

Title: First documented record of the ammonite *Turrilites costatus* LAMARCK, 1801 from the Cenomanian of northern Saudi Arabia: Implications for Arabian Plate paleogeography

Author: Abdullah Homod Alrwaili

Affiliation: Independent Researcher, Ar'ar, Saudi Arabia

Author's ORCID URL: <https://orcid.org/0000-0002-2746-2729>

Email for Correspondence: asd2791@gmail.com

Status Statement: This is a non-peer reviewed preprint submitted to EarthArXiv.

First documented record of the ammonite *Turrilites costatus* LAMARCK, 1801 from the Cenomanian of northern Saudi Arabia: Implications for Arabian Plate paleogeography

Abdullah Homod Alrwaili

Independent Researcher, Ar'ar, Saudi Arabia

Abstract

This study presents the first documented occurrence of the heteromorph ammonite genus *Turrilites* LAMARCK, 1801, from the Cretaceous strata of the Kingdom of Saudi Arabia. A dense, *in-situ* fossil assemblage, dominated by numerous specimens identified as *Turrilites costatus* LAMARCK, 1801, was discovered in an outcrop of the Aruma Formation located 9.5 km south of the city of Ar'ar in northern Saudi Arabia. To date, the published fossil record of this genus on the Arabian Peninsula has been restricted to the Natih Formation of the Sultanate of Oman, on the southeastern margin of the Arabian Plate. The presence of *Turrilites*, a well-established index fossil for open-marine, outer-shelf environments, in the interior of the Arabian Plate fundamentally challenges prevailing paleogeographic models that depict this region as a shallow, restricted epeiric sea during the Cenomanian. These findings provide the first direct paleontological evidence for the existence of a persistent, open seaway connected to the Neo-Tethys Ocean that extended across the northern Arabian Plate. This discovery necessitates a significant reassessment of the region's paleogeographic maps and deepens our understanding of its complex paleoenvironmental history during a critical period of global greenhouse conditions.

1. Introduction

1.1 Biostratigraphic and Paleoecologic Significance of *Turrilites*

The heteromorph ammonite genus *Turrilites* LAMARCK, 1801, characterized by its distinctive turreted, screw-like shell, is a cornerstone of Middle Cretaceous biostratigraphy. Species within this genus, particularly *Turrilites costatus*, serve as crucial index fossils for defining and correlating the Cenomanian Stage on a global scale (Hancock, 1991; Kennedy & Cobban, 1991). The relatively short stratigraphic range and wide geographic distribution of *T. costatus* make it an invaluable tool for high-resolution chronostratigraphic subdivision, specifically for identifying the Middle Cenomanian substage.

Beyond its biostratigraphic utility, *Turrilites* is also a powerful paleoenvironmental indicator.¹ Like many ammonoids, especially the uncoiled or heteromorphic forms, *Turrilites* is interpreted as having been a stenohaline organism, intolerant of significant fluctuations in marine salinity (Westermann, 1996). Its fossil occurrences are overwhelmingly associated with outer-shelf to upper-slope marine facies, characterized by normal salinity, stable oxygen levels, and direct connection to the open ocean. The genus is conspicuously absent from strata representing restricted, brackish, or hypersaline depositional environments. Consequently, the discovery of *Turrilites* provides compelling evidence for the former presence of a fully marine, open-shelf setting.

1.2 Cretaceous Paleogeography of the Arabian Plate: Prevailing Models

The paleogeography of the Arabian Plate during the mid-Cretaceous was dominated by the vast, warm, and shallow Neo-Tethys Ocean to the northeast. The plate itself formed a massive carbonate platform, with depositional environments largely controlled by eustatic sea-level fluctuations (Sharland et al., 2001). Prevailing geological models for the Cenomanian depict the interior of the Arabian Plate, including the region of modern-day northern Saudi Arabia, as a broad, shallow epeiric (or inland) sea.¹ This setting, often referred to as the Wasia-Aruma platform, is generally characterized by shallow-water carbonate deposition, with models suggesting that circulation could be restricted in areas far from the open-ocean margin (Al-Husseini, 2008). Such restricted circulation can lead to environmental conditions, including elevated salinity and temperature, that would be inhospitable to stenohaline oceanic

fauna like cephalopods.

