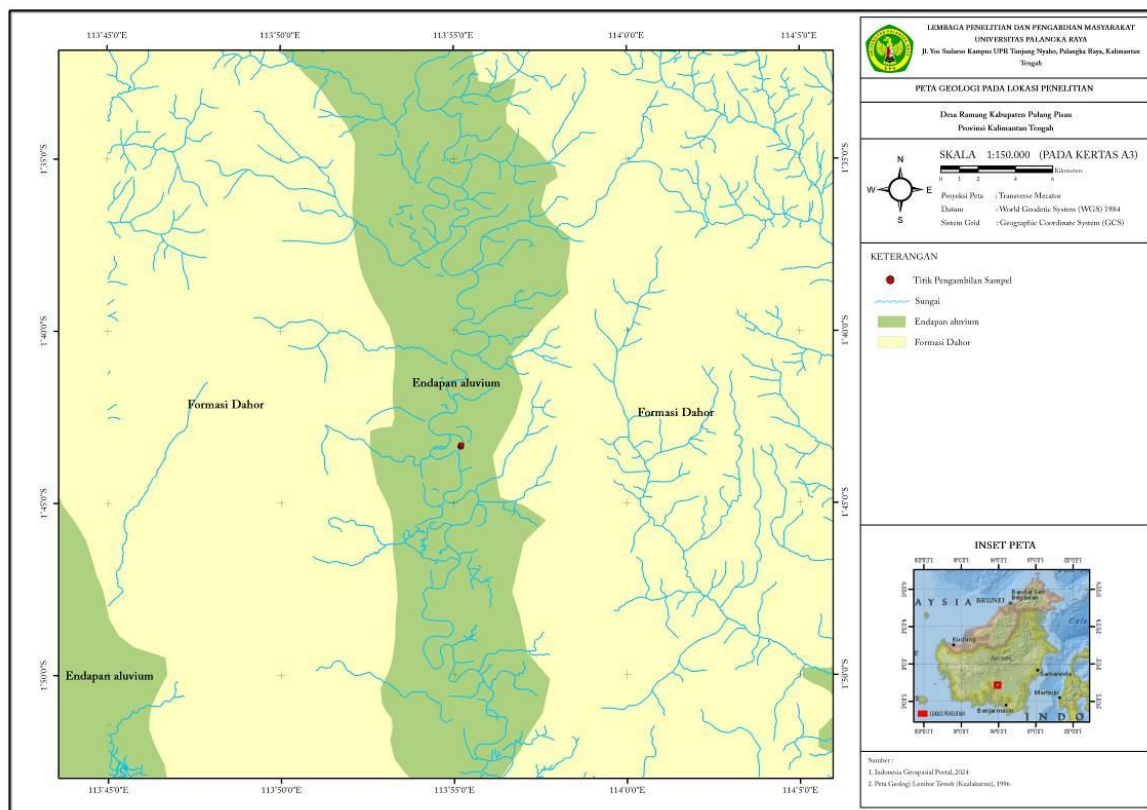


Figure 1. Geological Map of the Tewah Sheet, modified from Sumartadipura and Margono (1996)

The use of simple technology in gold processing often results in low mineral recovery rates. Consequently, metallic minerals are lost and dissolved along with other impurity minerals. Integrated tailings waste management can reduce production costs and provide added value (Poernomo et al., 2016).

Tailing from artisanal gold mining often contains quartz as the main phase, with varying gold content. For example, at the Miyove gold mine in Rwanda, tailings exhibit a gold content significant enough for economic extraction, with gold grades in the tailings ranging from 2 to 7 g/t (Munganyinka et al., 2022).

The availability of heavy metals in sediments is directly correlated with sediment properties and grain size. Sediments rich in clay minerals and organic carbon tend to bind more heavy metals due to their ability to retain such compounds. The oxidation of iron, manganese, and other organic materials is among the most critical geochemical components controlling heavy metal binding in sediments (Stecko & Young, 2000). Heavy metal concentrations in water are higher during the

rainy season than in the dry season and are also higher in river and sea samples compared to estuarine samples (Najamuddin et al., 2016).

Mineral dressing, particularly for metallic minerals in Indonesia, is conducted using methods appropriate to their properties and characteristics, one of which is gravity concentration using a shaking table. This equipment operates based on differences in specific gravity and particle size within a flowing layer, which exerts force on the particles on the deck (Arief, T., 2022).

