Government of Sharjah
Sharjah Archaeology Authority
مجلة الشارقة للدراسات الأثرية
Sharjah Journal of Archaeological Studies
Sharjah Archaeological Studies Journal
A Peer-Reviewed Semiannual Scientific Journal
MAY 2026
Vol. 1, No. 1

Thirty Years in Sharjah: Geospatial Technologies in Archaeology and International Collaboration

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ABSTRACT

Over the last three decades, the collaboration between the Universidad Politécnica de Madrid (UPM) and the Sharjah Archaeology Authority (SAA) has evolved into one of the most stable and productive geoarchaeological partnerships in the Arabian Peninsula.

This paper presents a comprehensive retrospective analysis of this collaboration, focusing on the progressive incorporation of geomatic and digital technologies into archaeological practice. The study examines the transition from early topographic and GPS-based surveys to advanced methodologies, including 3D modelling, digital image processing, UAV-based photogrammetry, 3D scanning, geographic information systems (GIS), and web-based platforms.

The research is based on a systematic review of projects developed between 1995 and 2025, integrating both technical and archaeological perspectives. The results demonstrate a clear evolution from isolated recording techniques to fully integrated digital workflows, enabling improved spatial accuracy, data management, and interpretative capabilities. The discussion highlights how these technologies have contributed to non-invasive analysis, landscape-scale understanding, and the dissemination of archaeological knowledge. The paper concludes that this long-term collaboration represents a model for interdisciplinary research, in which technological innovation is driven by archaeological needs and contributes to both scientific knowledge and heritage management.

Keywords

Archaeological documentation; geomatics, GIS, UAV, photogrammetry, digital archaeology, Sharjah

ARTICLE INFO

Received 31/3/2026

Accepted 29/4/2026

ثلاثون عامًا في الشارقة: التقنيات الجيومكانية في علم الآثار والتعاون الدولي

مرسيدس فارجاس أباديا

الكلمات المفتاحية
التوثيق الأثري؛ القياسات الأرضية ، نظم المعلومات الجغرافية، الطائرات بدون طيار، التصوير المساحي، علم الآثار الرقمي، الشارقة

بيانات المقال
تاريخ الاستلام 2026/3/31
تاريخ القبول 2026/4/29

ملخص

على مدى العقود الثلاثة الماضية، تطور التعاون بين جامعة بوليتكنيكا بمدريد وهيئة الشارقة للآثار، ليصبح واحدًا من أكثر الشراكات الجيولوجية الأثرية استقرارًا وإنتاجية في شبه الجزيرة العربية.

تقدم هذه الورقة تحليلاً شاملاً لهذا التعاون، مع التركيز على الدمج التدريجي للتقنيات الجيوماتيكية والرقمية في الممارسة الأثرية. تبحث الدراسة في الانتقال من المسوحات الطبوغرافية المبكرة والمسوحات القائمة على نظام تحديد المواقع العالمي إلى المنهجيات المتقدمة، بما في ذلك النمذجة ثلاثية الأبعاد، ومعالجة الصور الرقمية، والمسح التصويري القائم على الطائرات بدون طيار، والمسح ثلاثي الأبعاد، ونظم المعلومات الجغرافية (GIS)، والمنصات المستندة إلى الويب.

يعتمد البحث على مراجعة منهجية للمشاريع التي تم تطويرها للفترة بين 1995 و2025، مع دمج المنظورين الفني والأثري. تظهر النتائج تطورًا واضحًا من تقنيات التسجيل المعزولة إلى سير العمل الرقمي المتكامل تمامًا، مما يتيح تحسين الدقة المكانية وإدارة البيانات والقدرات التفسيرية. تسلط المناقشة الضوء على كيفية مساهمة هذه التقنيات في التحليل غير الجراحي، والفهم على نطاق المناظر الطبيعية، ونشر المعرفة الأثرية. وتخلص الورقة إلى أن هذا التعاون طويل الأمد يمثل نموذجًا للبحث متعدد التخصصات، حيث يكون الابتكار التكنولوجي مدفوعًا بالاحتياجات الأثرية ويساهم في كل من المعرفة العلمية وإدارة التراث.

1. Preamble

As I begin writing these lines, the verses of Carlos Gardel echo in my mind when he sings that "twenty years is nothing." As he says, when looking back, with temples silvered by time, one realises that life is but a breath. It has now been more than thirty years that the Universidad Politécnica de Madrid (UPM) has been collaborating—under my direction—with the Sharjah Archaeology Authority (SAA) of the United Arab Emirates. Three decades of a shared history.

The origin of this collaboration was as simple as it was unexpected. It all began with a business card handed to a team of archaeologists at a local agricultural fair. That spontaneous decision, encouraged by my mentor and friend, Professor Francisco Ayora, set in motion a chain of events that culminated in Professor Joaquín Córdoba visiting my office and inviting me to join his archaeological project in Sharjah.

Since then, the objective has remained clear: to represent the university, share knowledge, train students, collaborate with colleagues, and adapt geomatic methodologies to complex archaeological contexts. This article offers a journey through that trajectory, analyzing the technological and methodological evolution of archaeological research in Sharjah.

I am deeply grateful for the opportunity to write these lines and express my most sincere appreciation to the leadership of the Sharjah Archaeology Authority, H.E. Dr. Sabah Jasim and H.E. Eisa Yousif, as well as to their entire team. Their support and closeness have left a profound mark on both my professional path and my personal life. **THANK YOU.**

2. Introduction

The history of our cooperation is inseparable from the transformations that archaeology has undergone in recent decades: the transition from traditional planimetry to global geodetic frameworks; the shift from analogue photography to 3D modelling; the emergence of UAVs as standard tools in excavation; the development of BIM methodologies applied to heritage; and the widespread use of mobile reverse engineering technologies in challenging environments.

Sharjah—an emirate of extraordinary archaeological richness—has provided the ideal laboratory for this evolution. Its desert landscapes, oases, foothills of the Hajar Mountains, and associated archaeological systems (Mleiha, Al Madam, Jebel Buhais, Faya, Kalba, Khatm al Melaha, among others) form a cultural mosaic spanning from the Neolithic to the Late Pre-Islamic period.

