Advances in Archaeological Practice (2026), **14**, 341–357
doi:10.1017/aap.2025.10143

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HOW-TO SERIES

Let's Dig with QField! A F/OSS Mobile GIS Management System for Archaeological Excavation

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(Received 25 June 2025; revised 26 November 2025; accepted 28 November 2025; first published online 13 April 2026)

Abstract

In recent years, mobile GIS systems have become essential tools for the real-time management and recording of archaeological data, particularly in archaeological survey projects. This article explores their potential for the real-time digital management of archaeological excavations and presents a practical application. One of the main limitations to the use of mobile GIS applications in archaeological excavation has been that global navigation satellite system receivers embedded in mobile devices do not provide the necessary accuracy for detailed stratigraphic documentation. The free and open-source mobile GIS application QField offers a possible solution to this problem. Because of the Bluetooth connection with external differential global navigation satellite system receivers, QField achieves the high accuracy required by stratigraphic excavation workflows. At the same time, because it shares the core libraries of QGIS, QField supports the development of a real-time excavation GIS environment, in which each stratigraphic unit is uniquely encoded and becomes the focus of the digital data acquisition process.

Resumen

En los últimos años, los SIG móviles se han convertido en herramientas esenciales para la gestión y el registro en tiempo real de datos arqueológicos, especialmente en proyectos de prospección arqueológica. El objetivo de este artículo es explorar su potencial también para la gestión digital en tiempo real de excavaciones arqueológicas mostrando una posible aplicación práctica. Una de las principales limitaciones para el uso de aplicaciones SIG móviles en excavaciones arqueológicas siempre ha sido que los receptores GNSS integrados en los dispositivos móviles no proporcionan la precisión necesaria para una documentación estratigráfica detallada. La aplicación SIG móvil libre y de código abierto QField ofrece una posible solución a este problema. Gracias a la conexión Bluetooth con receptores DGNSS externos, QField alcanza una alta precisión requerida para el flujo de trabajo en una excavación estratigráfica. Al mismo tiempo, al compartir las mismas bibliotecas principales que QGIS, QField permite el desarrollo de un entorno SIG de excavación en tiempo real, donde cada unidad estratigráfica se codifica de manera única y se convierte en el centro del proceso de adquisición digital de datos.

Keywords: archaeological excavation; digital archaeology; geodatabase; GIS; mobile GIS

Palabras clave: excavación arqueológica; arqueología digital; geodatabase; SIG; SIG móvil

In the last 20 years, mobile GIS applications have emerged as increasingly valuable tools within archaeological research (Chyla and Buławka 2020). But what precisely is meant by "mobile GIS"? The term refers to software developed for the collection, editing, analysis, and visualization of geospatial data directly on mobile devices while ensuring seamless synchronization and interoperability with desktop GIS platforms.

The evolution of mobile GIS has closely followed advancements in global navigation satellite system (GNSS) technologies. The first generation of mobile GIS applications were developed in the early 2000s (Chyla and Buławka 2020:102; Fábrega-Álvarez and Lynch 2022:215–216). These early tools were predominantly proprietary software—such as Esri's ArcPaD—and required extensive GIS expertise to operate effectively (Tripcevich 2004). GPS technology has since become fully accessible to the general public and has been integrated into everyday devices, such as smartphones and tablets.[1] The widespread adoption of modern smartphones equipped with internal GNSS receivers has significantly boosted the development of free and open-source mobile GIS applications in the so-called second generation of mobile GIS applications (Fábrega-Álvarez and Lynch 2022:216). A major advantage of these new applications is their user-friendly design, which has substantially lowered the technical barrier for their use; they are now accessible to a broader community of archaeologists (Chyla and Buławka 2020).

Thanks to these innovations, open-source mobile GIS applications are playing an increasingly central role in archaeological practice, providing powerful solutions for improving field practices. They are particularly valuable in archaeological surveys, where teams frequently operate across wide areas and need to gather diverse types of information. In this context, mobile GIS enables faster and more flexible documentation directly on-site, often supporting real-time and multiuser data collection (Farinetti, Rossi, and Bottoni 2026). By streamlining workflows and improving both precision and collaboration, mobile GIS is transforming how archaeological surveys are conducted, from topographic to artifact surface surveys (Fábrega-Álvarez and Lynch 2022; Farinetti, Bottoni, et al. 2026; Lindsay and Kong 2020; Sgouropoulos et al. 2024).