1.3 The Knowledge Gap: Absence of *Turrilites* Records in Saudi Arabia

In accordance with these paleogeographic models, the known distribution of *Turrilites* on the Arabian Peninsula has, until now, been exclusively confined to its southeastern margin. Rich assemblages of *Turrilites costatus* and other Cenomanian ammonites are well-documented from the open-marine deposits of the Natih Formation in the Oman Mountains (Kennedy & Simmons, 1991). These occurrences in Oman represent the paleoenvironment of the continental shelf edge, directly facing the Neo-Tethys Ocean. In stark contrast, a comprehensive review of the paleontological literature for the Kingdom of Saudi Arabia reveals a complete absence of any prior documented records of the genus *Turrilites*. This conspicuous biogeographic gap has reinforced the interpretation of an environmentally restrictive barrier separating the plate interior from the open ocean.

1.4 Aims of the Present Study

This study presents the first documented discovery of *Turrilites costatus* in northern Saudi Arabia. The primary aims of this paper are threefold: (1) to formally document this discovery and provide a systematic paleontological description of the fossil material; (2) to establish the precise geological and stratigraphic context of the fossil-bearing locality; and (3) to conduct a thorough analysis of the profound paleoenvironmental and paleogeographic implications of this finding, which calls for a fundamental revision of our understanding of the Cenomanian seaway across the Arabian Plate.

2. Geological Setting

2.1 Stratigraphy of Northern Saudi Arabia

The Cretaceous stratigraphy of northern Saudi Arabia is primarily represented by the Wasia

and Aruma Groups. The Wasia Group comprises older Cretaceous units, while the overlying Aruma Formation represents a major Late Cretaceous transgressive sequence deposited across a vast area of the Arabian Platform. The Aruma Formation unconformably overlies older units and is itself composed of several members, generally consisting of shallow-marine limestones, dolostones, and marls (Powers et al., 1966).

2.2 The Aruma Formation: Lithology and Age

The fossil specimens described herein were discovered within the Aruma Formation. Based on the presence of the index fossil *Turrilites costatus*, the age of this specific horizon is confidently assigned to the Middle Cenomanian. The host rock at the discovery site is a whitish to yellowish, bioclastic limestone, which is consistent with the known lithologies of the lower part of the Aruma Formation in the region.¹ The rock is well-indurated and contains a high concentration of fossil material.

2.3 Description of the Fossil-Bearing Outcrop at the Ar'ar Locality

The discovery was made at a low-lying limestone outcrop located approximately 9.5 km south of the city of Ar'ar, Northern Borders Region, Saudi Arabia.¹ The central coordinate for the locality, which encompasses all documented specimens, was recorded using a Global Positioning System (GPS) as 30.881345° N, 40.916889° E. The fossils were found *in-situ* within a concentrated area of approximately two square meters on the weathered surface of several limestone blocks. The high density of specimens within this small area suggests the outcrop exposes a fossiliferous condensation layer, representing either a life assemblage (biocoenosis) or a minimally transported death assemblage (taphocoenosis). The latter interpretation is favored by the excellent preservation of delicate features on the external molds, which would not have survived significant transport.

3. Systematic Paleontology

The classification follows the scheme presented in the Treatise on Invertebrate Paleontology, Part L (Wright et al., 1996).

