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MICROEROSION DATING OF THE QIN DYNASTY ROCK INSCRIPTIONS DISCOVERED IN QINGHAI, CHINA

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Abstract. In June 2025, the Garitang Inscription of the Qin—the Qinghai-Tibet Plateau’s only in situ Qin-Dynasty rock inscription—was discovered in Maduo County, Qinghai. Linked to some historical debates (Kunlun Mountain’s location and Qin Shi Huang’s quest for immortality), its authenticity raised scepticism regarding its historical, environmental and logistical feasibility. Researchers addressed these concerns through rock varnish analysis (≥ 2500 years old), microerosion dating (quartz erosion, ~2100 years, aligning well with 210 BCE), and textual verification via the Shanhaijing to clarify ambiguities in characters like ‘Kunlun’ and ‘medicine’. This discovery fills gaps in Qin western expansion records, establishes an integrated framework for arid-zone inscriptions, and provides key calibration data for Qinghai-Tibet rock art dating. It also confirms early cultural exchanges between Han China and the western frontiers during the Qin-Han transition.

Introduction

On 8 June 2025, *Guangming Daily* published an article by Dr Tong Tao of the Institute of Archaeology, Chinese Academy of Social Sciences, titled ‘Verifying the ancient location of Kunlun: a Qin Dynasty inscribed stone discovered at the Yellow River’s source in Qinghai, recording Emperor Qin Shi Huang’s mission to seek immortal herbs in the Kunlun Mountains’, formally announcing the discovery of the Garitang Qin Inscription.

Located at Garitang in Zhuorong Village, Zaling Lake Township, Maduo County, Qinghai Province—the site is situated at an elevation of 4306 m asl., facing south toward Gyaring Lake (Zaling Lake) and approximately 200 m from its shore (Fig. 1). The inscription is engraved on a quartz sandstone slab measuring 83 cm in length and 33 cm in height (Fig. 2). It comprises 36 characters arranged in 12 lines, plus one ligatured character, totalling 37 characters, all rendered in Qin seal script (Qin zhuan) and relatively well preserved.

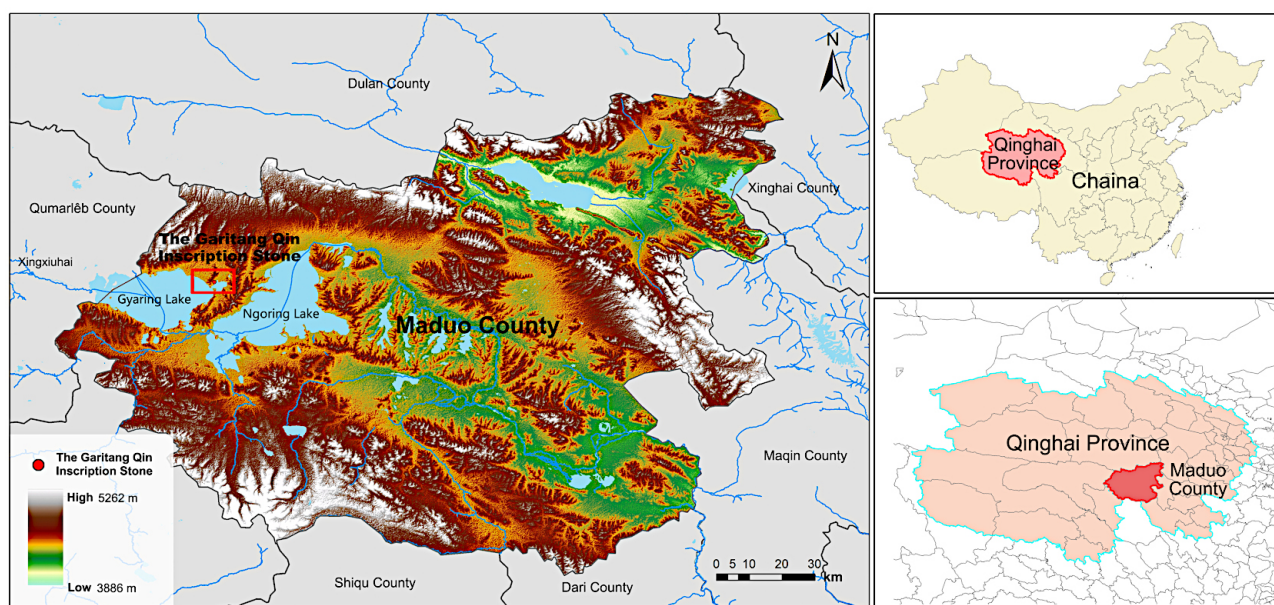


Figure 1. Location of the Garitang Qin Inscription, with an elevation of 4306 m and about 200 m from the shore of the Gyaring (Zaling) Lake.

