BRIEF REPORT

Mastodon footprints found to be water erosion in the Quebrada de Chalán (Licto, Ecuador) [version 2; peer review: 2 approved, 1 not approved]

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Abstract

The Chalán ravine is a deep bed creek that runs through Licto (Ecuador). It has been known since the 19th century for the abundance of paleontological remains of Pleistocene fauna and megafauna in its profiles, where entire remains of mastodons were recovered. The abundance of these remains made one of the high areas, where marmites exist in different forms, was traditionally considered as mastodon footprints. Archaeological prospecting, geographic information system (GIS) technology, unmanned aerial vehicle (UAV), photogrammetry, and the geological study of the place, allowed us to determine that the mythical traces of mastodon were marmites made by the water erosion produced in the same ravine over time.

Keywords

Andean geology, mastodon footprints, water erosion, Chalán

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Any reports and responses or comments on the article can be found at the end of the article.
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Introduction
In the late 19th century, foreign researchers began to arrive in the Quebrada de Chalán, attracted by the legend of the existence of giant hominid bones. It was Juan Félix Proaño who, in 1884, after a major collapse in the Quebrada, proceeded to excavate the remains of a complete mastodon that had been exposed. These remains were sent to the Central University of Ecuador (Quito), where they disappeared after a large fire (Branco, 1938; Román, 2010).

Later, other scholars such as Spillmann (1931) and Hoffstetter (1952) arrived, attracted by the abundance of Pleistocene animal remains, eager to conduct their research.

Therefore, the region is one of the main Pleistocene sites in Ecuador in terms of fossil remains from that period. With the arrival of these scholars in the first half of the 20th century, new legends emerged, one of which is the subject of our study, suggesting that the marmites area was actually fossilized mastodon footprints formed as the mastodons fled before the eruption of the nearby Tulabug volcano. This legend has been accepted as truth, being “endorsed by foreign scientists,” and even though it was never documented in a scientific study, it has been transmitted among the local inhabitants to this day. Consequently, even today, all the residents in the area believe that the marmites correspond to the aforementioned fossilized mastodon traces, leading to the creation of information panels and a marketing campaign in the area.

Newspapers such as “La Prensa de Riobamba,” “Diario de Riobamba,” or “El Telégrafo” (national) still consider these features as mastodon traces and occasionally publish reports about the mentioned footprints, perpetuating the myth and confusing both locals and visitors (La Prensa, 2021; de Riobamba, 2019; El Telegrafo, 2016).

The objective of this research was to determine whether the existing marks in the study area were the result, as tradition suggests, of mastodon tracks left by the mastodons that lived in the area during the Pleistocene, or if they were caused by water erosion (marmites) of the rock resulting from the passage of water.

Methods
A visual archaeological surface survey was conducted in the study area, which determined that there are no archaeological or paleontological remains in the marmite area (Fernández, 1989). For this purpose, aerial photogrammetry was utilized using an unmanned aerial vehicle (drone) equipped with a camera to obtain qualitative and quantitative information about the Earth’s surface through the recording, measurement, and interpretation of photographic images. The specific drone used for aerial digital cartography was a DJI Phantom 4 Pro V2.0 multirotor drone with a 20 MP camera designed for aerial photography. The generation of photogrammetric products involved three stages (Casella, Drechsel, Winter, Benninghoff, & Rovere, 2020; Gasparini, Moreno-Escribano, & Monterroso-Checa, 2020; Stott, Williams, & Hoey, 2020):

- In the first stage, the flight path or flight plan was defined using Pix4DCapture software, configuring parameters such as the flight area in hectares, flight time in minutes, number of images to be captured, flight height in meters, pixel size in cm/px, recommended horizontal and longitudinal overlap of 75% as suggested by the software, speed in m/s, camera angle of 90°, and the number of batteries to be used.

- The second stage involved the preliminary survey of the terrain and the placement of ground control points (GCP) for accurate orthophoto georeferencing and desired elevation models.
The third stage consisted of the actual flight, which took place on July 15, 2021, at an altitude of 150 meters, lasting 18 minutes and utilizing two batteries. A total of 199 aerial images were captured during the flight, with a spatial resolution of 4.5 cm/px.