In the mid1990-s, these sites lacked accurate cartography and stable topographic frameworks. The need was clear: to establish rigorous spatial foundations for excavation, conservation, and research according to international standards. Since then, the collaboration has continuously evolved:

- From classical topography → to high-precision GNSS
- From 2D cartography → to digital surface models
- From terrestrial photogrammetry → to UAV photogrammetry
- From CAD plans → to 3D and 4D BIM reconstructions
- From isolated documentation → to regional geodatabases
- From static recording → to simulations and dynamic models

The aim of this paper is to provide a synthesis of the UPM–SAA scientific collaboration, from its origins in 1995 to 2025. It presents selected examples from more than fifty final degree projects and numerous publications that have contributed to building a comprehensive cartographic and digital framework for the documentation, conservation, and dissemination of Sharjah's archaeological heritage.

3. Methodology

The methodological approach of this study is based on a retrospective and analytical reconstruction of the thirty years of archaeological and geomatic work carried out in support of archaeological research by the Polytechnic University of Madrid in the Emirate of Sharjah. The research draws on technical reports and academic publications; cartographic and topographic datasets; digital models and image-processing outputs; as well as field documentation and methodological records from our field campaigns.

The central hypothesis is that the convergence of advanced geomatics and landscape archaeology not only enhances the quality of archaeological recording, but also redefines research, conservation, and the dissemination of cultural heritage.

The analysis is organized chronologically, identifying key technological phases that correspond to major shifts in archaeological practice:

- Initial phase of contact and exploration
- Topographic and GPS-based documentation
- Early 3D models
- Image-processing methodologies
- UAVs, photogrammetry, & scanning technologies
- GIS integration and geodatabases
- Web platforms and data dissemination

Each phase is examined not only from a technical perspective, but also in terms of its archaeological impact—especially regarding documentary precision, interpretative capabilities, and heritage management. Every stage incorporated increasingly accurate and non-invasive tools adapted to the emirate's extreme desert environment, where dunes, aeolian erosion, and high temperatures impose unique challenges for archaeological documentation.

The cumulative results include more than 800 hectares mapped at different scales, sub-centimetric GNSS geodetic networks, over 50 virtual 3D models, dense point clouds, orthophotos, and BIM models with temporal (4D) and economic (5D) dimensions. This entire digital corpus now forms part of the SAA's heritage archive.

This article does not merely summarize the technical trajectory; it also underscores the human and academic value of the collaboration between the two institutions.

3.1 Origins (1995-1997)

Scientific cooperation between the Department of Topographic and Cartographic Engineering at the Polytechnic University of Madrid (UPM) and the archaeological institutions of the Emirate of Sharjah dates back to the mid-1990s. In December 1995, Professor Joaquín Córdoba—Chair of Ancient History at the Autonomous University of Madrid and director of the Al Madam archaeological project—approached me about the possibility of establishing a scientific collaboration. The aim was to integrate advanced topographic and cartographic techniques into the archaeological research being carried out in Sharjah. This proposal opened a new field of application for geomatic disciplines, enabling the use of surveying and spatial-documentation methods in the archaeological analysis of the landscape.

In February 1996, I travelled to Sharjah to assess, on site, the real possibilities for collaboration and to analyse the project's technical needs. During this first mission, we studied the working conditions of the area and the specific requirements for spatial documentation at the archaeological site of Tuqueibah, one of the key locations associated with the Al Madam project. This visit made it possible to define the methodological foundations of the cooperation and to establish the initial objectives of the topographic and cartographic work that would support the archaeological investigations.

The first tasks focused on implementing a basic topographic control network that would serve as a reference for subsequent surveys and for the accurate georeferencing of archaeological structures. The creation of this network was a fundamental step toward ensuring measurement precision and enabling the integration of different types of spatial information obtained during excavations and field studies.

At the same time, systematic cartographic documentation work began, aimed at recording the configuration of the site and its immediate surroundings. These tasks included detailed topographic surveys, the preparation of base cartography, and the production of maps to support the planning of future excavation and research campaigns.

As a result of the discussions held with the archaeology authorities of the Emirate and with the project's scientific team, this line of cooperation was formalized and expanded. Thus, what began as one-off collaboration to address specific technical needs became the starting point for a long-term scientific partnership. Over the years, this relationship would evolve into a broader working program, incorporating new technologies for documentation and spatial analysis applied to the study of the archaeological heritage of the Emirate of Sharjah.

3.2 First Decade: From Classical Topography to Digital Cartography (1997–2006)

The first major phase focused on the implementation of topographic methodologies. The aim was to establish reliable spatial frameworks for archaeological sites, replacing traditional descriptive methods with measurable and reproducible data.

Through the use of total stations and, later, GNSS technology, we created control networks that made it possible to:

- Map archaeological structures with precision,
- Georeference excavation areas,
- And integrate datasets across different field campaigns.

This phase marked the beginning of our spatial archaeology in Sharjah, enabling the analysis of site organisation beyond individual excavation units, and consolidating the collaboration through the transition from analogue to digital methodologies.

In 1997, two key projects were undertaken: A model for integrating archaeological documentation through multimedia cartographic techniques (Lamolda & Manzano, 1997) and Archaeological topography: 1:100-scale cartography of the Tuqueibah archaeological site (Bohigas, 1997). These works laid the foundations for integrating spatial data into multimedia environments and produced the first detailed cartography of the Iron Age settlement in Al Madam.

In 1998, progress was made in the digitalisation of cartography for the Emirate of Sharjah with a 1:25,000-scale topographic map and an online map displaying archaeological sites and historical-cultural points of interest (Lobo & Mellado, 1998). This product enabled, public visualisation and centralised management of the emirate's archaeological heritage (Figure 1).