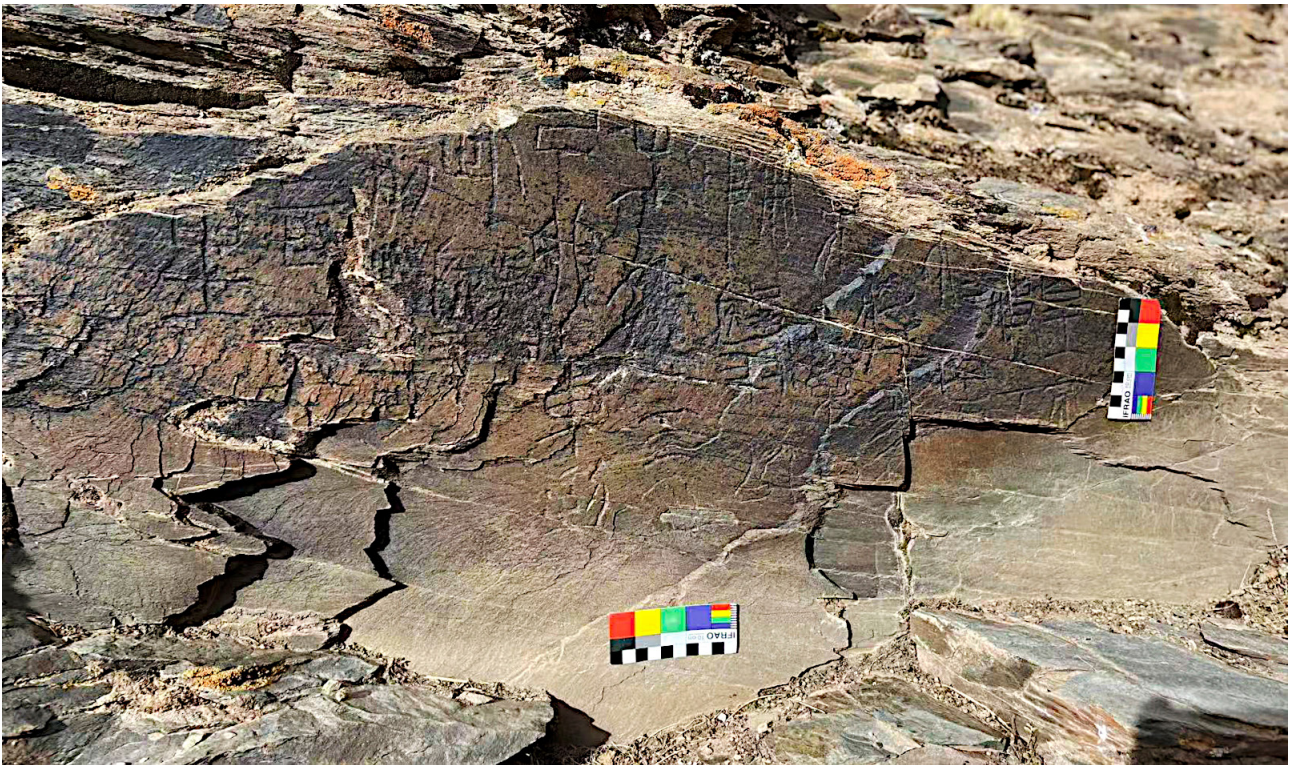


Figure 2. The Garitang Qin Inscription carved on a quartz sandstone slab (83 cm long, 33 cm high), bearing 37 characters in Qin seal script.

The original text is: ‘皇帝/使五/大夫臣翳/將方技/采樂昆/輪翳以/卅七年三月/己卯車到/此翳□/前□可/一百五十/里’, which appears to read: ‘By imperial command / Envoy Wu / Da Fu, Minister Yi / Leading fangshi practitioners / To gather immortal herbs at Kun / Lun. Yi, in the / thirty-seventh year, third month / on the day Ji-Mao, arrived here by chariot. / Yi □ / Ahead □ / One hundred fifty / li’. Broadly recording that in 210 BCE—during the thirty-seventh year of Emperor Qin Shi Huang’s reign—he dispatched his minister Yi to the Kunlun Mountains to procure elixirs of immortality. The discovery has immediately ignited intense and far-reaching debate across both scholarly and public spheres.

