



Brief Report

Brief discussion on tectonic uplift of the Yandang Mountain, Zhejiang Province, China**Jijun Zhang¹**

Yandang (also known as Yandangshan) Mountain in Yueqing City, Zhejiang Province, at 27°50'~28°30' N and 120°27'~120°41' E, with a total area of 450 square kilometers, is tectonically located in the eastern Cathaysia Block. It is famous for its grotesque topography and beautiful scenery. It is not only historically known as the "No. 1 Mountain in Southeast China", but also called the "Natural Museum" by Chinese and foreign geologists. In 2005, UNESCO Global Geoparks Council announced in Paris that Yandang Mountain was selected as a Global Geopark.

Before the 1980s, Yandang Mountain did not receive much attention from geologists. It was not until the 1990s that Yandang Mountain indeed came into the eyes of science, and in-depth research was conducted extensively. However, most of the studies at that time focused on the higher altitude areas of Yandang Mountain, namely, on the volcanic rock areas, while insufficient studies were done on the basal area of the mountain. The reason for this may be that the surface of basal mountain rocks is usually covered with a layer of black oxide, fluvial and alluvial materials, without distinct outcrops. Therefore, they are often overlooked and mistaken for volcanic rocks. With the in-depth development and road reshaping of this world geopark, more and more roadcut rocks are beginning to be exposed in front of our eyes.

Previous studies show that Yandang Mountain is a typical caldera erupted from late Mesozoic rhyolitic magma on the southeastern coast of China. Volcanic eruption was initiated in the Hauterivian Stage of the Cretaceous about 130 million years ago, which developed an amazing variety of the Cretaceous rhyolite landforms¹.

Key words: Yandang Mt.; rhyolite; pyroclastic flow; uplift; diorite porphyrite; syenite; Plinian eruption

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Because of the westward subduction of the Paleo-Pacific Plate (or called the Izanagi Plate), Yandang Mountain, as an important part of the Pacific Rim tectonic system, developed a series of large-scale volcanic activities during the Late Mesozoic (Cretaceous). As a result, 4 phases of volcanic eruptions (KY1-KY4), and a final phase of central subvolcanic intrusion (hypabyssal intrusion) in calderas took place as follows:

- Phase I, known as Plinian eruption occurred 128 million years ago (Hauterivian Stage). It is characterized by pyroclastic flow facies, predominated by rhyolitic welded crystal-lapilli tuffs and low silicon rhyolitic ignimbrites identified as Formation KY1.
- Phase II Eruption took place about 121 million years ago. The lithofacies are mostly ignimbrites, pyroclastic flow deposits, and massive or flow-banded rhyolite with enriched spherulites and occasional lithophysae (Formation KY2).
- Phase III Eruption occurred about 104 million years ago. It is characterized by pyroclastic flow and effusive facies, which are predominated by rhyolitic lapilli tuffs and interlayered rhyolites (Formation KY3)^{2,3}.
- Phase IV Eruption was the last violent Plinian eruption estimated about 99 million years ago. This phase is dominated by rhyolitic welded crystal-vitric ignimbrites of pyroclastic flow facies with well-developed columnar joints and eutaxitic texture, and local effusive tuff lava (Formation KY4).
- Phase V is a central subvolcanic intrusion in Caldera occurred about 98 million years ago (Turonian Stage) as estimated⁴. The lithofacies are predominated by the intermediate grained quartz syenites (Formation KY), which marked the end of the volcanic activities in Yandang Mountain³.

This fall, I had the privilege of revisiting Yandang Mountain and consciously browsed its geology and rocks. On several roadcuts, I found rocks that were different from those I had seen before (Figure 1), and have never been reported, which encouraged me to write this short article.