However, their use in archaeological excavations has been much more limited. Although desktop-based managing systems for archaeological excavations do exist (see the Italian QGIS plug-in Pyarchinit; Cocca and Mandolesi 2013), there is a noticeable gap in the use of off-the-shelf free and open-source (F/OSS) mobile GIS tools for real-time excavation management (Psarros et al. 2022).

A primary limitation lies in the positioning accuracy of standard mobile devices, such as smartphones or tablets. This accuracy often varies between 2 and 12 m, depending on factors such as the connection to a data network (an assisted global positioning system; A-GPS) and the number of satellites in the visible sky (position dilution of precision; PDOP; Tomastik et al. 2016). Archaeological excavations are frequently conducted in areas with limited network connectivity or in environments characterized by dense vegetation cover. These conditions significantly impair the performance of built-in GNSS receivers in mobile devices. Although the resulting positional accuracy may be adequate for tasks such as artifact surface surveys, stratigraphic excavations demand substantially higher precision to produce reliable and detailed spatial documentation (Farinetti, Rossi, and Bottoni 2026).

This need for precision has driven archaeologists toward more complex and specialized solutions. Systems that integrate mobile recording devices with high-precision instruments such as total stations or DGNSS receivers are often combined with web-based database platforms (see ArchField: Smith and Levy 2014; OpenDig: Vincent et al. 2014; FAIMS mobile: Ballsun-Stanton et al. 2018), proprietary applications (see ArcPad: Tripcevich and Wernke 2010), or customized IT solutions (see IDIG: Psarros et al. 2022; Dhaskalio excavation: Boyd et al. 2021).

Typically developed by IT specialists, these tailored solutions are frequently designed to meet specific research goals. Although their specialized nature can be beneficial, this also means that they often lack flexibility, offer limited customization options, and demand substantial technical expertise (Uildriks 2016). Consequently, these tools become challenging for the average field archaeologist to adopt and use effectively. These advanced systems may also require constant maintenance and updates, which may not be sustainable given the limited financial resources that characterize many research and academic excavation projects.

Today, the second generation of mobile GIS applications can be easily connected to high-precision instruments, solving the positioning issue and further enhancing their potential for archaeological practice. Yet, in contrast to the rapid evolution and the increasing availability of ready-to-use and user-friendly applications, their adoption in excavation projects has remained surprisingly limited, in favor of using proprietary software and expensive tailored solutions. A detailed comparison of the various free mobile GIS tools currently available on the market lies beyond the scope of this article. Instead, its aim is to address this gap in the use of these applications by presenting one practical workflow for the comprehensive digital management of excavation data. The proposed solution is built around QField, one of the most widely adopted F/OSS mobile GIS platforms, which is freely available for both Android and iOS devices. By describing an integrated workflow that combines high-precision GNSS technology with open-source GIS tools, this article demonstrates the effective application of F/OSS mobile GIS for the digital management of archaeological excavations. The proposed approach seeks to overcome common challenges by balancing user-friendliness, financial constraints, and the high level of precision required for accurate stratigraphic excavation documentation.

Tools and Methods

The QField Application

Developed by core contributors to the QGIS project, QField leverages shared QGIS core libraries to ensure the best integration between desktop and mobile environments. This interoperability is further enhanced by a dedicated QGIS plug-in that facilitates data synchronization and transfer, enabling efficient workflows across devices (more information can be found at https://docs.qfield.org/get-started/).

A particularly innovative feature of QField is its native Bluetooth integration with third-party high-precision GNSS receivers. This functionality is essential in excavation contexts, where centimetric positional accuracy is required for the reliable documentation of stratigraphic units and archaeological features. To connect to a GNSS receiver, QField supports the NMEA 0183 protocol via Bluetooth (Android only) or via TCP/UDP over Wi-Fi (Android and iOS). Within the app's positioning settings, users can enable logging of key NMEA sentences (GGA, GSA, GSV, RMC, etc.) to a separate text file, thereby providing detailed information on the status of the GNSS receiver. Additional metadata, such as fix status and dilutions of precision (DOPs) can be also stored directly in entity attribute tables by activating default value expressions in QGIS (for more details, see https://qfield.org/docs/prepare/gnss.html). QField's positioning settings also support the use of accuracy thresholds, antenna height compensation, and averaged positioning functionality. In addition, altitude conversion can be managed directly within the app using a vertical grid shift file. Compared with alternative F/OSS solutions currently available on the market, Qfield's capabilities provide a higher degree of control over the positional constraints required in an archaeological excavation. Another key advantage of QField is its high degree of customization. The application allows for extensive tailoring of spatial and nonspatial entities, as well as the attribute forms, enabling archaeologists to adapt the system to the documentation needs of each excavation project.