The inscription’s core significance lies in its direct connection to three historical enigmas in Chinese civilisation: the geographical identification of the Kunlun Mountain, the legend of Qin Shi Huang’s quest for the elixir of immortality, and the interpretation of ancient Chinese script. It not only provides physical evidence linking ‘Kunlun’ to the Starry Sea region of the Yellow River source but also offers unprecedented corroboration of the emperor’s westward pursuit of immortality, surpassing the mythic limitations of the ‘Xu Fu’s Eastern Voyage’ narrative, who, in accordance with the *Records of the Grand Historian*, was also dispatched by Qin Shi Huang to lead a fleet eastward from the East China Sea in search of the elixir of immortality.

However, scepticism emerged swiftly. Critics argued the inscription was a modern forgery, citing a lack of historical records, inaccessibility due to extreme winter conditions, and the inability of Qin-era

transportation to support horse-drawn carriages to such a remote location. Over 90 academic rebuttals and countless public discussions followed, reflecting profound scholarly divisions.

To address these disputes, the National Cultural Heritage Administration swiftly assembled a multidisciplinary team for two field investigations and expert evaluations. While confirming it as China’s highest-altitude and only in-situ preserved Qin inscription, the administration did not specify its exact dating. Given the centrality of chronology to resolving authenticity claims, on 16 November 2025, a research team, assisted by local cultural authorities, conducted on-site inspections and microerosion analysis of unpatinated characters. This report presents the findings, aiming to provide scientific evidence for dating and validating the inscription’s historical authenticity.

1. Rock varnish

Patina—also known as desert varnish, rock varnish, oxidation layer, Gobi varnish or simply ‘stone rust’—is one of the key indicators used to date ancient artefacts. Although these terms differ based on formation environments and visual characteristics, they all refer essentially to a secondary mineral coating that develops over time on rock surfaces through natural processes. Desert varnish and Gobi varnish are typical products of arid regions; ‘rock varnish’ emphasises its glossy, lacquer-like texture, while ‘stone rust’ and ‘oxidation layer’ are more general terms. All forms result from the combined effects of physical evaporation and chemical oxidation.