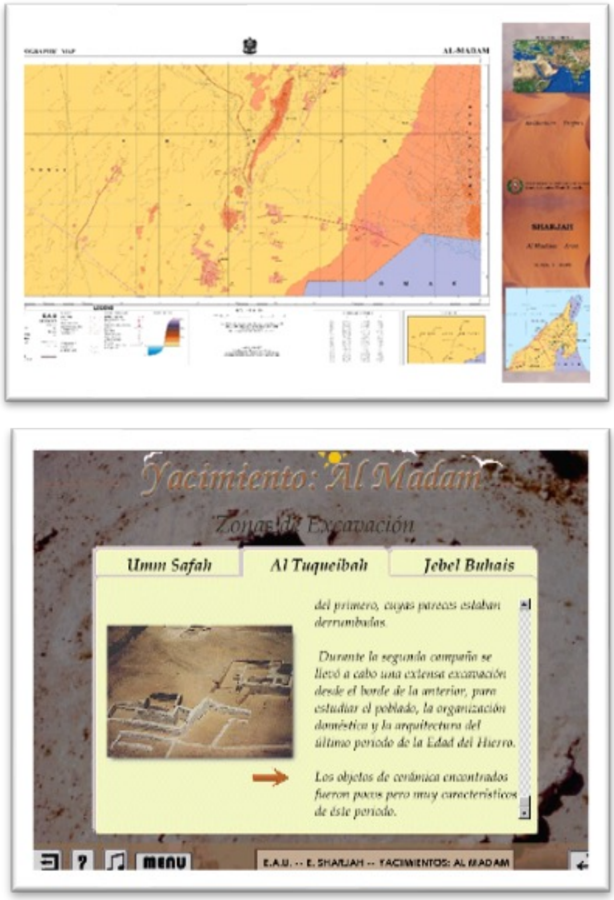

Figure 1. Cartography of Al Madam and multimedia applications. Source: authors.

The year 2000 brought significant advances: the editing and updating of existing cartographic documents, the creation of a multimedia map of the emirate (Acosta & Ledesma, 2000), the development of a three-dimensional virtual model of site AM-32 (Domínguez & Bartolomé, 2000), and the 1:1,000 topographic survey of the Jebel Buhais area, including the creation of a digital model (Hernández & Pascual, 2000). These projects documented Bronze Age tombs, generating reference plans and 3D models that facilitated stratigraphic analysis and excavation planning (Figure 2).

In 2001, we presented a first GIS design with the project Archaeological Information System of Al Madam using ArcView (Farjas, 2001).

In 2002, a GPS topographic network was established at Tuqueibah, and a 1:1,000-scale survey of the area was carried out using GPS receivers (Figure 3), consolidating sub-centimetric accuracy across wide zones (Bodas & Vélez, 2002). This period also saw the production of general cartography for Jebel Buhais and Mleiha, and in 2003 tourist mapping of the archaeological areas of Al Madam was completed and integrated into a multimedia web application (García, 2003), incorporating online publication and dissemination into the research framework.

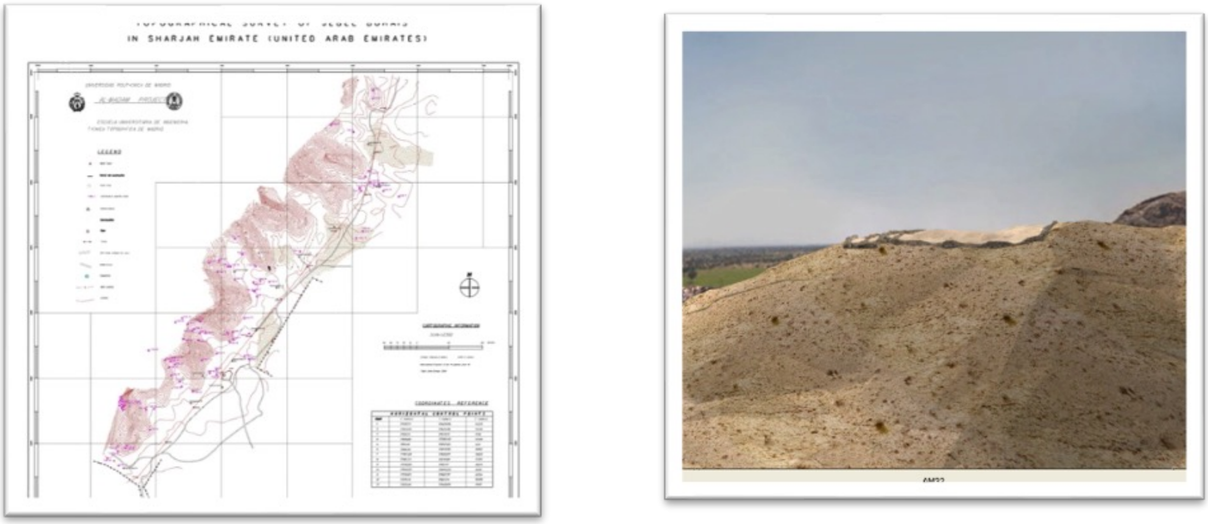

Figure 2. Cartography of Jebel Buhais and virtual reconstruction of AM32. Source: authors.

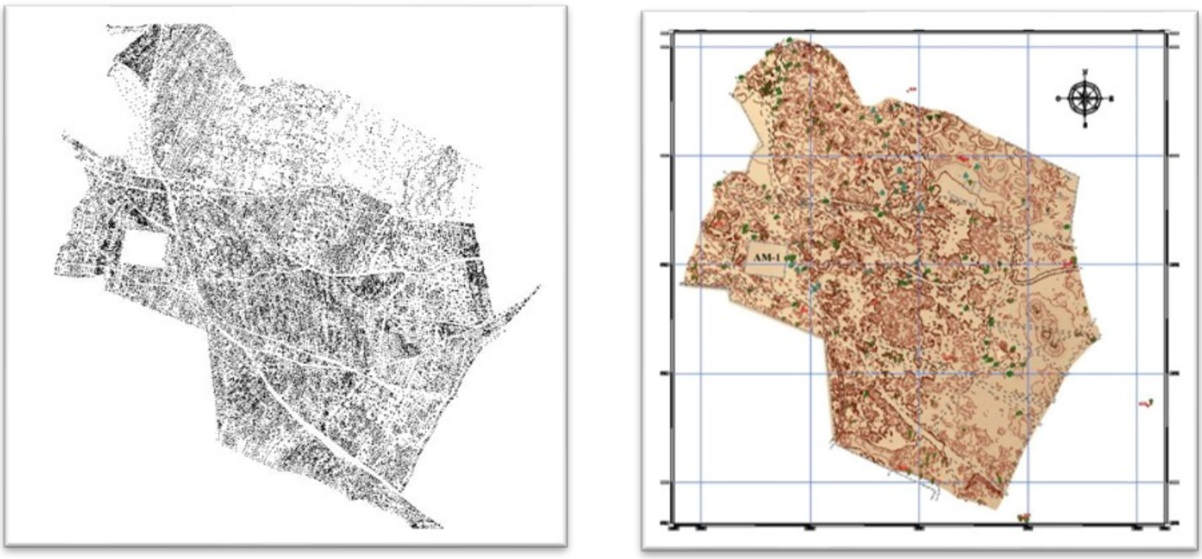

Figure 3. Cartography of Tuqueibah. Source: authors.