The captured photographs were stored in the drone’s internal memory and then downloaded to the computer. The images were processed using the Pix4DMapper software, following the methodology recommended by the manufacturer and described below:

- When the software was launched, the option for creating a new project was selected, and the path where the postprocess files would be stored was defined.
- After generating the new project, the drone-captured photographs were added to the software. The software automatically detected the camera used and the coordinate system, which in this case were geographical coordinates. These coordinates were then transformed within the software to the Universal Transverse Mercator (UTM) coordinate system.
- For 3D processing, the option for 3D Maps processing was selected to generate the orthomosaic, point cloud, and digital elevation models. During the initial processing, the image scale and geometrically verified pairing were determined.
- The dense point cloud was processed with classification to improve the generation of the digital terrain model (DTM), digital surface model (DSM), and orthomosaic. Additionally, an orthorectification and contour generation process was performed with a 5 m interval.

In addition, at each processing stage, the software generates a quality report that evaluates the relative accuracy of the project by comparing the coincidences between 2D key points, vertices, and lines. These measurements indicate the number of shared points between two or more images, providing an assessment of the project’s accuracy.

The obtained results were then transformed into digital cartography using the measurement tools available in a Geographic Information System (GIS) environment, specifically ArcMap (ESRI, 2020) and Global Mapper (Blue Marble Geographics, 2021). The digital elevation model derived from the data allowed for determining the water flow direction in the Chalan Gorge and capturing certain details that are not observable from the surface. Furthermore, geological areas of interest were identified based on the digital cartography, facilitating subsequent field visits to recognize geological formations and classify them according to their lithology. Additionally, satellite images from Google Earth Pro were utilized to identify significant features and key morphologies that required further verification during fieldwork (Lanis & Razuvae, 2018). Based on this initial information, a comprehensive field investigation was conducted over a period of five days to verify and validate the data obtained. The investigation focused on the Quebrada de Chalán area and the vicinity of the marmites.

Results and discussion
The Quebrada de Chalán (Figure 1) is situated in the south-central region of the Ecuadorian Inter-Andean Valley, specifically on the border between the Licto and Punín parishes, in Riobamba, Chimborazo province. It was carved out by the slopes of the Tulabug volcano, which stands at an elevation of 3336 meters above sea level (m a.s.l.). The average altitude of the Chalán Gorge is 2953 m a.s.l. Its coordinates are 17M 763279.11/9802664. The gorge is located approximately 15 km from the city of Riobamba, accessible via the Riobamba-Macas road (Román, 2010).

In the dry seasons (July to December), there are completely arid areas and other moistened spaces that provide a small but constant flow of water, contributing to the stream’s volume as it descends and leading to an increase in the water flow. The terrain at the top of the ravine has a gentle slope, while in the middle part, it transforms into a deep bed with rugged and steep slopes, characterized by steep flanks. In certain sections, the ravine’s slope decreases, resulting in the formation of sinks, holes, and water drainage through fractures in the rocks and soil porosity. Towards the bottom, the ravine narrows to take on a V-shape, and the water current creates rapids and small waterfalls before eventually merging with the Quebrada Colorada, named for the reddish hue of its strata (Reinoso, 1974).

Geological context
As described by Sauer (1965), Wolf (1892), Clapperton and Vera (1986) and Buenaño (2019) (Buenaño, 2019), the Quebrada de Chalán is located in the geological unit called the Cangahua Formation (Cangagua). This formation, in the province of Chimborazo, has a maximum thickness of 22 m. The Cangahua Formation is the result of the volcanic
activity of the Tulabug, which produced fine pyroclasts easily transportable by the wind. These pyroclasts were deposited in depressions of the inter-Andean valley or in stagnant lakes, and in certain areas, they were consolidated without developing any stratification. Sauer (1965) determined that the andesites and dacites present in the formation originated after the second glaciation, based on their mineralogical composition. Additionally Román (2010) described that the Chalán ravine belongs to the Upper Pleistocene, specifically to the Third Interglacial Phase. This determination is supported by the presence of ichnofossils (*Coprinisphaera ecuadoriensis*) found in the Cangahua geological unit (Sauer, 1965). The topsoil in the area has variable thickness and is composed of fine powder with a whitish coloration and many cangagua balls. These fossil spheres serve as guide horizons to establish the relative age of other strata, which accumulated in thicknesses of several centimeters as a result of frequent volcanic eruptions in the region (Reinoso, 1974).