QField also benefits from its intuitive and user-friendly interface. Its capacity to import QGIS project configurations—including custom widgets and database relations—simplifies data entry and minimizes the user's learning curve. This makes the tool accessible not only to experienced GIS professionals but also to archaeologists with limited technical expertise. Moreover, QField supports connections to PostgreSQL/PostGIS systems, allowing users to manage excavation data in more robust and complex database environments.

A significant development within the QField ecosystem is the introduction of QFieldCloud, a cloud-based service designed to easily synchronize projects between QGIS and QField. QFieldCloud eliminates the need for manual file transfers by enabling seamless, remote updates and access to project data. Archaeological teams can upload, share, and collaboratively manage datasets from the field or office, thereby supporting multiuser cooperation and even crowd-sourced data collection workflows. Each user's changes are tracked, allowing for the correction of errors and the restoration of previous dataset versions when needed. The system also includes conflict resolution mechanisms (collision mitigation), which can operate in a "last-write-wins" mode or allow for the manual review of conflicting edits. This version control mechanism ensures data integrity and provides a reliable safeguard during both fieldwork and postprocessing phases (see Figure 1). Although QFieldCloud offers a free community user account—with 100 MB of cloud storage and access to public project collaboration—advanced features such as expanded cloud capacity and multiuser collaboration on private projects require a subscription plan.[2]

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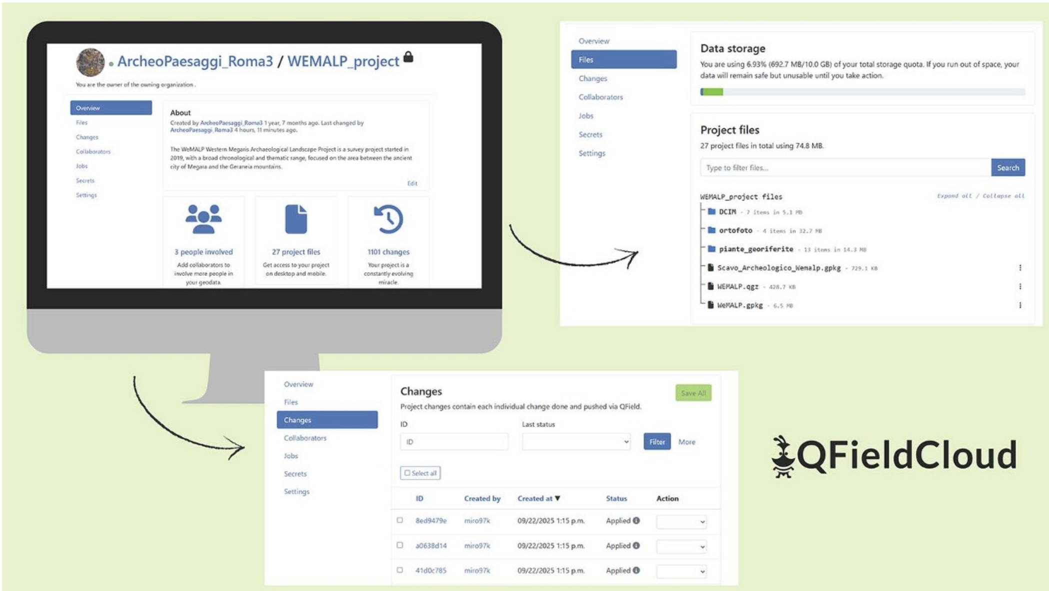

Figure 1. Screenshot of the QfieldCloud browser interface, where it is possible to manage the project files and each user's changes at the project.

Overall, QField provides a flexible and accessible framework that integrates high-precision positioning tools and advanced GIS functionality with collaborative cloud services, offering an effective solution for the digital documentation and management of archaeological excavations.