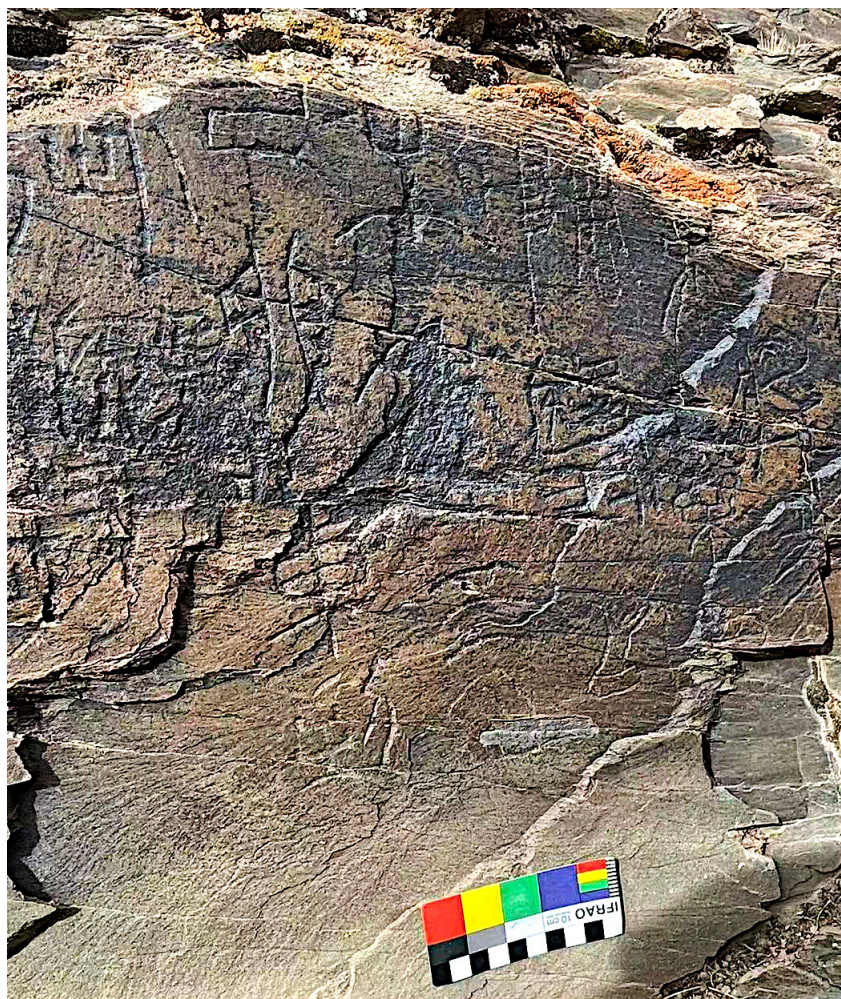


Figure 3. Microscopic comparison of rock varnish in carved grooves and on the adjacent rock surface of the Garitang Qin Inscription, showing patina in grooves that is comparable to or thicker than that on the surrounding surface.

The formation of patina either requires soluble, mobile minerals originally present within the rock as raw materials, or the involvement of microbial activity securing these from air-borne matter. Iron and manganese oxides (such as haematite, limonite and pyrolusite), silica and calcium–magnesium salts all belong to this category, with iron and manganese oxides being the primary sources of the red, brown and black hues characteristic of patina. Even in arid deserts, brief rainfall or morning dew can infiltrate rock fissures, reacting chemically with primary minerals like iron-bearing feldspar or pyroxene to produce mineral-laden aqueous solutions. When these solutions reach the rock surface, intense solar radiation and dry air cause rapid evaporation. This sharply increases solute concentration until supersaturation is reached. Simultaneously, ferrous (Fe^{2+}) and manganous (Mn^{2+}) ions undergo oxidation by atmospheric oxygen and ultraviolet radiation, converting into ferric (Fe^{3+}) and manganic (Mn^{4+}) ions, which then precipitate as oxides (Bednarik 2007).

This cycle—water infiltration → mineral disso-

lution → capillary rise → surface evaporation → oxidative precipitation—repeats countless times. Each micro-scale wetting-and-drying event deposits an extremely thin layer of minerals on the rock surface. After tens of thousands of such cycles, these nanometre- to micrometre-thick layers accumulate, merge, compact, and are further polished by wind erosion, eventually forming a continuous, dense, lustrous mineral coating visible to the naked eye: patina. The development of patina is directly proportional to time—the longer it forms, the thicker, darker and glossier the coating becomes. Once formed, this varnish acts like an armour, significantly slowing down the weathering and erosion of the underlying rock, thus becoming a distinctive feature of arid-region landforms.

Although patina can form in various climates, a dense, glossy varnish only develops in arid zones. In humid regions like southern China, patina may occur but fails to produce the characteristic lacquer-like finish, highlighting the geographical specificity of desert and Gobi varnishes. The Garitang Qin Inscription Stone is located near Gyaring Lake, where annual precipitation ranges from 50 to 300 mm—an arid environment. Combined with high altitude and intense solar exposure, these condi-

tions are highly conducive to rock varnish formation. Field observations reveal a clear, relatively thick layer of varnish on the stone, providing material evidence of its antiquity, though precise dating still requires corroboration from other methods.

From the archaeological perspective of ‘stratigraphic disruption’, any incised marks on a rock surface must be younger than the rock itself. Initially, the freshly carved grooves develop thinner and less intensely coloured patina compared to the original rock surface. However, the V- or U-shaped section geometry of these grooves better traps moisture and mineral deposits, facilitating more efficient patina accumulation over time. Eventually, after sufficient duration, the patina within the grooves can match or even exceed that on the surrounding flat surface in both colour depth and thickness. Professor Emmanuel Anati, a renowned Italian rock art scholar, demonstrated through extensive research that for engraved petroglyphs dating from the Iron Age to recent times, complete colour and thickness convergence between groove patina and surface patina requires at least 2500

years (Anati 1963: 189).

Microscopic field examination of the Garitang Qin Inscription Stone shows that the patina within its grooves matches—or even exceeds—the adjacent rock surface in both hue and thickness (Fig. 3). Based on Professor Anati's findings, we can preliminarily conclude that this inscription is at least 2500 years old. While this estimate is not a precise scientific dating, it offers a crucial reference point for determining the artefact's age. After observing rock inscriptions and rock art in Western Australia, Bednarik obtained a more precise estimation of the ratio relationship between rock varnish and time. The patina thicknesses of dated inscriptions near Abydos and Woodstock in the Pilbara are directly related to their relative ages, reaching 30–50 µm after 80–120 years (Bednarik 2024: 209).