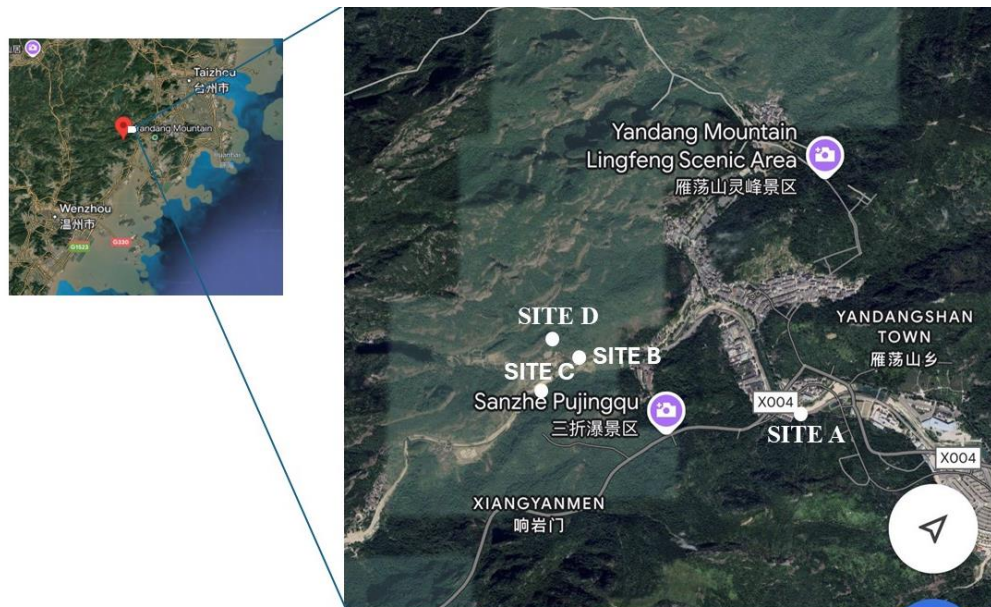


Figure 1. Location map of study area. Base map is from Google Map

As shown in Figure 2, multitudinous hydrothermal quartz veins intruded vertically into the fractured parent rock known as diorite-porphyrite proposed by Prof. Duan (Zheng Duan, personal communication, Nov. 2024). The vertical veins are approximately a few centimeters to about 20 centimeters in width.



Figure 2. Showing diorite-porphyrite and hydrothermal quartz veins at Site A

Hydrothermal quartz veins are formed by hydrothermal fluids under high temperature and pressure. Hydrothermal fluids are high-temperature, high-pressure fluids rich in water, which are common in underground rocks. When hydrothermal fluids flow into rock cracks or faults, and meet certain temperature and pressure conditions, veins containing quartz will precipitate, forming hydrothermal quartz veins.

Diorite-porphyrites are also discovered at sites B and C, only about 1 km away to the west from Site A (Figures 3 and 4a).