In 2004, two key projects were completed:

- Tthe 1:500-scale survey of the Mleiha ML2 archaeological area with the creation of a three-dimensional model, and
- The development of cartographic documentation for the Jebel Buhais area, together with a multimedia dissemination application.

The Final Degree Project on the ML2 site at Mleiha (Fuentes & Granado, 2004) documented 28 hectares using a GPS network of 17 vertices, RTK surveying, a digital terrain model with 0.5-m contour intervals, and a 3D model created in Maya 5.0 and textured in 3D Studio Max (Figure 4). Using GPS data and photographic documentation, the project produced a virtual reconstruction that facilitated historical interpretation and musealization by enabling:

- 3D visualisation of the site,
- integration of geometry and texture,
- and exploration of spatial relationships

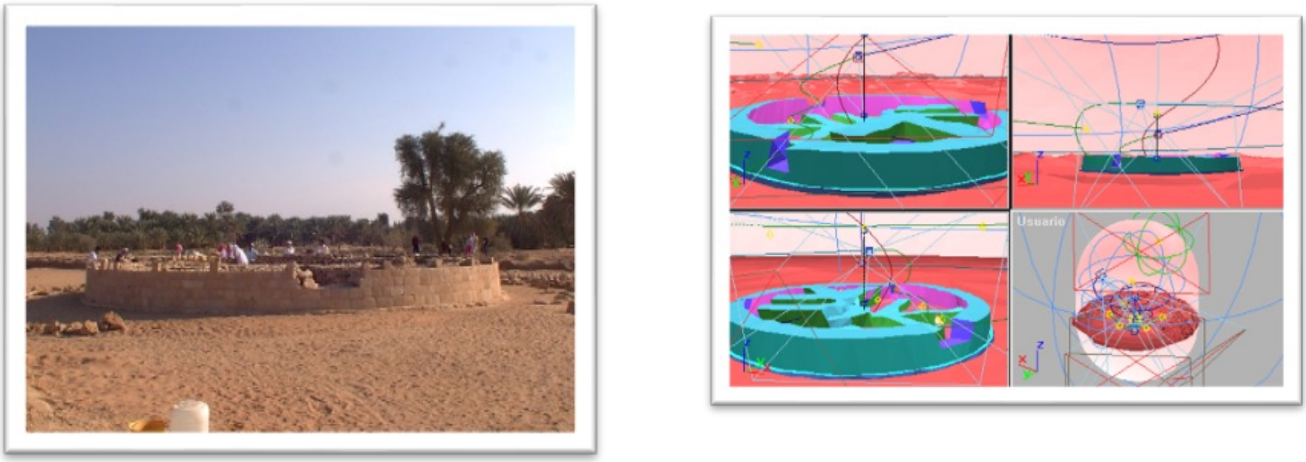

Figure 4. ML2 tomb in Mleiha. Source: authors.

Although constrained by the technology available at the time, this initiative introduced a fundamental concept: archaeological documentation as a digital environment, not merely a record.

In Jebel Buhais (Prieto, 2004), more than 80 cemeteries, domestic structures, and camel-burial necropolises were documented, producing 1:1,000 cartography and detailed digital terrain models (Figure 5).

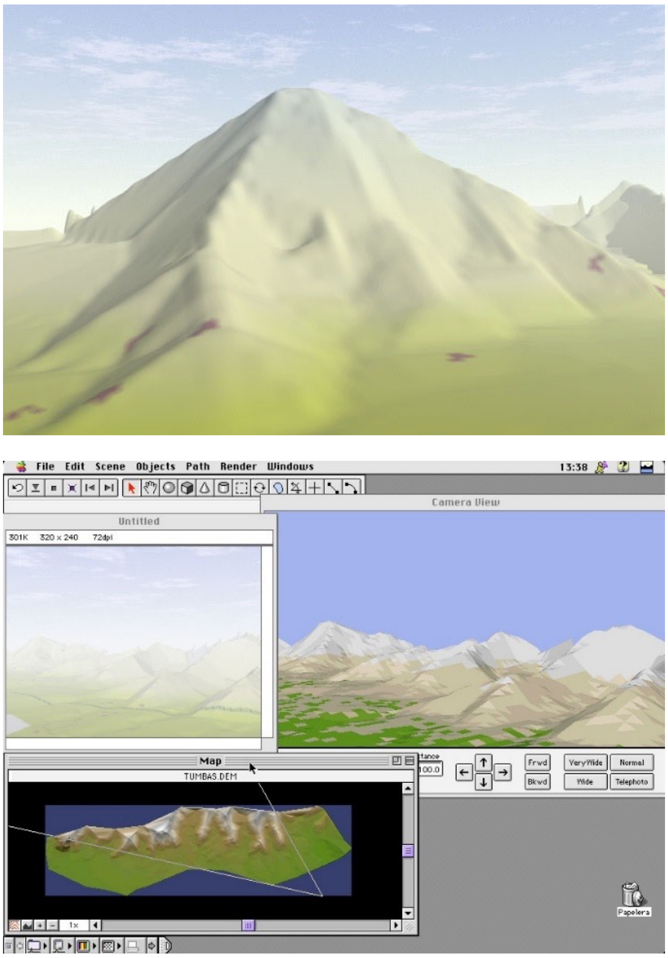

Figure 5. Digital model of Buhais. Source: authors.

In 2005, to address the need for spatial analysis and geolocation, satellite imagery—specifically Landsat data—was incorporated. Using two images provided by the Spanish National Institute of Aerospace Technology (INTA), a graphic support for site location and thematic cartography of Al Madam was developed from Thematic Mapper satellite images (Figure 6).