2. Microerosion dating

Microerosion dating is a scientific method used to determine the age of petroglyphs by measuring and analysing the degree of natural weathering on engraved grooves. Before explaining this technique, it is essential to distinguish between two broad categories of rock: one is sedimentary rock, which is prone to granular disintegration and chemical corrosion—such as sandstones with carbonate cement, calcite and dolomite; the other is hard rock with excellent wear and corrosion resistance, such as granite, granodiorite, diorite and gabbro. This study focuses on engravings made on the latter type. These rocks contain chemically stable minerals like quartz and feldspar: quartz (SiO₂) has a Mohs hardness of 7 and a melting point of 1713°C, while feldspar—a group of aluminosilicate minerals containing potassium, sodium, calcium or barium—is slightly less stable but still highly resistant to oxidation. Both minerals exhibit minimal reactivity under typical atmospheric conditions.

During the creation of rock art, freshly impacted quartz and feldspar crystals within the grooves initially possess sharp edges and angular facets. Over time, natural weathering processes—particularly wind abrasion and minor chemical interactions—gradually round these sharp features into smooth, curved surfaces known as 'wane' (or microerosion facets). Crucially, the width of this wane shows a linear positive correlation with the duration of exposure. The core principle of microerosion dating lies in establishing this relationship: by measuring the wane width of fractured quartz crystals within engravings and applying a region-specific calibration coefficient, researchers can estimate the time elapsed since the petroglyph was made.

In China, numerous rock inscriptions bear explicitly stated dates, providing reliable reference points for calibration. Their measured wane data serve as benchmark parameters against which undated petroglyphs can be compared—an approach that is both straightforward and highly accurate. Between 2014 and 2019, an international team of Chinese, Australian

and Indian rock art scholars—part of the China Rock Art Dating Project—conducted microerosion surveys at over 20 major rock art sites across the country. These included Mount Juci and Nanyang in Henan; Lianyungang in Jiangsu; Chifeng in Inner Mongolia; Helan Mountain in Ningxia; the Greater Khingan Range in Heilongjiang; Yushu in Qinghai; Shiqu in Sichuan; Huashan in Guangxi; Zhangzhou in Fujian; and the Ili River Valley and Altai Mountains in Xinjiang. From these sites, they collected more than 100 microerosion age estimates (Tang et al. 2017, 2018, 2020). To date, microerosion analysis remains the most effective scientific method for directly dating petroglyphs.

The Garitang Qin Inscription Stone is engraved into a quartz sandstone panel measuring 83 cm in length and 33 cm in height, facing south toward Gyaring Lake—the only suitable surface for inscription in the immediate area. The rock surface is clearly covered by desert varnish, and notably, the varnish within the engraved grooves is thicker and darker than on the surrounding flat surface. This aligns with the known behaviour of desert varnish: over time, accumulation within grooves eventually surpasses that on planar surfaces due to enhanced moisture and mineral trapping.

The varnish on this stone is well-developed, deep black in colour, yet lacks strong lustre—indicating minimal exposure to abrasive wind erosion. The upper portion of the inscription is heavily obscured by thick patina, making microerosion measurements of quartz crystals impossible there. However, the lower characters—such as 'qu' (去), 'ji' (已), 'yue' (月) and 'dao' (到)—show no desert varnish coverage. This is likely because the ancient ground level was higher than today's surface; vegetation at that time would have shaded these lower engravings from direct sunlight, inhibiting varnish formation. Moreover, the crude execution and distorted forms of the lowest characters suggest that the carver worked in a confined space just above the original ground level.

Significantly, neither the rock face nor the area immediately below these lower characters shows any desert varnish—strong evidence that this section was recently exfoliated, newly exposing the fresh rock surface to air and sunlight. Additionally, the inscribed panel exhibits a slight inward concavity. Behind it, six or seven low stone terraces on the hillside effectively shield the carving from northerly winds. Combined with the region's arid climate (annual precipitation of 50–300 mm), this unique microenvironment has played a crucial role in preserving the inscription for over two millennia.

Most of the carved grooves contain thick rock varnish, but the three characters 帝 (emperor), 到 (arrival), 此 (here) on the lower part of the rock surface are almost free of rock varnish in their grooves due to sunlight blockage by ground vegetation. Therefore, we observed and measured the wane on the quartz crystals within the incisions of these three Chinese



Figure 4. In-situ microerosion observation and measurement points of the Garitang Qin Inscription.

characters using a 60× monocular microscope (Fig. 4). A total of 24 valid measurements were obtained, with descriptive statistics summarised in Table 1.