A shaking table is a gravity concentration device that separates minerals based on differences in density, particle size, and shape. The process involves a flat deck with riffles that oscillates back and forth. The feed material, mixed with water, flows across the table. Heavy mineral particles settle into the riffles and are transported to the concentrate discharge end, while lighter particles are swept away by the water flow. The efficiency of separation depends on factors such as deck inclination, vibration frequency, water flow rate, and feed characteristics (Wills & Finch, 2016).

Pre-concentration stages are commonly used for processing base and precious metals when the feed grade is low. Pre-concentration can remove major impurities and enrich the desired metal content, thereby enhancing the efficiency of subsequent concentration stages (Jena et al., 2021).

The table inclination and wash water flow are critical factors influencing particle separation. Research indicates that optimal inclination and appropriate water flow can enhance separation efficiency (Jordão et al., 2016). Ideal concentration results are achieved with a deck inclination ranging from 3° to 7°, particle sizes between -100 + 200 mesh and -200 + 300 mesh, and a vibration rotation speed between 100 rpm and 200 rpm (Ferdana et al., 2018). The effectiveness of a shaking table is influenced by several parameters that must be met to achieve optimal results and ensure a reliable outcome (You & Liu, 2023).

The identification results of minerals from the concentrate samples indicate that several types of minerals are found in the mining tailings, including monazite, cassiterite, zircon, anatase, rutile, tourmaline, fluorite, garnet, and pyrite (Fauzi, 2022).

Research on the content of metal mineral concentrates in gold mining tailings can be conducted using various methods. One of the most common methods is gravity separation using a shaking table. To obtain higher and more profitable grades, valuable minerals are separated from non-valuable minerals through concentration. Specific gravity, also known as gravity concentration, is a method based on density differences.

RESEARCH METHODS

This study is experimental-descriptive with a quantitative approach to identify the types and concentrations of metallic minerals in the concentrate obtained from shaking table separation of artisanal gold mining tailings. The research was conducted from October to November 2024 in the Kahayan River Basin (DAS Kahayan), Ramang Village, Banama Tingang District, Pulang Pisau Regency. Sample processing was carried out in the Mineral Processing Laboratory, Mining Engineering Program, Universitas Palangka Raya.

Field sampling equipment included hoes, small shovels, sedimentology hammers, GPS devices, plastic sample bags, sample markers, and measuring tapes. Laboratory equipment used in mineral processing included a 10-mesh sieve, shaking table, a 30 kg sample scale, a 5 kg digital scale, and an oven.

The laboratory-scale shaking table operated at a slope of 3°, with a vibration frequency of approximately 200 times per minute, a water flow rate of around 5 liters per minute, and a maximum feed size of 2 mm.

Descriptive research typically does not aim to establish relationships, explain causation, or test hypotheses. Instead, it systematically and accurately presents phenomena, facts, or events regarding the characteristics of a population or a specific area through surveys to gather information from a sample (Auliya et al., 2020). In this study, quantitative descriptive data was

obtained through field observations and measurements. Sample collection was conducted using the grab sampling method, which involves taking samples from stockpiled mining materials. For investigations, grab sampling is typically performed in a regular pattern (Rauf, 1995).

The research activities were carried out based on the following stages:

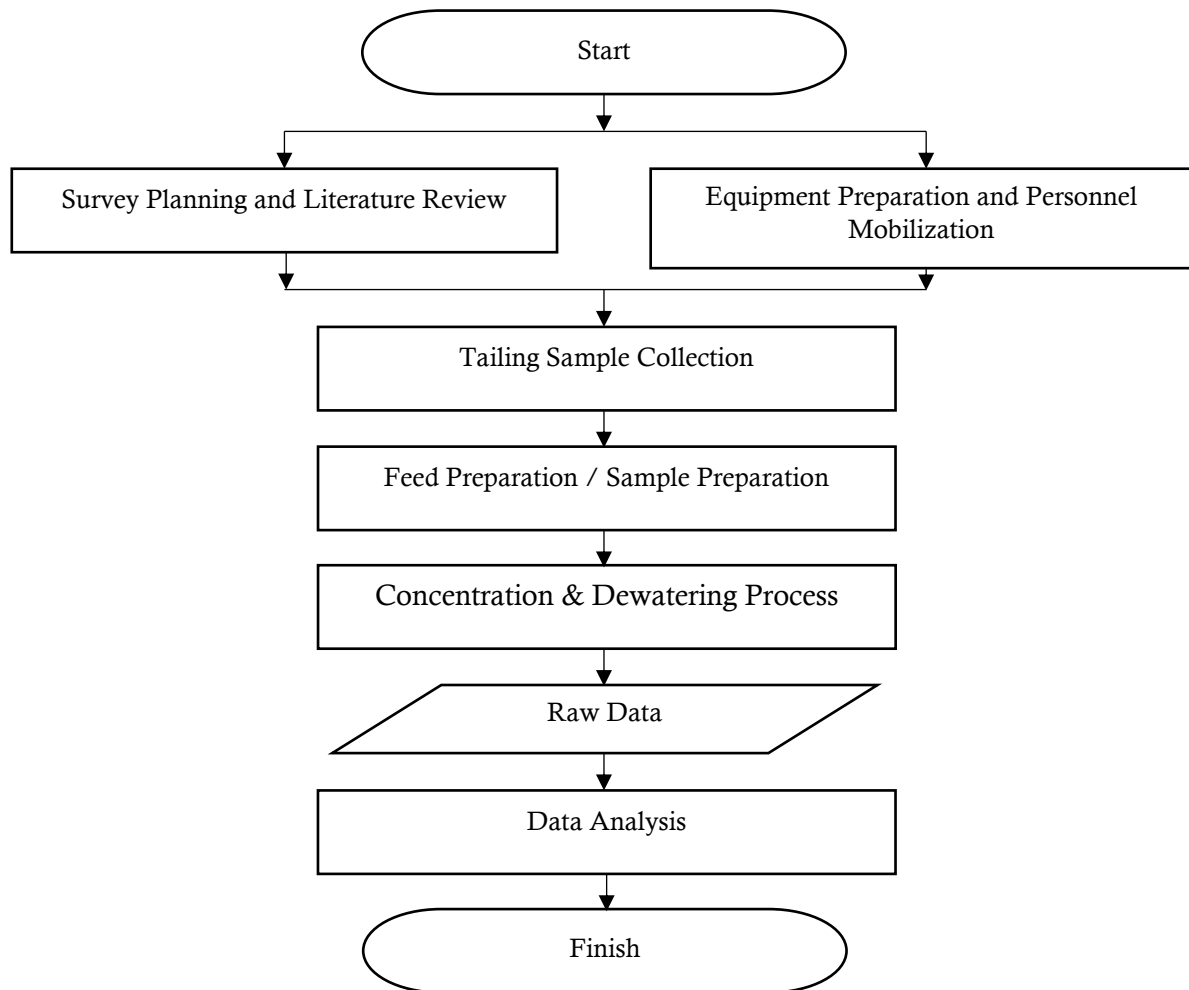


Figure 2. Research Flowchart

The process begins with the planning and preparation of field and laboratory equipment. It is followed by the sampling of tailings from small-scale gold mining activities, which are then dried and sieved to a maximum particle size of 2 mm. The samples are subsequently processed using a laboratory-scale shaking table that operates based on the principle of gravity separation, resulting in three main fractions: concentrate, middling, and tailings. The concentrate fraction is then dried and analyzed for its metallic mineral content, such as gold and other heavy metals, based on their characteristics and optical appearance. The analysis results are used to evaluate the remaining metal content in the tailings.

RESULTS AND DISCUSSION

Tailing Sample Collection

Sample point determination was conducted using the grid sampling model, a tailing sampling technique used to understand the distribution of metallic minerals at the designated location. This method involves creating a square or rectangular grid on a map and collecting samples from the center of each grid cell. Grid sampling is an attractive option for mapping due to

its simplicity. For this reason, the grid does not need to be randomly placed within the study area, as required in systematic random sampling.



Figure 3. Tailing Sample Collection Process

Sample points were placed along the river at 30-meter intervals, with a total of six (6) rectangular-shaped sampling points (Figure 4). Samples were collected at a depth of approximately ± 30 cm, with a total weight of 25 kg per point.

Table 1. Sample Point Coordinates

Sample Point	Coordinates X	Coordinates Y
X1 Downstream	113° 55' 12,367" E	1° 43' 23,696" S
X2 Downstream	113° 55' 13,267" E	1° 43' 24,164" S
Z1 Upstream	113° 55' 13,393" E	1° 43' 22,001" S
Z2 Upstream	113° 55' 14,203" E	1° 43' 22,393" S
Y1 Midstream	113° 55' 12,961" E	1° 43' 22,868" S
Y2 Midstream	113° 55' 13,785" E	1° 43' 23,250" S

The samples were divided into three zones: downstream, midstream, and upstream. This classification facilitates the identification and analysis of the relationship between tailings and the influence of the Kahayan River flow on the distribution of metallic minerals, as well as the impact of tidal fluctuations on the study area.