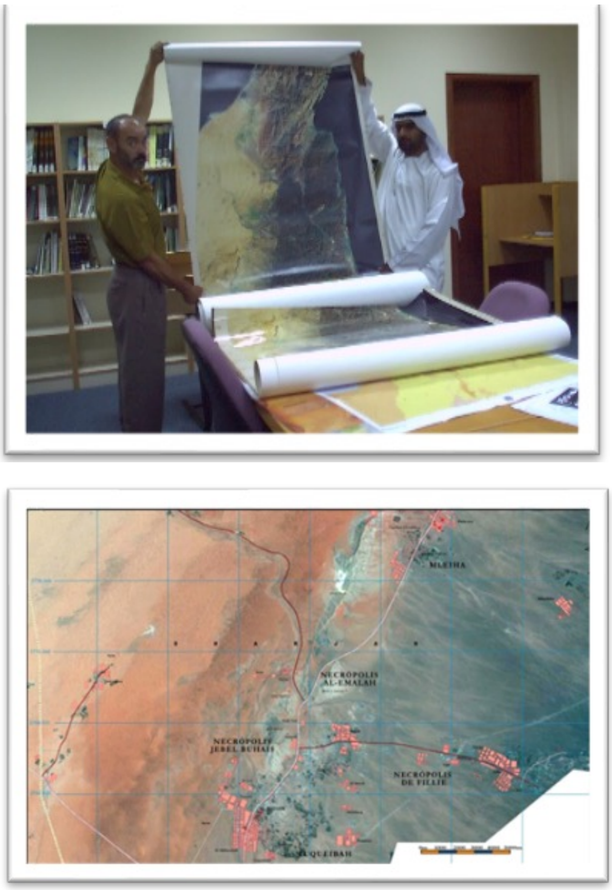

Figure 6. Cartography derived from satellite imagery. Source: authors.

At that time, we began considering how to compile the cartographic documentation, and turned to the potential of atlases. The Archaeological Atlas of Al Madam (Alcántara, 2006) assembled an extensive collection of maps, producing a comprehensive cartographic resource that included (Figure 7):

- regional maps,
- topographic maps,
- and an archaeological inventory.

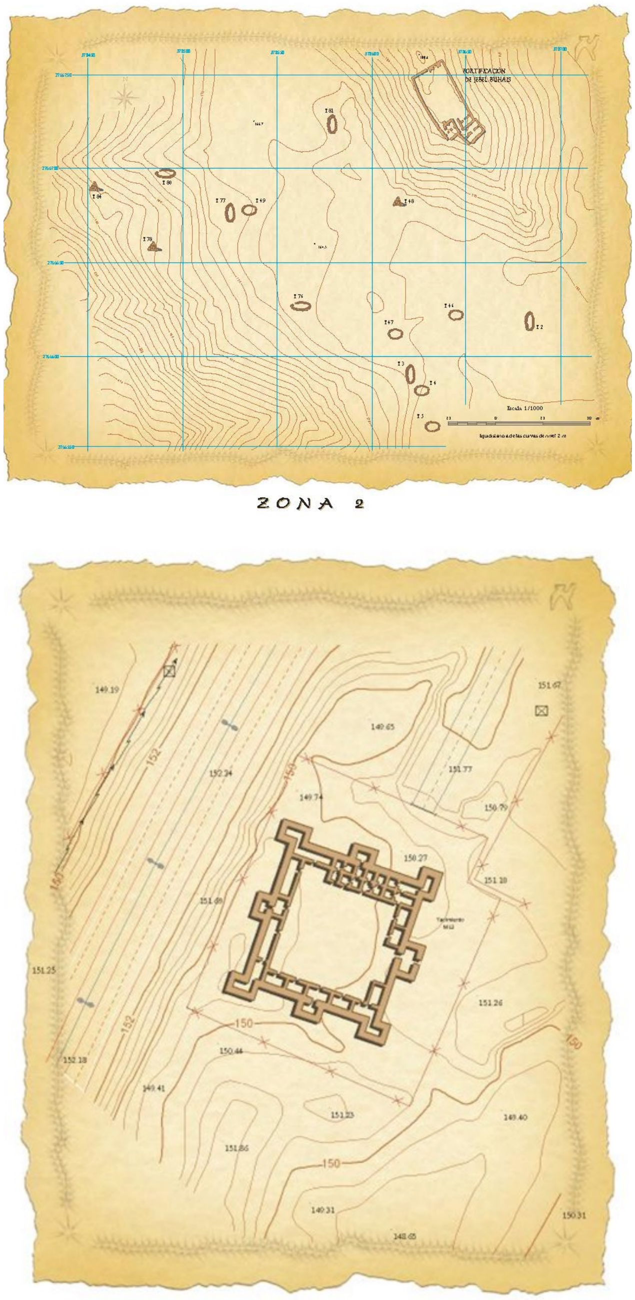

Figure 7. Examples of cartography from the Al Madam Atlas. Source: authors.

Meanwhile, we were implementing close-range photogrammetry tools (Bernardino, 2006) to carry out the photogrammetric survey of the Al-Buhais 18 burial.

The lecture A Decade in Archaeology, which I delivered in 2006, synthesised this first decade of work. Presented with iconic images of camels and dunes, it traced the transfer of Spanish expertise (Recópolis 1:500 and Zorita de los Canes) to the desert context. It highlighted the creation of the first basic GPS network in Tuqueibah (11 vertices, 0.01 m accuracy), dense point clouds, edited contour lines, and 3D models of adobe structures and falaj, which enabled non-invasive documentation, excavation planning, and the earliest virtual reconstructions of pre-Islamic architecture.

3.3 Photogrammetry and UAVs: A New Scale of Observation (2012–2014)

The incorporation of drones into data acquisition workflows represented a significant technological leap. In 2012, the first UAV tests were carried out in Faya and MLH-8; and in 2013, 1:200-scale surveys of Mleiha Zones 5 (Navarro, 2013) and 6 (Ruiz, 2013) were completed using this methodology. Microdrones MD4-200 equipped with Pentax Optio A40 cameras were employed. Digital Surface Models (DSM) and centimetre-precision orthophotos were also generated. Further studies included accuracy assessments of UAV-derived surface models at the Mleiha sites, methodologies for physiographic and cartographic characterisation, and analyses of photogrammetric products based on UAV imagery (Bellido, 2013; González, 2013).