Phylum Mollusca CUVIER, 1795
Class Cephalopoda CUVIER, 1797
Order Ammonoidea ZITTEL, 1884
Suborder Ancyloceratina WIEDMANN, 1966
Superfamily Turrilitoidea GILL, 1871
Family Turrilitidae GILL, 1871
Genus Turrilites LAMARCK, 1801
Turrilites costatus LAMARCK, 1801
(Figures 1, 2)

Material

The study is based on a dense, in-situ fossil assemblage documented on the weathered surfaces of several limestone blocks at the Ar'ar locality (Coordinates: 30.881345° N, 40.916889° E). The material consists of at least nine identifiable specimens, along with numerous additional fragments. The specimens are preserved as partially dissolved original shell material and as high-fidelity external molds. All documented material remains in-situ at the discovery site.

Description

The shell is a high-spined, tightly coiled turricone with dextral coiling. The whorl section is subquadrate to subrectangular, with flat sides. The ornamentation, clearly visible on both the shell fragments and the external molds, is highly characteristic of the species. It consists of strong, sharp, slightly sinuous ribs that run obliquely across the whorl flank. Each rib bears three prominent rows of tubercles. The uppermost row, situated at the upper whorl suture, consists of small, clavate tubercles. The middle row, located at mid-flank, comprises the most prominent, sharp, conical tubercles. The lowest row, situated at the lower whorl suture, consists of tubercles similar in size and shape to the uppermost row. The base of the whorls is not clearly visible in the available material. The sutures are not preserved. The dimensions of the specimens vary, with the largest measurable fragment having a whorl height of approximately 25 mm.

Remarks

The combination of a high-spired turricone shell, flat-sided whorls, and distinctive ornamentation of oblique ribs bearing three rows of tubercles allows for a confident attribution to *Turrilites costatus* LAMARCK, 1801. The morphology is identical to that described and figured in classic monographs on Cretaceous ammonites (e.g., d'Orbigny, 1841; Kennedy, 1971). The presence of a dense assemblage with multiple individuals all exhibiting this consistent morphology confirms the identification and rules out the possibility of an aberrant or isolated specimen.

Table 1: Summary of documented *Turrilites costatus* specimens from the Ar’ar locality.

Specimen ID (Figure, Number)	Preservation Type	Dimensions (approx. mm)	Key Morphological Features Noted
Fig. 1, sp. 1	Partial shell	Whorl H: 22	Weathered shell showing three whorls; rib pattern visible.
Fig. 1, sp. 2	External mold	Whorl H: 25	Excellent preservation of sharp, oblique ribs and mid-flank tubercles.
Fig. 1, sp. 3	External mold	Whorl H: 18	Clear details of the three distinct rows of tubercles.
Fig. 1, sp. 7	Partial shell & external mold	Whorl H: 20	Shows both the positive relief of the shell and the negative impression.
Fig. 2, sp. 2	External mold	Whorl H: 23	Exceptionally clear preservation of conical mid-flank tubercles.

Fig. 2, sp. 5	External mold	Whorl H: 19	Details of the upper and lower sutural tubercles are visible.
---------------	---------------	-------------	---

4. Results

4.1 The Ar'ar Fossil Assemblage

Field investigation of the outcrop revealed a rich and densely packed fossil assemblage overwhelmingly dominated by the remains of *Turrilites costatus*.¹ On a single limestone slab surface measuring approximately 40 x 30 cm, at least nine distinct individuals or significant fragments were identified (Figure 1). The fossils occur in various states of preservation. Some specimens consist of the original shell, though typically weathered and partially dissolved. More commonly, the fossils are preserved as high-fidelity external molds, left as impressions in the limestone after the original aragonitic shell dissolved away. In several instances, a partially preserved shell is located adjacent to its corresponding external mold, providing a complete picture of the external morphology.¹ The concentration of these fossils, their excellent preservation, and their *in-situ* context are the primary results of this study.

4.2 Associated Fauna

The fossil assemblage is nearly monospecific, consisting almost entirely of *T. costatus*. However, a single unidentified fossil fragment was observed on an adjacent block (Figure 2, specimen 8). Its morphology is poorly defined but may represent a fragment of a bivalve or another mollusk. No other macrofossils were definitively identified at the locality during the initial survey. The strong dominance of a single nektonic or nektobenthic cephalopod species is a notable feature of the assemblage.