**Paleontological context**

The Quebrada de Chalán is recognized for its paleontological and archaeological richness, as it contains fauna from the late Pleistocene and evidence of prehistoric human presence in Ecuador (Román, 2010). Within this context, local settlers have described the presence of “bones of giants” in the vicinity of the ravine, which were first recorded by chroniclers of the Indies in stories and legends. These accounts alluded to ancient races of giants that supposedly inhabited the region in times immemorial. Velasco (1789) in his work “History of the Kingdom of Quito” described the biological importance of the country and mentioned the discovery of gigantic bones buried in different strata of the soil and various locations across the country. From such findings, Ecuadorian legends about giants and strange beings from the distant past emerged (Reinoso, 1974).

The Pleistocene fauna in the Quebrada de Chalán and its surroundings contains several groups of fossil mammals (Wagner, 1883). Branco (1938) provided a detailed description of the ungulates in the area, particularly equids, camelids, and cervids. As described by Román (2013), the first mastodon discovery in the Pleistocene site of Quebrada de Chalán
was excavated in 1894. The remains of this specimen were well-preserved as fossils and are currently housed at the Central University of Quito.

In this context, numerous reports from the national press support the possibility that the marks on the rocks in the upper part of the ravine are mastodon footprints. These marks became visible after intense rainfall events caused significant runoff and soil erosion. Even today, as the soil continues to erode, more of these indentations in the rocky bed keep appearing (Maggi, 2016; Moncayo, 2019; Yurak, 2020; La Prensa, 2021).

Prospecting in the Quebrada de Chalán

On 8, 9 and 10 September 2021, several surveys were conducted through the ravine to obtain a detailed geological description of the area. Most of the outcrops were in inaccessible places, however, observations made from a long distance revealed that the strata are interleaved between white and yellow layers. The white strata consist of fine grains giving rise to popcorn structure covering these layers; on the other hand, the yellow strata are composed of slightly coarser grains that do not allow the formation of such a structure. Based on the works presented by Sauer (1965), these strata correspond to loosely consolidated volcanic tuffs.

The area of greatest interest of the Quebrada de Chalán is located at the coordinates 17M 763287.78 East/9803423.94 North at an altitude of 2963 m a.s.l. This location corresponds to an outcrop formed by three strata arranged in the form of terraces resulting from water erosion. The terraces are the result of the varying degrees of resistance to erosion exhibited by each stratum, as shown in Figure 2.

Stratum 1 was the most superficial, and its thickness could not be measured as its roof was eroded. It exhibited a reddish color, possibly the result of weathering by water, and lacked stratifications. The stratum was well-consolidated, and the clasts inside were sub-angular, varying in size between 1 to 5 mm, and poorly ordered. The matrix was composed of fine grains, primarily consisting of plagioclase quartz and hornblende minerals. Stratum 2, adjacent to Stratum 1 with a concordant contact, had a thickness of 2 m and appeared yellowish. It also lacked stratifications and was well-consolidated. Inside, the clasts were angular, ranging in size from 2 to 15 mm and without any specific order. The matrix was composed of fine grains without significant mineral content. On the roof of this stratum, there were a series of marks

![Figure 2. Stratigraphic succession of the study area.](image-url)
ranging from 8 to 30 cm in diameter (Figure 3). According to its characteristics and in accordance with Sauer (1965) this stratum was classified as a volcanic tuff with a chemical affinity towards an andesitic or dacite composition.