The introduction of UAV technology marked a turning point in both the scale and efficiency of archaeological documentation. With UAV systems, our aims were to:

- capture high-resolution aerial imagery,
- generate orthophotos and digital terrain models,
- document extensive areas rapidly.

Photogrammetry enabled these images to be transformed into accurate 3D models, linking field observation with digital analysis. This phase allowed us to adopt a true landscape perspective, moving beyond isolated sites toward an understanding of broader spatial patterns (Figure 8).

Figure 8. UAV-based photogrammetric model of MLH 5. Source: authors.

The results demonstrated sub-centimetric accuracy in planimetry and 10–5 cm accuracy in altimetry—far superior to traditional methods for large desert expanses (Farjas, Bellido & Gonzalez, 2014).

In 2014, GIS and remote-sensing methodologies were integrated into the Al Madam project. Mleiha Zone 7 was surveyed at 1:200 scale (Corral, 2014), and thematic land-cover cartography was produced using satellite imagery, linking the cartographic documentation of the Mleiha area with that of Khor Fakkan through Landsat 8 imagery (Pérez & Picazo, 2014).

These projects generated high-resolution orthophotos, dense point clouds, and regional cartographic bases that enabled predictive landscape analyses and the integration of archaeological data into GIS platforms.

3.4 3D Object Modelling and Parametric 3D-4D-5D BIM Modelling (2015–2016)

The years 2015–2016 represent the qualitative leap toward parametric modelling and full lifecycle management of archaeological heritage. In 2015, BIM techniques were applied to the virtual reconstruction of MLH 5 (Haba, 2015) and the MLH 8 palace complex (Martín, 2015).

In 2016, we completed three additional landmark projects: Reconstruction of the archaeological site MLEIHA 6 using BIM technologies (Moreno, 2016); BIM techniques applied to the reconstruction of the MLEIHA 7 archaeological site (Capelo, 2016); and the As built documentation of the Mleiha 5 site using EyesMap technologies (Madrigal, 2016).

The 3D modelling of the MLEIHA 6 archaeological site (Figure 9) constitutes a fully integrated application of 3D 4D 5D BIM to an archaeological context in Sharjah. Beginning with the 1:200 topographic cartography generated in 2014 by Raquel Ruiz Fernández, the CAD base was converted into a complete parametric model in Autodesk Revit (LOD 300–350). The methodology included:

1. conversion and optimisation of point clouds and plans using AutoCAD and TCP MDT;
2. phased reconstruction (Phase 0: site layout and 3D surfaces; Phase 1: walls, floors, and base slabs; Phase 2: roofs, irregular staircases, curved walls, and furniture);
3. parametrisation of archaeological components (adobe walls, falaj, irregular staircases);
4. 4D temporal planning using Microsoft Project/ Synchro (WBS, task and resource allocation);
5. 5D budgeting with Arquimedes.

Figure 9. BIM model of MLH 6. Source: authors.

The resulting model, containing millions of parametric elements, makes it possible to simulate historical construction phases—from the initial layout to pre Islamic fortifications—optimise resources without physical intervention, and evaluate virtual reconstruction costs. It produced 3D views, reference plans, metric sheets, and IFC interoperability analyses. This work extended UPM’s methodology into the temporal and economic dimensions of adobe ruins and falaj irrigation systems, and helped consolidate the transition from metric documentation to comprehensive heritage management.

Complementary reverse engineering technologies were applied to the rock art of Khatm al Melaha (Ovejero, 2016) using EyesMap and its 3D scanning capabilities. All these models were integrated into the geodatabase, enabling non invasive simulation of historical phases and providing a robust platform for heritage management. The work of Ovejero (2016) and Madrigal (2016) applied EyesMap to both petro¬glyphs and tower tombs (Figure 10), generating dense 3D models with these new lightweight scanning devices.

Regarding 3D representation and musealisation of archaeological artefacts through 3D laser scanning, the projects of Roces (2014) and Matesanz (2014) are noteworthy for their 3D printed replicas and detailed precision analyses of these emerging technologies (Figure 11). The results obtained with laser scanning and photogrammetry demonstrated sub millimetric accuracy in the resulting models.

3.5 Image Processing and Non-Invasive Archaeology

A significant methodological advance came with the application of digital image-processing techniques to archaeological research (Gutiérrez, 2017). Initially developed for remote sensing, these techniques were adapted to the study of:

- petroglyphs,
- rock art,
- and lithic surfaces.

Through algorithms based on spectral analysis and statistical processing, it became possible to reveal features invisible to the human eye.

This phase represents a transition toward non-invasive archaeology, in which information is extracted without physical intervention, thereby preserving the integrity of the archaeological record.

3.6 GIS and Geodatabases: Integrating Archaeological Knowledge

The accumulation of data over several decades generated a new challenge: the management of this growing body of information.

The solution was the implementation of GIS systems and geodatabases, which made it possible to:

- integrate heterogeneous datasets,
- carry out spatial analyses at multiple scales,
- and ensure long-term storage and accessibility.

GIS thus became not only a technical tool, but also a conceptual framework for structuring archaeological information. Proposals for collaborative GIS and web-based cartography, developed in 2013 enabled the integration of data in QGIS, GvSIG, and OSM, providing open-data regional cartography of the oasis.

3.7 WebGIS and Dissemination: Sharing Archaeological Knowledge

The most recent phase of the collaboration places emphasis on accessibility, on mobile platforms for direct archaeological documentation, and on the creation of collaborative working environments, as well as on dissemination. Through WebGIS platforms, archaeological data can now be:

- Visualised online,
- Shared with researchers and institutions,
- and used for heritage management.

This represents a transition from data collection to knowledge dissemination, fully aligned with contemporary approaches to open science.

The culmination of this process is the systematic organisation of the accumulated data into coherent structures, exemplified by the project Sharjah: 20 Years of Cartography, developed by Alicia Hernández and Carlos Henche. Both researchers undertook the comprehensive digitalisation of two decades of topographic, cartographic, and archaeological work carried out by UPM in cooperation with the

Figure 10. As-built model of MLH 5 using EyesMap technology. Source: authors.