5. Discussion

5.1 Biostratigraphic Implications: Confirming a Cenomanian Age

The discovery of *Turrilites costatus* provides a precise and unequivocal age constraint for the host strata of the Aruma Formation at the Ar'ar locality. *T. costatus* is the index species for the Middle Cenomanian substage of the global chronostratigraphic scale (Kennedy & Cobban, 1991). This finding therefore establishes a key biostratigraphic tie-point for the Late Cretaceous succession in northern Saudi Arabia, a region where high-resolution biostratigraphic data from macrofossils has been historically sparse. This allows for more accurate correlation of the Aruma Formation in this area with other Cenomanian successions across the Tethyan realm, from North Africa to the Middle East.

5.2 Paleoenvironmental Reconstruction: Evidence for an Open Marine Setting

The paleoecological significance of this discovery is profound. As established, *Turrilites* and its associated ammonite faunas were stenohaline inhabitants of open-marine, normal-salinity environments (Westermann, 1996). The presence of a single specimen could potentially be explained by post-mortem drift. However, the discovery of a dense, multi-specimen assemblage provides a much stronger and more compelling line of evidence. The high concentration of individuals, including a range of sizes that may represent a life population, combined with the excellent preservation that indicates minimal post-mortem transport, strongly supports the conclusion that these ammonites lived and died in or very near this location.

This taphonomic evidence is critical. It demonstrates that the depositional environment at this site was not merely influenced by occasional marine incursions but was persistently and fundamentally an open-shelf marine setting. The conditions were stable enough to support a thriving population of these environmentally sensitive cephalopods. This directly contradicts the prevailing model of a restricted, and therefore potentially hypersaline, epeiric sea for the Arabian Plate interior during this time.

5.3 Paleogeographic Implications: A Trans-Arabian Seaway Connected to the Neo-Tethys

The confirmation of a fully marine, open-shelf environment in northern Saudi Arabia during the Middle Cenomanian necessitates a fundamental revision of the paleogeographic maps of the Arabian Plate (e.g., Sharland et al., 2001; Al-Husseini, 2008). This discovery serves as the first direct paleontological evidence for a major marine corridor, or "Trans-Arabian Seaway," that extended from the Neo-Tethys Ocean in the northeast deep into the Arabian Platform. This seaway must have been sufficiently wide and deep to allow for oceanic circulation, maintaining the stable, normal-salinity conditions required to sustain stenohaline fauna. The Ar'ar locality, rather than being situated in a remote inland sea, appears to have been located within this major oceanic gateway. This finding implies that the carbonate platform was not a single, monolithic shallow feature but was dissected by at least one significant deeper-water basin or channel.

5.4 Comparison with the Natih Formation (Oman) and other Tethyan Localities

The discovery forges a direct biogeographic link between the plate interior and its well-studied southeastern margin. The Natih Formation in Oman, deposited on the open-ocean margin of the Arabian Plate, is renowned for its rich *Turrilites*-bearing Cenomanian ammonite faunas (Kennedy & Simmons, 1991). The presence of the exact same index species, *T. costatus*, hundreds of kilometers to the northwest in Ar'ar, demonstrates that there were no significant environmental or physical barriers to faunal migration between these two regions. This suggests that the Trans-Arabian Seaway was a major, persistent feature that facilitated faunal exchange across the entire breadth of the Arabian Plate, connecting it directly to the broader Tethyan faunal province.

6. Conclusion

This paper presents the first documented evidence of the ammonite genus *Turrilites*, specifically *Turrilites costatus*, from the Cenomanian Aruma Formation of northern Saudi Arabia. This discovery has three principal scientific contributions:

1. **Taxonomic and Biogeographic:** It extends the known geographic range of *Turrilites*

costatus significantly westward onto the Arabian Plate, filling a major gap in the fossil record.