Stratum 3 is bounded by stratum 2 through a concordant contact. Its thickness cannot be measured as the base is not visible. The stratum appeared white, although in certain areas, it exhibited a purple hue due to water-induced weathering. Similar to the previous strata, it lacked stratifications, was well-consolidated, and contained no clasts. The matrix was composed of very fine grains without significant mineral content.

To understand the erosive process, stream potholes are erosive morphologies associated with fluvial processes such as abrasion or hydraulic erosion. These develop in diverse types of substrates, from soft materials like clays to resistant bedrock such as granites. They are also present in fluvial channels on rocky beds with varying levels of incision. Additionally, the erosion process is induced by defects in the bed that generate flow alterations, producing turbulence or whirlpools. At this point, joints play an important role in the initiation and progression of the formation of the potholes, and they are related to the position and geometric configuration of the channel. Similarly, lithology plays a significant role in the erosion of rivers in rocky beds, affecting it at different scales, from valley geometry to sculpted forms. Potholes can form from minor depressions resulting from weathering or the impact of large rocks (Ortega, Gómez, Perez & Wohl, 2014; Pelletier, Sweeney, Roering & Finnegan, 2015; Kale, & Joshi, 2004). A schematic of how potholes are formed is described in Figure 4, which highlights the evolution of erosion over time (Lorenc, Muñoz, & Saavedra, 1995).

Following the methodology used by Ortega et al. (2014), a macro-scale analysis of the area where the mastodon footprints (potholes) are located was conducted. It was observed that the water flow originates from 2780 to 2730 meters above sea level (m a.s.l.), where the formation of a waterfall is evident (Figure 5a). In the micro-scale analysis, the number of holes was counted in three zones: Zone 1 with 36 holes, Zone 2 with 140 holes, and Zone 3 with 18 holes. The characteristics of the holes are heterogeneous, with diameters ranging from 10 cm to 70 cm (Figure 5b).
Similarly, to understand the origin of the footprints, it is necessary to know that the predominant mastodon species in Latin America was Cuvieronius hyodon, which ranged across the Andes from Ecuador to Chile (Mothié et al., 2016). The diet of South American mastodons has been extensively studied in recent years through dental enamel microwear analysis and oxygen and carbon isotope studies (Dantas et al., 2022; Dominato et al., 2010). However, there are only two known records of mastodon footprints in South America, both of which are found in Chile, specifically in Punta Pelluco in the Lakes Region, this area is renowned for its fossil forest from the late glacial period (Late Pleistocene) and also includes tracks of horses and camelids (Campos-Medina et al., 2022). Similarly, the records obtained in Argentina come from late Pleistocene deposits of Pehuén-Co and Laguna del Monte in the Buenos Aires Province (Oliva & Arregui, 2018). These footprints appear to have been left by a medium-sized proboscidean, allowing the identification of pathologies that affect the legs of modern elephants (and ungulates) in this individual (Oliva & Arregui, 2018).

In this context, having geological evidence, microscale arrangement, and the forms of erosion found in the upper part of the Chalán Ravine, the shapes of these holes correspond to geological formations known as “marmites” (Figure 6) from a geomorphological perspective. These marmites exhibit different diameters and depths, so they have been classified as follows: Type A, characterized by natural abrasion with diameters and depths less than 50 cm; Types B, C, and D, which are deeper abrasions where particles cannot be lifted by vertical energy; Type E, where lateral erosion predominates, leading to the development of angular edges at the top of the holes; and Type F, which are asymmetric and favor tangential

Figure 4. Description of the evolution of marmite erosion (Lorenc, Muñoz, & Saavedra, 1995).
Figure 5. a. Macro scale, flow direction in the upper part of the Quebrada de Chalán. b. Micro scale zones of identification of holes.

Figure 6. Marmites found in the upper part of the Chalán ravine.
water flow, often resulting in the formation of other marmites. These categorizations were described by Lorenc, Muñoz, and Saavedra (1995).

Conclusions
Although it is true that the Quebrada de Chalán has a large number of paleontological remains of Pleistocene fauna and megafauna, perhaps one of the most important in the Andean territory, where even today remains can be seen on several walls in the lower areas of the Quebrada, the upper part of the ravine, where this study was conducted, shows significant erosion over time.