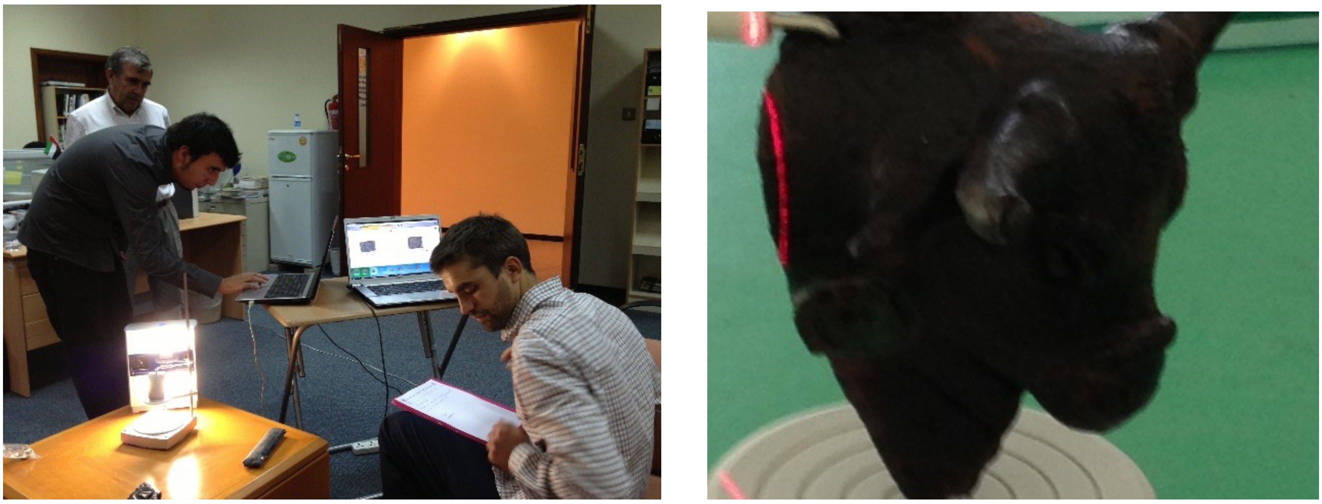

Figure 11. 3D laser scanning workflow applied to archaeological artefacts. Source: authors.

Sharjah Archaeology Authority (SAA) (Hernández, 2017; Henche, 2017). Their central objective was to transform this extensive documentary corpus into an interactive digital book, supported by a robust GIS architecture and designed for consultation and analysis of the principal sites in the Al Madam area. The project combined archaeology, cartography, and spatial analysis through the intensive use of the ArcGIS platform (Desktop, Online, Web AppBuilder, and Story Maps). This infrastructure enabled the creation of a unified visualisation environment where digital models, orthophotos, topographic surveys, and archaeological documentation from multiple field campaigns converge.

One of the project's most remarkable technical achievements was the compilation and systematisation of more than 179,000 files, originally spread across 150 CDs and associated with 20 years of projects. The process included:

- Topographic surveys,
- UAV and satellite orthophotographs,
- Digital terrain models,
- Photogrammetric products,
- and archaeological documentation in various formats.

The standardisation of these materials enabled their coherent integration into a single digital repository. To properly manage the volume and diversity of information, a geodatabase was built, using a model that ensured scalability, interoperability, and a solid analytical structure. A series of GIS products were developed, forming the operational core of the digital book:

Published web services and layers:
- Cartography of Jebel Buhais, Tuqueibah and Faya,
- Orthophotographs of Mleiha (MLH-5, MLH-7), Faya and Al Madam,
- Inventories of tombs and structures,
- 3D models of archaeological objects.

Web applications created (2D/3D):
- Mleiha Tombs App
- Faya 3D App
- Al Madam Landsat 8 App
- Tuqueibah Carto App

These tools enabled spatial analysis, thematic queries, and 3D exploration through ArcGIS Online. In addition, a Digital Map Book was produced.

The resulting interactive digital book of Sharjah—complementing the printed version—became a modern, unified, and enduring consultation platform. ArcGIS (Desktop, Online, Web AppBuilder, Story Maps and Web Scenes) was used to generate web maps, 3D scenes, thematic applications, and an Operations Dashboard.

These works demonstrated the effectiveness of a well-designed GIS as an instrument for:
- The visualisation and dissemination of archaeological heritage,
- The structured and scalable management of large datasets,
- and the publication of web services ensuring remote access and continuous updating.
- The outcome is a set of interactive tools that allow users to navigate historical projects, visualise 3D and BIM models, access UAV orthophotos and GNSS data, and explore archaeological sites immersively from any web browser, with no installation required.

3.8 Digital Platforms and Field Data Capture

As we continued with the cartographic documentation of archaeological sites and the systematic acquisition of 3D models of petroglyphs (Ovejero, 2016), the most recent developments focused on improving field-data acquisition and on how to share information and datasets, both for dissemination and for scientific analysis. I dedicated myself personally to this challenge, producing a master's thesis Sharing the Past: Sharjah (United Arab Emirates) (Farjas, 2018).

The thesis consolidated a complete Geoarchaeology Online infrastructure, based on a structured geodatabase (GDB) and web services generated with ESRI tools (ArcGIS Pro, ArcGIS Online, ArcGIS Server and WebAppBuilder). The system significantly improved accessibility, management, and dissemination of archaeological heritage, allowing real-time consultation of spatial information and facilitating its use for both research and institutional management.

With funding obtained through the R&D project AVIPES-CM (H2019/HUM-5742) - which enabled us to hire additional staff—and continuing the collaboration with the Sharjah Archaeology Authority, I directed the evolution of Geographic Information Systems (GIS) applied to archaeological documentation in Sharjah towards an innovative methodology for the digital inventory of rock inscriptions, creating a mobile tool that integrates data and 3D models within web platforms.

This represented a step forward from the early projects developed with ArcView (2001) and later desktop systems such as ArcGIS (2018), toward solutions based on dedicated servers and web platforms, with direct field-data entry through mobile devices and role-based access control. This transition enabled:

- Shared online cartography,
- Confidentiality-level management,
- Advanced spatial analysis,
- Georeferenced digital documentation,
- Multidisciplinary collaborative work.