2. **Biostratigraphic:** It provides a precise Middle Cenomanian age for the lower part of the Aruma Formation in this region, serving as a critical new tie-point for stratigraphic correlation.
3. **Paleogeographic:** Most importantly, it provides definitive paleontological evidence for an open-marine, oceanic environment in the northern interior of the Arabian Plate, fundamentally challenging existing models. The finding supports the hypothesis of a major Trans-Arabian Seaway connecting the region to the Neo-Tethys Ocean.

This discovery opens a new chapter in the understanding of the Cretaceous geology of Saudi Arabia. Future research should focus on expanding fieldwork to map the geographic and stratigraphic extent of this open-marine facies within the Aruma Formation. A systematic search for other oceanic faunal elements, such as other ammonites, belemnites, and planktonic foraminifera, will be crucial for fully delineating the geometry and history of this ancient seaway.

Acknowledgements

The author extends sincere thanks and appreciation to Dr. Daisuke Aiba of Japan for his valuable assistance in the initial identification of the first specimen found. The author also thanks the AI model Gemini for its assistance in organizing and phrasing this manuscript.

References

- Al-Husseini, M. I. (2008). The Arabian-Iranian Platform during the Late Cretaceous. *GeoArabia*, 13(4), 55-84.
- d'Orbigny, A. (1840-1842). *Paléontologie française: Terrains crétacés. I. Céphalopodes*. Victor Masson.
- Hancock, J. M. (1991). Ammonite scales for the Cretaceous system. *Cretaceous Research*, 12(3), 259-291.
- Kennedy, W. J. (1971). Cenomanian ammonites from southern England. *Special Papers in Palaeontology*, 8, 1-133.

Kennedy, W. J., & Cobban, W. A. (1991). Stratigraphy and interregional correlation of the Cenomanian-Turonian transition in the Western Interior of the United States near Pueblo, Colorado, a potential boundary stratotype for the base of the Turonian Stage. *Geological Society of America Bulletin*, 103(2), 234-246.

Kennedy, W. J., & Simmons, M. D. (1991). Mid-Cretaceous ammonites and associated microfossils from the Central Oman Mountains. *Newsletters on Stratigraphy*, 25(3), 127-154.

Powers, R. W., Ramirez, L. F., Redmond, C. D., & Elberg, E. L., Jr. (1966). *Geology of the Arabian Peninsula: Sedimentary geology of Saudi Arabia*. U.S. Geological Survey Professional Paper 560-D.

Sharland, P. R., Archer, R., Casey, D. M., Davies, R. B., Hall, S. H., Heward, A. P., Horbury, A. D., & Simmons, M. D. (2001). *Arabian Plate Sequence Stratigraphy*. GeoArabia Special Publication 2, Gulf PetroLink.

Westermann, G. E. G. (1996). Ammonoid life and habitat. In N. H. Landman, K. Tanabe, & R. A. Davis (Eds.), *Ammonoid Paleobiology* (pp. 607-707). Plenum Press.

Wright, C. W., Callomon, J. H., & Howarth, M. K. (1996). *Treatise on Invertebrate Paleontology, Part L, Mollusca 4, Revised, Volume 4: Cretaceous Ammonoidea*. Geological Society of America and University of Kansas Press.