Precisely this erosion, primarily caused by wall collapses in the ravine and water running through it, gives rise to the features that were initially mistaken and later mythologized as a series of mastodon footprints fleeing before one of the eruptions of the Tulabug volcano. However, these features are actually potholes. This conclusion was reached through photogrammetric study, macro and micro-scale analyses, arrangement of the potholes, their shape, water flow analysis, and geological interpretation. These analyses revealed that these features are not fossilized mastodon footprints but rather erosion of the rock layers, which, over time and under the described conditions, create these hole-like formations in the rock.

To fully complete the study and demonstrate that they are potholes, future analysis of the dimensions of the formations using geophysical techniques such as the Schmidt hammer test is necessary. Additionally, comparing these results with the footprints found in archaeological sites in Chile and Argentina would further strengthen the evidence supporting their classification as potholes.

Data availability
Underlying data
Zenodo: Mastodon footprints or water erosion in the Quebrada de Chalán (Licto, Ecuador), https://zenodo.org/record/6959979 (Mendoza et al., 2022).

This project contains the following underlying data:

**CHALAN 2_dtm.prj** (orthophoto obtained with the drone, the digital elevation model of the terrain)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

References
Blue Marble Geographics: Global Mapper Pro v23. Hallowell, Maine: Blue Marble Geographics. Release September, 2021; 2021.
Branco W: About A Fossil Mammal Fauna of Punín. Quito, Ecuador: Annals of the Central University of Ecuador; 1938.
Buenafía P: Geological and geophysical analysis applied to hydrogeological prospecting between the towns of Riobamba and Pungalá. Quito: National Polytechnic School; 2019.
Clapperton C, Vera R: The Quaternary glacial sequence in Ecuador: a reinterpretation of the work of Walter Sauer, Journal of Quaternary Science. 1986; 1(1): 45–56.
Campos-Medina J, Moreno K, Rojas J, et al.: The Oldest Record of the Lucménya Tribe and Proboscidia Order in the Southwestern Margin of the Andes Mountain Range: Late Pleistocene Mammlian Footprints at the Pellico Fossil Forest Sanctuary. 2022: Available at SSRN 4088783.
Casella E, Drechsel J, Winter C, et al.: Accuracy of sand beach topography surveying by drones and photogrammetry. Geo-Marine Letters. 2020; 40(2): 255–268.
Dantas MAT, Liparini A, Asevedo L, et al.: Annual isotopic diet (δ13C, δ18O) of Notiomastodon platensis (Ameghino, 1888) from Brazilian Intertropical Region. Quaternary International. 2022; 610: 38–43.
de Ribamba D: Quebrada de Chalán. In the footsteps of megafauna. Diario de Ribamba. Recalled on 12 of 2021. 05 of 12 of 2019.
Dominato VH, Avilla L, da Silva C, et al.: Registro da ação de besouros necrófagos (Coleoptera: Dermestidae) em restos de Stegomastodon waringi (Gomphotheriidae: Mammalia) do Pleistoceno da Colômbia. To Simposio Brasileiro de Paleontologia de vertebrados 18–23 julho 2010. Esri: ArchMap 10.8. Redlands, CA: Esri. Release March, 2020; 2020.
Fernández Díaz M: The Profession of Drone Pilot in the field of Cultural Heritage and Archaeology: science and dissemination from the air. 2018.
Fernández V: Archaeological prospecting: approaches, aids and techniques. Theory and Method of Archaeology. Fernández V, editor. Madrid: Synthesis; 1989; pp. 54–67.
Gasparini M, Moreno-Escribano JC, Monterroso-Checa A: Photogrammetric Acquisitions in Diverse Archaeological Contexts Using Drones: Background of the Ager Mellariensis Project (North of Córdoba-Spain). Drones 2020; 2020; 4(3): 47.
Publisher Full Text
Hoffstetter R: Les Mammifères Pléistocènes de la République de l’Equateur. Memoirs of the Société Géologique de France. Nouvelle Série-Tome.XXXI-Fasc. 1952: 1–4.
Kale VS, Joshi VJ: Evidence of formation of potholes in bedrock on human timescale: Indrayani river, Pune district, Maharashtra. Current Science. 2004; 723–726.
Lanis T, Razuvaev D: Systematization of features and requirements for geological survey of railroad subgrades functioning in cold regions. Sciences in Cold and Arid Regions. 2018; 9(3): 205–212.
La Prensa: La Quebrada de Chalán. La Prensa Chimborazo. 11 de 09 de 2021. Recuperado el 12 de 2021, de.