The overall average wane width across all measurements is 5.9 μm . For comparative age estimation, two independent calibration curves were applied: the Lushan regional calibration curve (Tang and Gao 2004) and the global universal calibration curve (Bednarik 2019). The Lushan petroglyphs show an average wane width of 6.0 μm , corresponding to a microerosion age of roughly 2300 years BP. Applying the same regional calibration (Figs 5–7, Table 1), the Garitang Qin Inscription yields an estimated age of approximately 2260 years BP. Calibrated by the global universal curve (Figs 8–10, Table 1), it yields an estimated age

of approximately 2070 years BP.

This closely aligns with the historical context implied by the inscription itself—specifically, the 37th year of Qin Shi Huang's reign (corresponding to 210 BCE, or 2210 years before present)—thereby offering strong independent support for its authenticity and antiquity.

3. Textual issues

The inscription comprises 37 characters in total, including one ligatured (combined) character. Nearly all of these have been securely identified, and scholarly consensus has largely been reached—except for three points of uncertainty: the characters 'Kunlun' (崑崙), the character 'yao' (藥) means 'herb or medicine' in

Group	Wane-length (μm)	Wane-width (μm)	Mean (μm)	Micro-wane	Age estimate
'di' / '帝' (emperor)	L=18	6,5,6,6,7,7,5,5,5	5.8	China-Qinghai-Garitang Qin Inscription-01-EQ-2025 Calibrated by Universal curve	E 2030+470/-30
				China-Qinghai-Garitang Qin Inscription-01-EQ-2025 Calibrated by Lushan curve	E 2204+500/-300
'dao' / '到' (arrival)	L=28	7,6,5,5,5,8,6	6.0	China-Qinghai-Garitang Qin Inscription-02-EQ-2025 Calibrated by Universal curve	E 2100+700/-350
				China-Qinghai-Garitang Qin Inscription-02-EQ-2025 Calibrated by Lushan curve	E 2280+770/-380
'ci' / '此' (here)	L=27	6,5,6,6,6,7,7,5	6.0	China-Qinghai-Garitang Qin Inscription-03-EQ-2025 Calibrated by Universal curve	E 2100+350/-350
				China-Qinghai-Garitang Qin Inscription-03-EQ-2025 Calibrated by Lushan curve	E 2280+420/-380

Table 1. Microerosion dating results of the Garitang Qin Inscription, calibrated by the Lushan regional curve and the global universal curve.

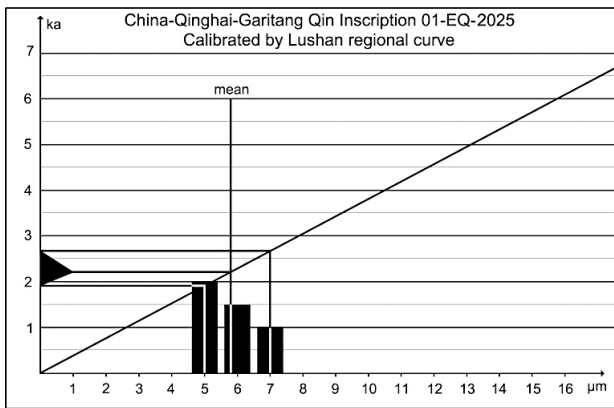


Figure 5. Microerosion age estimate from the character '帝' (emperor) of the Garitang Qin Inscription, calibrated by the Lushan regional curve.

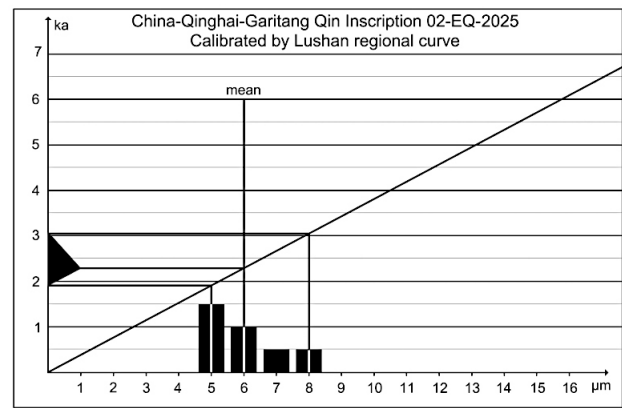


Figure 6. Microerosion age estimate from the character '到' (arrival) of the Garitang Qin Inscription, calibrated by the Lushan regional curve.