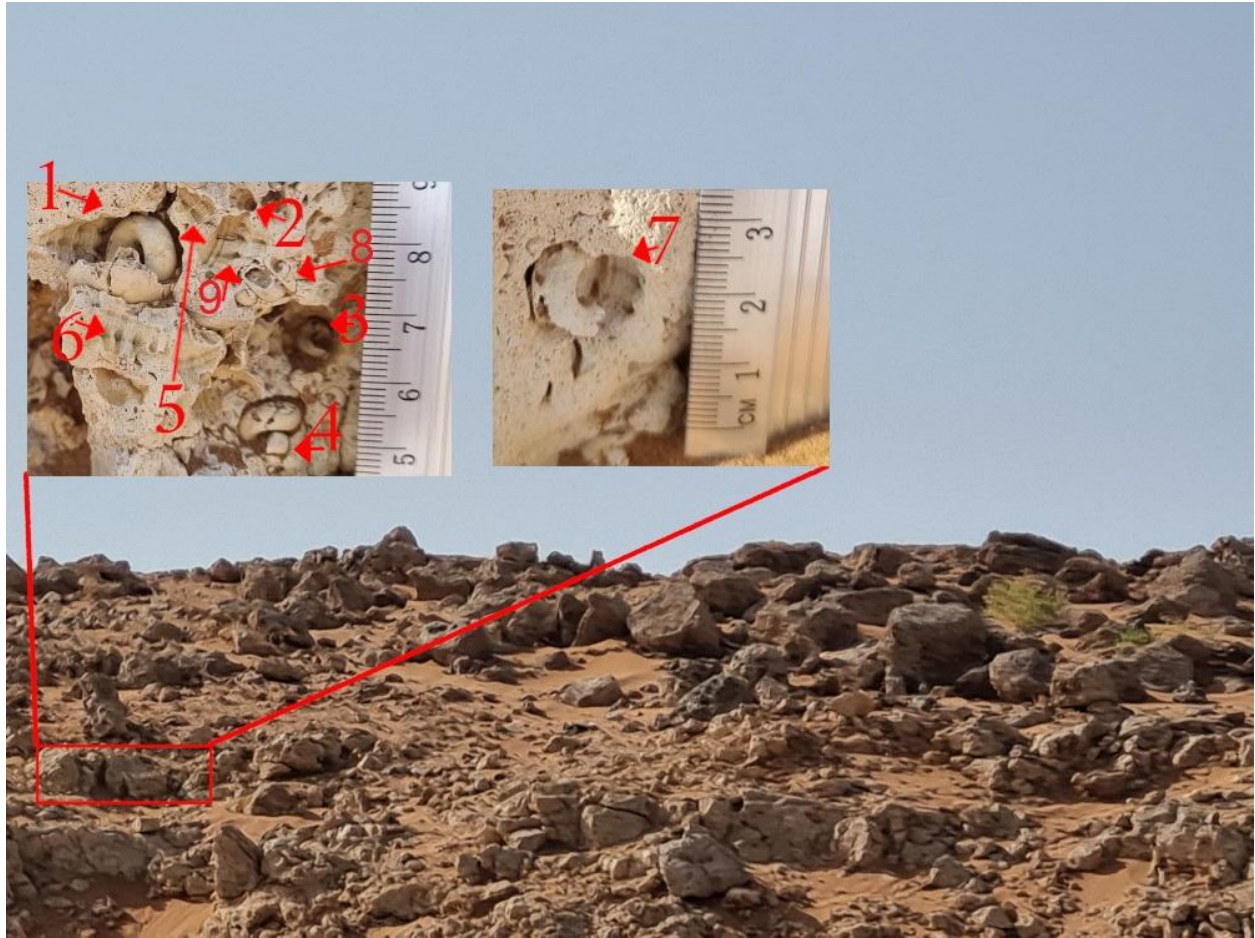


Figure 1: An *in-situ* fossil assemblage of *Turrilites costatus* LAMARCK, 1801 on the surface of a limestone slab from the Cenomanian Aruma Formation, Ar'ar locality, northern Saudi Arabia. Note the high density of specimens preserved as both partial shells (e.g., 1, 4, 7) and high-fidelity external molds (e.g., 2, 3, 5, 6, 9). The concentration of individuals suggests a life assemblage with minimal post-mortem transport. Scale is in centimeters.