Maggie E: The telegraph. 26 of 11, 2016. Retrieved 12, 2021, from The Telegraph.

Mendoza B, Jiménez M, Carretero P, et al.: Mastodon footprints or water erosion in the Quebrada de Chalán. Licto, Ecuador: 2022.

Moncayo D: Diario de Riobamba. Obtained from Diario de Riobamba. 05 of 12 of 2019.

Oliva C, Arregui M: Mammalian Ichnopathology: a case study of Holartic Ungulates (Gomphotheriidae, Equidae, Camelidae) of the Late Pleistocene of South America. Ichnotaxomic implications. Boletín de la Sociedad Geológica Mexicana. 2018; 70(2): 417–447.

Ortega J, Gómez M, Pérez R, et al.: Multiscale structural and lithologic controls in the development of stream potholes on granite bedrock rivers. Geomorphology. 2014; 204: 588–598.

Pelletier J, Sweeney K, Roering J, et al.: Controls on the geometry of potholes in bedrock channels. Geophysical Research Letters. 2015; 42(3): 797–803.

Reinoso G: Puntín and Chalán. Cuenca: Separata de la Revista N°4 de Antropología; 1974.

Román J: Resumption of paleontological research at the Pleistocene site of Puntín, Quebrada de Chalán, province of Chimborazo, Ecuador. In X Argentine Congress of Paleontology and Biostratigraphy and VII Latin American Congress of Paleontology (La Plata, 2010). 2010.

Sauer W: Geología del Ecuador. Quito: Editorial del Ministerio de Educación; 1965.

Wolf T: Geografía y geología del Ecuador; publicada por orden del supremo gobierno de la república por Teodoro Wolf. Tipografía de FA Brockhaus; 1892.

Yurak: Yurak. 05 de 11 de 2020. Recuperado el 12 de 2021, de.
Since the nineteenth century, paleontologists have excavated numerous well-preserved Pleistocene mastodon remains in the abundant fossil deposits around Quebrada de Chalán, a deep ravine in south-central Ecuador. The abundance of mastodon fossils led to the assumption that a series of round holes in the bedrock above the deep-bed stream were footprints left by mastodons. For more than 100 years, this identification became embedded in traditional descriptions of the Chalán Gorge's geological treasures. Only two other locales in South America, Chile and Argentina, boast mastodon tracks reported in 2018 and 2022, respectively.

The co-authors thoroughly analyzed the geophysical and hydrological data of the Chalán Gorge and the properties of the holes and their context. Their interpretation of the evidence concluded that the “mastodon tracks” are really marmites created by water erosion in the ravine over millennia. There are clear descriptions and images showing how turbulent fluvial action carve the rounded holes in the streambed over time. I find the article well-conceived and organized, with convincing conclusions.

The authors might wish to expand the discussion of local and Indigenous legends about giant bones in Ecuador. This is mentioned only briefly. As early as the 1500s, Spanish explorers, such as Pedro Cieza de Leon, preserved accounts by Inca, Manta, Arica, and other Indigenous peoples about the bones of fearsome giants that invaded Ecuador and were destroyed en masse, by fire. (see A. Mayor, *Fossil Legends of the First Americans*, Princeton 2005, pp 80-84). The giants' bones were actually the fossil remains of mastodons and other megafauna of the Pleistocene, extremely plentiful in southern Ecuador. Also, given that marmites figured in a modern explanatory myth perpetuated by scientists for more than a century, the authors might consider looking for previous local explanations of the pot holes often called “Giants' kettles” or “cauldrons” in other cultures, to see whether Indigenous inhabitants of the region, not just Europeans, tried to account for the remarkable formations along the gorge.
References
1. Mayor A: Fossil Legends of the First Americans. *Princeton*. 2005. 80-84

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

*Competing Interests*: No competing interests were disclosed.