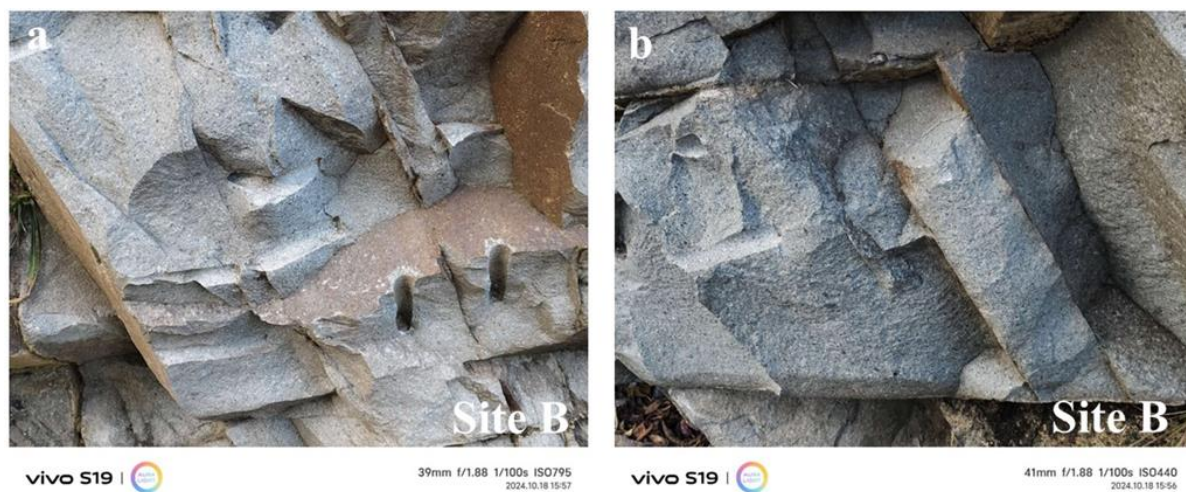


Figure 3. Showing diorite-porphyrite and joints at Site B

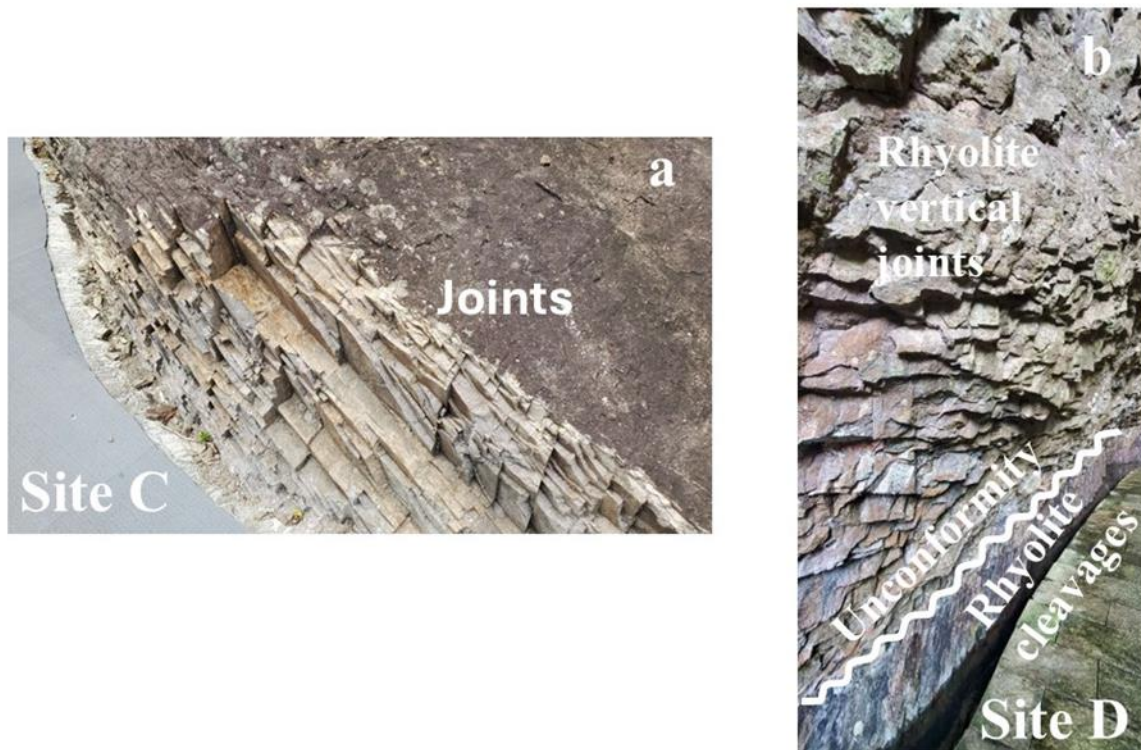


Figure 4. a: Showing diorite-porphyrite and joints at Site C; b: Showing rhyolite with dense vertical joints, cleavages and an unconformity from the Middle Tier Falls, Yandang Mt., Site D

At the Middle Tier Falls (See Site D) at the scenic spot of Three Tier Falls, rigid rhyolite with dense vertical joints overlies the rhyolite with slightly tilted cleavages, separated by an unconformity. It may imply that 2 phases of volcanoes could exist here before, possibly the Phase I and Phase II volcanoes in Yandang Mt (Figure 4b). Figures 2-4 indicate that this area has experienced violent tectonic movement and uplifting.