Building a Relational Geodatabase in QGIS

In this section, I present an example of a workflow for the real-time management of archaeological excavations. Taking advantage of all the capabilities of the QField app, the proposed approach starts with the project's configuration in QGIS and the preparation of a relational geodatabase (Figure 2). From its initial design, this database was created to adhere to the FAIR (*F*indable, *A*ccessible, *I*nteroperable, *R*eusable) principles (Wilkinson et al. 2016), with a special focus on interoperability and reusability. The system is also integrated into the SHAReLAND project, a Roma Tre University initiative for the open dissemination of archaeological data (Bottoni et al. 2024).

The entire geodatabase was developed within a single GeoPackage (GPKG) file format that was chosen for three main reasons: (1) its efficient compatibility with QField and QFieldCloud, allowing centralized storage of all spatial and nonspatial data in a single file; (2) its ability to support diverse data types—including raster (basemap and georeferenced orthophotos), vector, and tabular datasets—that are ideal for the varied nature of archaeological documentation; and (3) its support for SQL, facilitating advanced querying and manipulation of excavation data. The GPKG open format also aligns with the FAIR principles, ensuring the interoperability and reusability of the resulting dataset.

Data Structure: Excavation Workflow Entities

The excavation geodatabase is organized into six thematic layer groups that reflect the operational phases of the stratigraphic excavation and its documentation data (Figure 3): *General Info, Pre-Excavation, Mid-Excavation, Post-Excavation, Positioning*, and *Others* (Montagnetti and Guarino 2021). These groups represent the core of the stratigraphic excavation workflow, covering all stages from initial context

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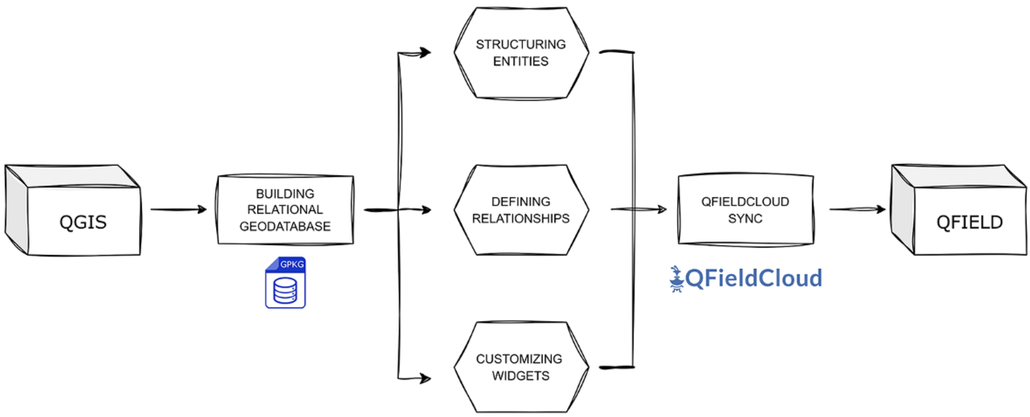

Figure 2. Diagram of the construction phases of the relational geodatabase in QGIS.