The goal was to optimise digital field inventory through a web application connected to a spatial database, enabling data recording at the moment of survey—even without network coverage.

The SharingThePast web application was designed from scratch, developed with JavaScript, HTML5, CSS3 and PHP, and linked to a MySQL database. The workflow integrates:

- Geolocation of the inscription,
- Recording through a standardised form,
- Photographs and technical sketches,
- Immediate generation of a 3D model using Pix4D Catch,
- Post-processing and automated data upload.

The system supports offline work, user-access control, metadata storage, and integration of images, point clouds and 3D models. During the 2022 field campaign, the system was applied to document of six inscriptions with Arabic texts, each one recorded with:

- Precise location,
- Technical record,
- Photographs,
- Sketches,
- Georeferenced 3D model.

All information is stored in a centralised repository and is accessible in real time through both public and private web viewers. An offline positional error of 3–5 metres was detected, which can be corrected by using higher-precision GNSS.

The methodology:

- Significantly reduces post-processing time,
- Generates a complete georeferenced inventory,
- Improves the quality and precision of the record,
- Facilitates spatial analysis and data dissemination,
- Effectively combines analogue (sketch) and digital (app + 3D) documentation,
- and constitutes a robust tool against falsification and risks of urban destruction.

This work represents the most recent phase in the long-standing research collaboration between the Polytechnic University of Madrid and the SAA, integrating mobile technologies, 3D models and web-based GIS into the archaeological documentation of the emirate.

4. Conclusions

The collaboration between UPM and the Sharjah Archaeology Authority represents a particularly significant case of methodological evolution in archaeology.

Over more than thirty years, the integration of geomatic technologies has:

- Improved the precision of archaeological documentation,
- Enabled non-invasive analytical methods,
- Expanded spatial and interpretative frameworks,
- and facilitated the management and dissemination of data.

The results obtained throughout the period 1995–2025 can be grouped into five major conclusions.

4.1. A Regional Spatial Infrastructure Unprecedented in the Archaeology of Sharjah

The progressive implementation of GPS and GNSS topographic networks since 1996 made it possible to establish a homogeneous reference system based on WGS84/UTM 40N. This technical achievement—documented in the early projects at Tuqueibah, Al Madam, and Jebel Buhais—provided a precise geometric framework that facilitated the integration of excavation campaigns separated by years or even decades.

The consolidation of this infrastructure enabled the archaeological record to evolve from local plans without geodetic control to a robust and replicable spatial system, forming a fundamental foundation for both current and future research.

4.2. Transformation of the Archaeological Landscape into Multi-Scalar Scientific Cartography

The surveys carried out between 1997 and 2006 produced the first modern cartography of the Al Madam oasis, as well as of Mleiha and Jebel Buhais, incorporating scales ranging from 1:100,000 to 1:200. The creation of The Archaeological Atlas of Al Madam synthesised this information into a reference tool that made it possible to understand the spatial distribution of settlements and necropolises, and opened new possibilities for territorial analysis and archaeological prospection.

This phase did not merely produce maps: it built an archaeographic model, a cartographic language that enabled the reinterpretation of occupation dynamics from the Stone Age to the pre-Islamic period.

4.3. The Revolution in Geometric Recording: UAVs, GIS, Geodatabases and 3D Documentation

The arrival of UAVs between 2012 and 2014 marked a decisive shift in field documentation. The high-resolution digital surface models and orthophotos obtained at Mleiha demonstrated that low-altitude aerial photogrammetry could be integrated with centimetric precision into traditional topographic surveys.

In parallel, the creation of the regional geodatabase (2012–2013) made it possible to unify decades of dispersed information, generating a structured digital archive. This, in turn, led to the development of web viewers and archaeological management tools. The three-dimensional documentation of objects (2014) and the use of 3D printing opened the possibility of analysing and reproducing archaeological materials with sub-millimetric precision, while EyesMap (2016) introduced the first portable reverse-engineering methods for hard-to-access environments, such as the petroglyphs of Khatm al Melaha and the tower-tombs of Mleiha 5.

Taken together, these technologies transformed scientific production in Sharjah by enabling:

- more complete, precise and rapid documentation,
- the recording of fragile sites without physical intervention,
- and the creation of long-term digital archives.

4.4. The Consolidation of Archaeological BIM and Web Services: Reconstruction, Analysis and Temporal Simulation

The incorporation of BIM methodology between 2015 and 2016 represented a conceptual turning point in the way ancient architectures of the emirate are documented and understood. The 3D–4D models of MLH-5, MLH-6, MLH-7 and the MLH-8 Palace demonstrated that it is possible to integrate:

- Construction phases,
- Material attributes,
- Architectural typologies,
- and temporal sequences of use and abandonment,
- Both in partially preserved structures and in buildings that have disappeared or can only be reconstructed from archaeological and topographic data.

BIM made it possible to move beyond mere geometric representation toward historical and functional interpretation, becoming a key tool for museography, conservation, and the public dissemination of heritage.

The UPM–SAA collaboration has created a geospatial archive for the archaeology of Sharjah that enables the digital reproduction of the emirate's archaeological landscape. It has raised the technical standards of documentation, provided tools for preventive conservation—anticipating risks and recording structures before their deterioration—and, above all, it has forged a lasting academic bridge between Spain and the Emirates, demonstrating that sustained international cooperation produces far-reaching methodological advances.

Three decades after the beginning of this scientific endeavor, it can be stated that the UPM-SAA collaboration has achieved not only the documentation and preservation of the emirate's archaeological heritage, but also the creation of a digital language capable of narrating its history. This legacy forms the foundation for future projects incorporating advanced sensors, artificial intelligence, 4D GIS, and augmented-reality platforms.

Finally, it should be noted that this evolu
tion has been driven not by technology itself, but by archaeological needs. The collaboration stands as a successful model of scientific research and interdisciplinary partnership that has enriched both institutions and has contributed decisively to the understanding, conservation, and global visibility of Sharjah's archaeological heritage.

And after this long journey through these years of work, I want to emphasise that the word which, for me, best summarises these three decades remains unchanged: THANK YOU.

Acknowledgements

This work has been funded through the R&D Activities Programme, reference PHS2024/PH-HUM-45, acronym AVIPES II-CM, awarded by the Community of Madrid.

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