Assuming that the diorite-porphyrite and hydrothermal quartz veins were formed two kilometers underground, then the total amplitude of tectonic uplift in the Yandang Mt area could be at least 2,000 meters. This is consistent with Duan Zheng's study, who proposed that Yandang Mountain has been uplifted three times, with a total amplitude of approximately 1,400-1,750 meters (Duan)⁵. This magnitude is not surprising. Since the late Mesozoic, the world has experienced intense Yanshan orogeny and Himalayan orogeny, causing the Himalayan Mountains to rise about 10,000 meters from sea floor, the Alps to 4,800 meters, and the Andes to 6,960 meters. In addition, the Sirt Basin (Sahara Desert) in eastern Libya has subsided by an average of at least 5,000 meters⁶.

In addition, based on the discovery of the pebble deposit near the top of Daping Mt, Ruili Town, Yueqing City (Figure 5), and other studies^{5,7}, it is postulated that the study area suffered strong vertical uplift during the middle Miocene (ca 12 million years ago). The current altitude of Daping Mt is estimated about 100 meters above the sea-level. Here, I assume that the uplift of

the Daping Mountains mainly occurred in the last large-scale uplift of the Late Cenozoic Era (middle Miocene).

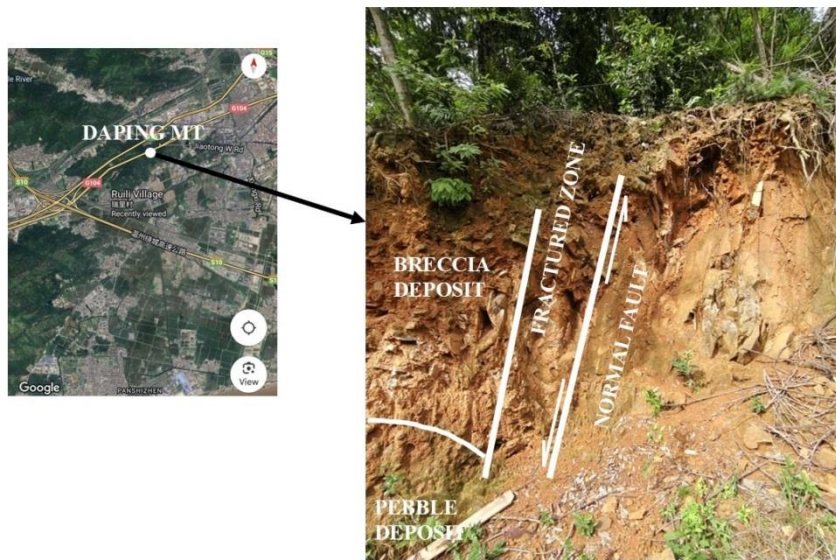


Figure 5. Pebble deposit at lower-left corner is overlain by breccia deposit near the top of the Daping Mt, Ruli Town, Yueqing City, Zhejiang Province, China

It is presumed that the uplift in the middle Miocene is related to the collision of the Australian Plate and the Philippine Sea Plate, causing the Philippine Sea Plate to drift northward. The uplift amplitude in this period may have exceeded 100 meters, while Prof. Duan proposed the uplift amplitude of 100-200 meters⁷. As the Philippine Sea Plate and the Paleo-Pacific Plate (Izanagi Plate) continued to subduct westward, the eastern continental margin of China, including Yandang Mountain, was violently compressed and uplifted⁸. The large-scale plate collision not only triggered the uplift of Yandang Mountain, but also triggered numerous shield volcanic eruptions on both sides of the Yangtze River. In the past 2 million years, as Taiwan Island separated from Luzon Island and drifted northwestward rapidly⁹ (at a speed of 6-8 cm per year), China's eastern continental margin has been undergoing compression and uplift, and this uplift may still continue today.

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Data availability

The data that support the findings of this study is available from the author upon reasonable request.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.