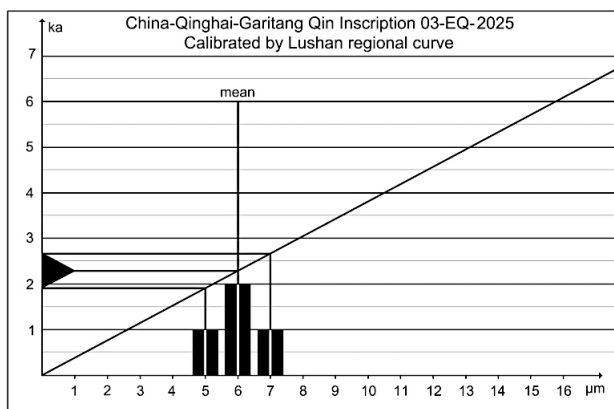


Figure 7. Microerosion age estimate from the character '此' (here) of the Garitang Qin Inscription, calibrated by the Lushan regional curve.

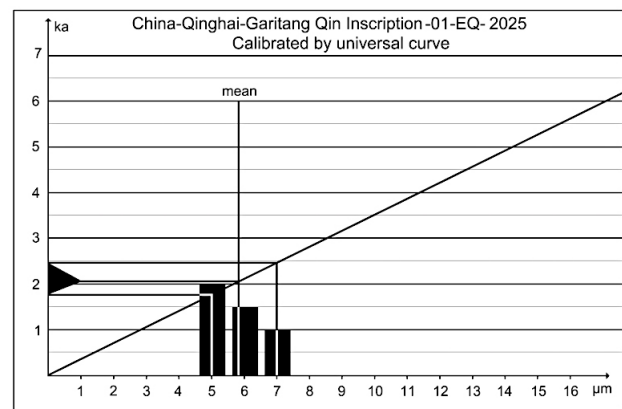


Figure 8. Microerosion age estimate from the character '帝' (emperor) of the Garitang Qin Inscription, calibrated by the global universal curve.

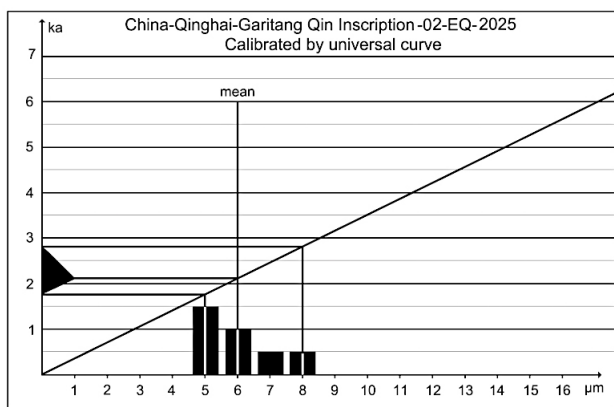


Figure 9. Microerosion age estimate from the character '到' (arrival) of the Garitang Qin Inscription, calibrated by the global universal curve.

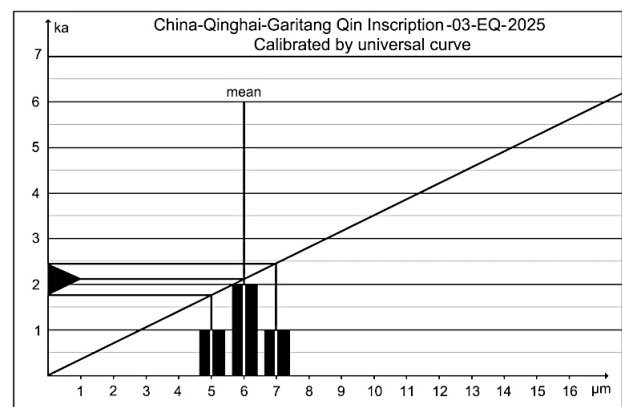


Figure 10. Microerosion age estimate from the character '此' (here) of the Garitang Qin Inscription, calibrated by the global universal curve.

the phrase 'cai yao' ('to gather herbs'), and the numeral 'yi' ('一', means 'one') in 'one hundred.'

Some scholars argue that the lower component of the character interpreted as kun (昆)—which resembles 'bi' (比)—cannot be confirmed due to surface spalling on the stone, casting doubt on its identification as 'kun'. Similarly, the character read as 'yao' (藥)

is questioned because its grass radical (艹) appears eroded or missing; it might instead be 'le' ('樂', meaning 'music' or 'joy').