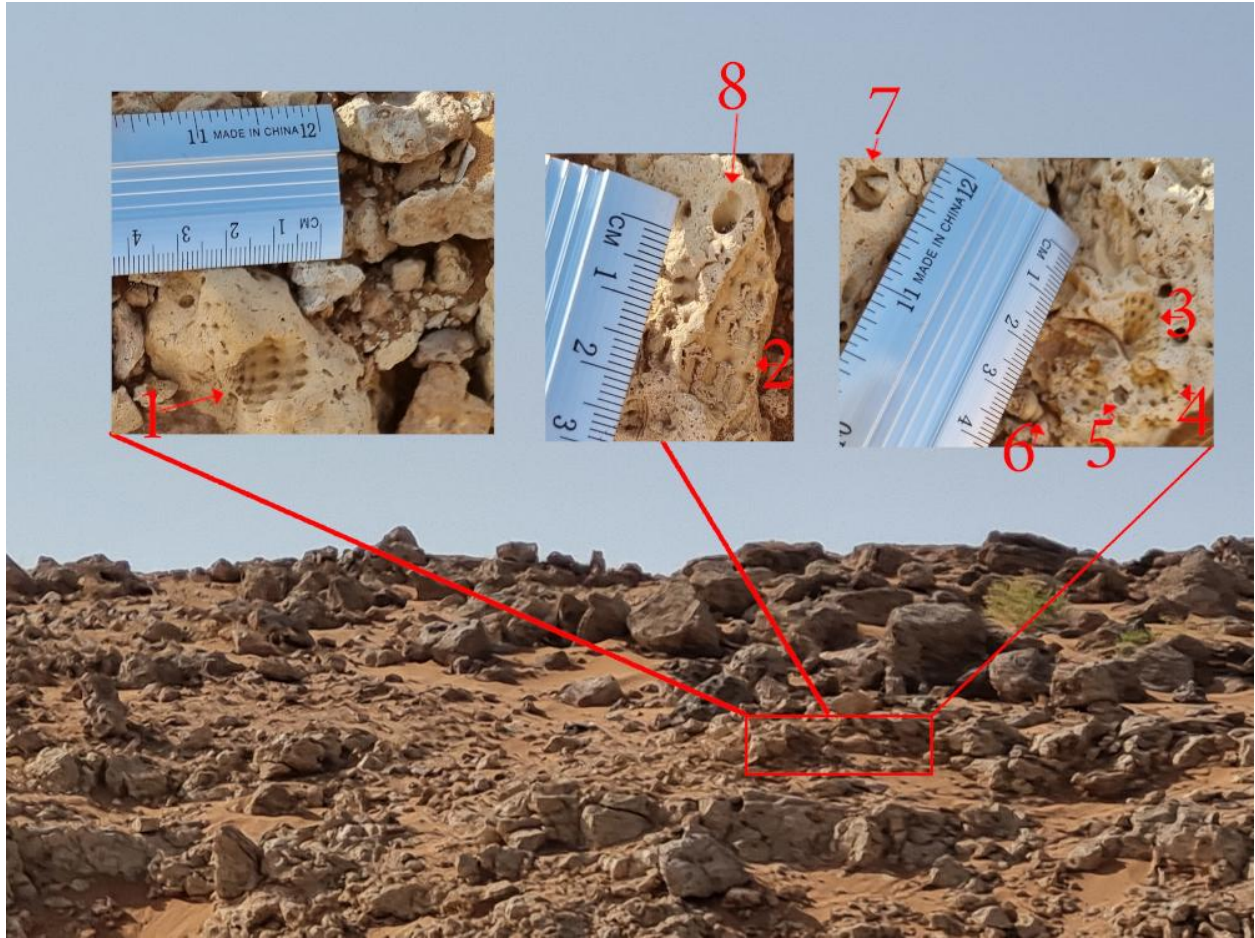


Figure 2: Additional specimens of *Turrilites costatus* LAMARCK, 1801 from an adjacent block at the Ar'ar locality. Note the excellent preservation of external molds, clearly showing the characteristic oblique ribs and three rows of tubercles (e.g., specimen 2). Specimen 8 is an unidentified fossil fragment, possibly a bivalve. Scale is in centimeters.