*Reviewer Expertise*: Fossil folklore, history of science, legends and myths about fossilization

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 01 August 2023

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Valeria Lupiano
National Research Council of Italy, Research Institute for Geo-Hydrological Protection, CNR-IRPI, Perugia, Italy

I believe the article has reached a sufficient level of improvements and is ready for indexing.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Geology, geomorphology, landslides

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
No source data required

Are the conclusions drawn adequately supported by the results?
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Footprints

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

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**Author Response 17 Jul 2023**

**Benito Mendoza**

Dear reviewer, while the presented work requires more data to determine whether the traces are mastodon footprints or erosional scours, a thorough revision has been conducted. Additional paragraphs have been added to reinforce the initial theory presented in the paper, supported by a literature review and macro and microscale analysis. It is important to note that there are limited indications of mastodon footprints in South America, and this topic is just beginning to be studied. Consequently, the conclusions leave open the possibility of furthering this research through geophysical methods and comparative analysis with similar features found in Argentina and Chile. This will be explored in future work to ascertain whether these are indeed mastodon footprints or erosional scours.

**Competing Interests:** No competing interests were disclosed.

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**Reviewer Report 12 January 2023**

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The authors present a paper that aims to show how the footprints, found in Quebrada de Chalán (Licto, Ecuador), attributed to Mastodon by local people, are instead a geomorphological phenomenon (river potholes) related to fluvial erosion and the lithology of the site. They did a field survey and used aerial photogrammetry to prove this.

The manuscript is well structured but needs a revision of English language.

It is necessary to explain the mechanism that leads to the formation of river potholes by commenting on Figure 5. Also mention the factors that predispose to the phenomenon. See for example:

1. Ortega, J. A., Gómez-Heras, M., Perez-López, R., & Wohl, E. (2014). Multiscale structural and lithologic controls in the development of stream potholes on granite bedrock rivers. Geomorphology, 204, 588-598.

2. Kale, V. S., & Joshi, V. U. (2004). Evidence of formation of potholes in bedrock on human timescale: Indrayani river, Pune district, Maharashtra. Current Science, 723-726.

The conclusions are very meager, should be supplemented with some consideration.

Minor revision:
1. figure 1: insert a small map with Ecuador location; In the legend change "m.s.n.m." in "m a.s.l.";

2. In the text change "masl" in "m a.s.l.";

3. ArcMap and globalmapper cite as:
   ESRI year. ArcMap, Release xx. Redlands, CA: Environmental Systems Research Institute.
   Blue Marble year. Globalmapper Release....;

References
1. Ortega J, Gómez-Heras M, Perez-López R, Wohl E: Multiscale structural and lithologic controls in the development of stream potholes on granite bedrock rivers. Geomorphology. 2014; 204: 588-598 Publisher Full Text
2. Kale VS, Joshi VU: Evidence of formation of potholes in bedrock on human timescale: Indrayani river, Pune district, Maharashtra. Current Science. 2004. 723-726

Is the work clearly and accurately presented and does it cite the current literature? Yes

Is the study design appropriate and is the work technically sound? Yes

Are sufficient details of methods and analysis provided to allow replication by others? Yes
Partly

**If applicable, is the statistical analysis and its interpretation appropriate?**
Not applicable

**Are all the source data underlying the results available to ensure full reproducibility?**
No source data required

**Are the conclusions drawn adequately supported by the results?**
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Geology, geomorphology, landslides

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 17 Jul 2023

**Benito Mendoza**

Dear reviewer, a thorough review of the English writing was conducted, taking into account minor corrections. Additionally, the study was analyzed with respect to new suggested literature, which led to further explanation on how the marmites could have originated.

**Competing Interests:** No competing interests were disclosed.

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