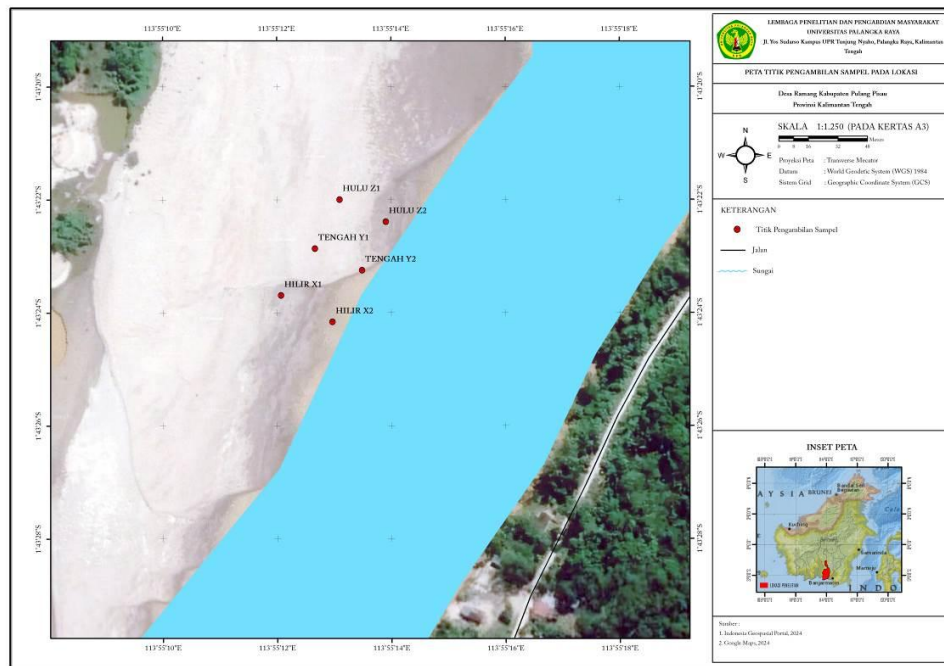


Figure 4. Sample Collection Location Map

Sample Preparation and Concentration Stage

At this stage, the samples collected from each point underwent preparation by sieving through a 10-mesh (2 mm) screen. The material passing through the -10 mesh was then reduced using the quartering method, resulting in a 5 kg sample for the concentration stage. This process utilized specific gravity and gravitational force through a shaking table.

The separation of metallic minerals relies on differences in specific gravity within a fluid medium and variations in settling velocity among minerals. The gravity concentration process produces products such as a concentrate consisting of valuable minerals, such as zircon (Zr), and waste or tailings composed of impurity minerals, such as quartz sand and clay.

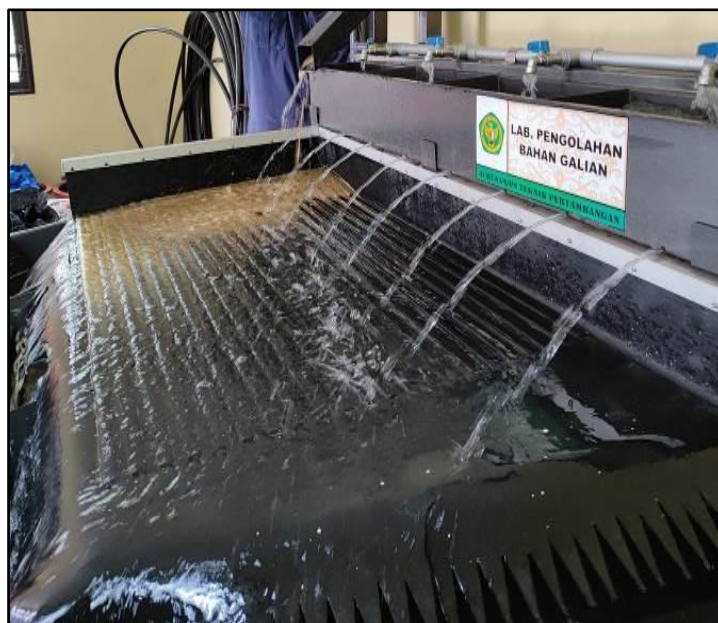


Figure 5. Concentrate and Impurity Separation Process

Identification of Metallic Minerals

Based on the separation results of the concentrate and impurities in Figure 5, zircon mineral content was identified, along with impurities such as sand and silt deposits. The zircon concentrate content is presented in Table 2 below:

Table 2. Zircon Content at the Research Location

No.	Sample Point	Zr Content (%)
1	X1 Downstream	0,002
2	X2 Downstream	0,062
3	Z1 Upstream	0,112
4	Z2 Upstream	0
5	Y1 Midstream	0,048
6	Y2 Midstream	0,024

The low concentration of zircon minerals in tailings is due to the gold processing methods used by local miners, where much of the zircon concentrate becomes trapped in the process. Zircon minerals originate from the breakdown of monazite, which is abundant in granitic rocks. Based on regional geological maps, the northern and upstream areas of the study location contain granitic rock formations, such as the Granit Kapur Formation (Kgr) and the Sepauk Tonalite Formation (Kls), which are granitoid in nature.

This is also evident from the presence of quartz-rich sand derived from weathered and fragmented granitic or granitoid rocks in the Dahor and Alluvium formations within the study area. These quartz minerals are resistant minerals that originate from the breakdown and weathering of granitic or granitoid rocks.

The study area is a tidal region where water flows from upstream to downstream. Tidal fluctuations occur due to river sedimentation and high water discharge during heavy rainfall in the upstream area, forming floodplains (Figure 6). This process leads to the washing away of tailings along the Kahayan River Basin, particularly in Ramang Village, resulting in a low concentration of zircon (Zr) in the study area.

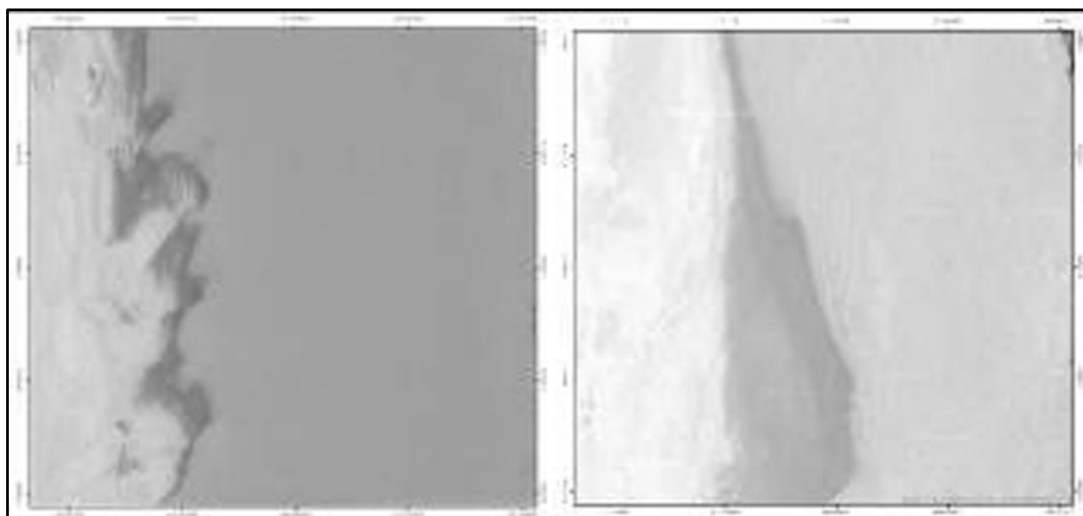


Figure 6. Floodplain Changes in the Study Area

The development of a flat valley floor resulting from lateral erosion characterizes the surface of a mature river. As the river meanders (Figure 1), the flow shifts toward the outer bend, causing strong erosion on the outer curve, while deposition occurs on the inner bend due to weaker currents.

CONCLUSION

The concentration of zircon in the tailings is considered very low (0–0,112%), with the highest distribution found in the upstream zone (0,112%) and the lowest in the downstream zone (0,002%). This low concentration is due to the suboptimal gold processing methods used by artisanal miners, which cause zircon minerals to be discarded along with the tailings and washed away by the tidal-influenced flow of the Kahayan River. The zircon minerals originate from the weathering of granitic rocks, specifically the Kapur Granite and Sepauk Tonalite Formations, located in the upstream area. These minerals are transported as alluvial sediments and accumulate in the Aluvium and Dahor Formations. Therefore, standard procedures are required for tailings management, including containment, reprocessing, and environmental quality monitoring in artisanal mining activities, to optimize the recovery of metallic minerals.

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