During our on-site inspection, however, we observed that the space above this character is sufficiently large to accommodate a grass radical. While absolute certainty remains elusive, the contextual evidence

strongly supports reading it as 'yao'. The phrase 'cai yao' (gather herbs) coheres naturally with the preceding reference to *Kunlun*, and conversely, the mention of 'gathering herbs' reinforces the likelihood that the earlier toponym is indeed *Kunlun*. In other words, the two readings are mutually corroborative.

This intertextual linkage is well grounded in classical literature. Texts such as the *Shan Hai Jing*, the *Huainanzi* and the *Bowuzhi* repeatedly associate *Kunlun* with 'herbs' or the 'elixir of immortality':

Shan Hai Jing (Hainei Xijing) describes *Kunlun Xu* (Kunlun Mound) as the 'Lower Capital of the Emperor,' adding that 'east of Kai Ming [Gate] dwell the shamans Peng, Di, Yang, Lü, Fan and Xiang, flanking the corpse of Yaya, each holding the herb of immortality to ward off decay'.

Shan Hai Jing (Dahuang Xijing) recounts the geography of *Kunlun Qiu* (Kunlun Hill) and then introduces a figure 'wearing a sheng headdress, with tiger teeth and a leopard's tail, dwelling in a cave—named the Queen Mother of the West (Xiawangmu)', who is precisely the deity entrusted with the elixir of immortality.

Elsewhere, the *Shan Hai Jing* notes that the 'Ten Shamans of Spirit Mountain ascend and descend from there, where all manner of medicinal herbs are found'. Spirit Mountain (Lingshan) and *Kunlun* both belong to the same mythological complex of western sacred mountains.

The *Huainanzi* (Dixing Xun) states: 'On *Kunlun Hill* ... grows the Tree of Grain, five xun tall. To its west stand the Pearl Tree, Jade Tree, Xuan Tree, and the Tree of Immortality ...'.

The *Huainanzi* (Lanming Xun) recounts: '... Yi requested the elixir of immortality from the Queen Mother of the West, but Heng'e stole it and fled to the moon ...'.

The *Bowuzhi* also records: 'At *Kunlun Xu* stands a nine-tiered Zengcheng ... On its summit grows the Tree of Grain; there too is the Tree of Immortality—those who eat of it attain longevity; there flows the Sweet Spring—those who drink from it never die.'

Given this rich textual tradition, the co-occurrence of 'Kunlun' and 'gathering herbs' in the inscription forms a clear case of mutual textual reinforcement, wherein each term validates the other through established mytho-geographical conventions.

Regarding the numeral in 'yi bai' (一百, 'one hundred'), some scholars have proposed it might actually read 'èr bai' (二百, 'two hundred'). However, after careful examination with a 20× magnifying lens, we confirm it is unequivocally the character 'yi' (一, 'one'), not 'èr' (二, 'two'). A faint horizontal mark sometimes mistaken for a second stroke above the 'one' is in fact a natural flake scar on the rock surface, showing no trace of intentional carving.

Moreover, measuring westward from the stele's location on the northern shore of Gyaring Lake, a distance of exactly '一百五十里' ('150 li', a Chinese li is 500 m, so 150 li is 75,000 m) leads directly to the Xingxiu Hai—the traditional source region of the Yellow River. The classical literature *Erya* states, 'The

River issues from Kunlun Xu; its colour is white'. This description likely refers to the shimmering expanse of Xingxiu Hai, which, when viewed from afar, appears as a vast field of silvery-white light.

Conclusion

The Gaertang Qin Inscription constitutes a rare and significant material remnant of the Qin dynasty on the Qinghai–Tibet Plateau. It not only addresses critical gaps in the historical record regarding the Qin state's administrative expansion into the northwestern frontier and its pursuit of the legendary 'elixir of immortality' associated with *Kunlun*, but also offers a robust, integrated methodological model for dating rock inscriptions in arid regions—one that combines environmental feature analysis, scientific chronometric techniques and cross-referencing with textual sources. Furthermore, its securely dated epigraphic inscription provides a valuable local calibration point for future chronological studies of petroglyphs and cliff inscriptions across the Qinghai–Tibet Plateau.

When examined through multiple interdisciplinary perspectives—including Qin-era frontier governance strategies, indigenous Qiang-Rong cultural traditions, *Kunlun* mythology, the *fangshi* (*fangxian*) immortality cults of the Qin–Han period and high-altitude archaeology—the inscription promises to yield deeper insights into the dynamic cultural exchanges between the Central Plains and the western frontiers during this formative era. Its full interpretive potential, we believe, remains to be fully realised through continued scholarly investigation.

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