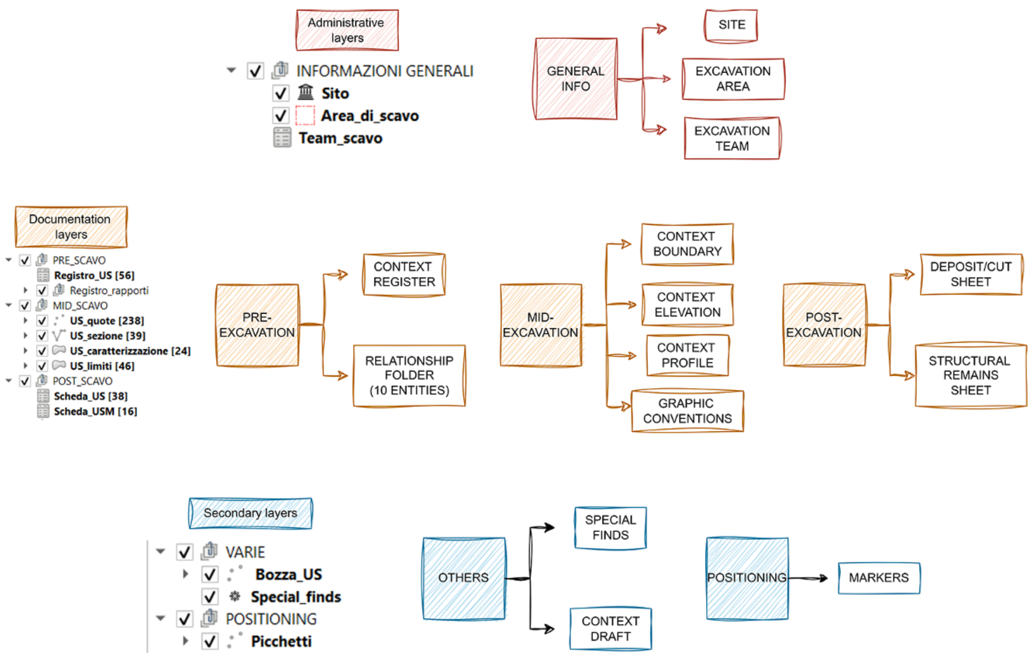

Figure 3. The geodatabase entities, split into six thematic layer groups reflecting the excavation workflow.

registration, through its spatial documentation, to the completion of context sheets after its physical removal (Table 1).

The *General Information* group contains two higher-level administrative layers. The **Site** (**Sito**) layer is a point dataset representing individual excavation sites, containing attributes such as the site's name and a brief description of it. The **Excavation_area** (**Area_di_Scavo**) layer, structured as polygons, outlines the boundaries of specific excavation zones and includes metadata such as the year of excavation and a reference to the associated site. These two spatial entities provide the geographical and contextual framework within which individual contexts are registered and documented. Included in this group is the **Excavation_Team** (**Team_Scavo**) table, a nonspatial entity that stores information on excavation team members, including their names, institutional affiliations, and designated roles within the project.

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Table 1. Summary Table of Database Entities.

Group	Layer (IT)	Translation (EN)	Type	Purpose
General Info	Sito	Site	Point	Site metadata
	Area_di_Scavo	Excavation_Area	2DPolygon	Excavation area metadata
	Team_Scavo	Excavation_Team	Table	Staff and roles
Pre-Excavation	Registro_US	Context_Register	Table	Registration of new stratigraphic units (SU)
	Registro dei Rapporti	Physical Relations Folder	Table	Relationships between contexts
Mid-Excavation	US_limiti	Context_Boundary	2DPolygon	Stratigraphic units' boundaries
	US_quote	Context_Elevation	Point	Stratigraphic units' heights
	US_sezione	Context_Profile	3DLine	Stratigraphic units' profiles
	US_caratterizzazione	Graphic_Convention	2DPolygon	Standardized attributes for graphical representation
Post-Excavation	Scheda_US	Deposit_Cut_Sheet	Table	Descriptive record of strati-graphic units
	Scheda_USM	Structural_remain_Sheet	Table	Documentation of masonry contexts
Positioning	Picchetti	Reference_Marker	Point	Georeferencing reference target/marker
Others	Bozza_US	Context_Draftbook	Point	Preliminary contex boundary
	Special_finds		Point	Georeferenced recording of significant finds

The *Pre-Excavation* group comprises two primary entities that correspond to the essential documentation steps undertaken before the physical removal of a stratigraphic unit: the registration of the new context and the recording of its physical relationships. The initial phase is managed through the **Context_Register** (**Registro_US**), a no-geometry layer characterized by six key attributes:

1. Context_number (US_numero): a unique numerical identifier assigned to each context
2. Excavation_area (Area_di_Scavo): designation of the excavation area
3. Site (Sito): name of the archaeological site
4. Definition (Definizione): a brief textual description of the context
5. Recorder (Compilatore): name of the individual responsible for data entry
6. Date (Data): date on which the context was registered

The second documentation step is managed within the **Physical Relations Folder** (**Registro dei Rapporti**), which stores all physical relationships between stratigraphic contexts. Each type of relationship—for example, covers/covered by, cuts/cut by, et cetera—is represented by a dedicated table structured with two primary attributes: (1) Context_n (US_n): the context subject of the relationship and (2) Context_relationship (US_rapporto): the context object of the relationship.

The *Mid-Excavation* group comprises four spatial entities that support the spatial documentation process conducted immediately before the physical removal of a context. The primary entity, **Context_Boundary** (**US_limiti**), is a 2D-multi-polygon layer used to delineate the top surface boundaries of each context (Figure 4). In this way, the top surface of an underlying context automatically serves as the bottom surface of the immediately overlying one. Its associated attribute table records the context's unique numeric identifier along with several key data attributes, including topographic information (site name and excavation area), context type (deposit, cut, structural remain), excavation status (completed or ongoing), and recording metadata (name of the recorder and date of documentation).

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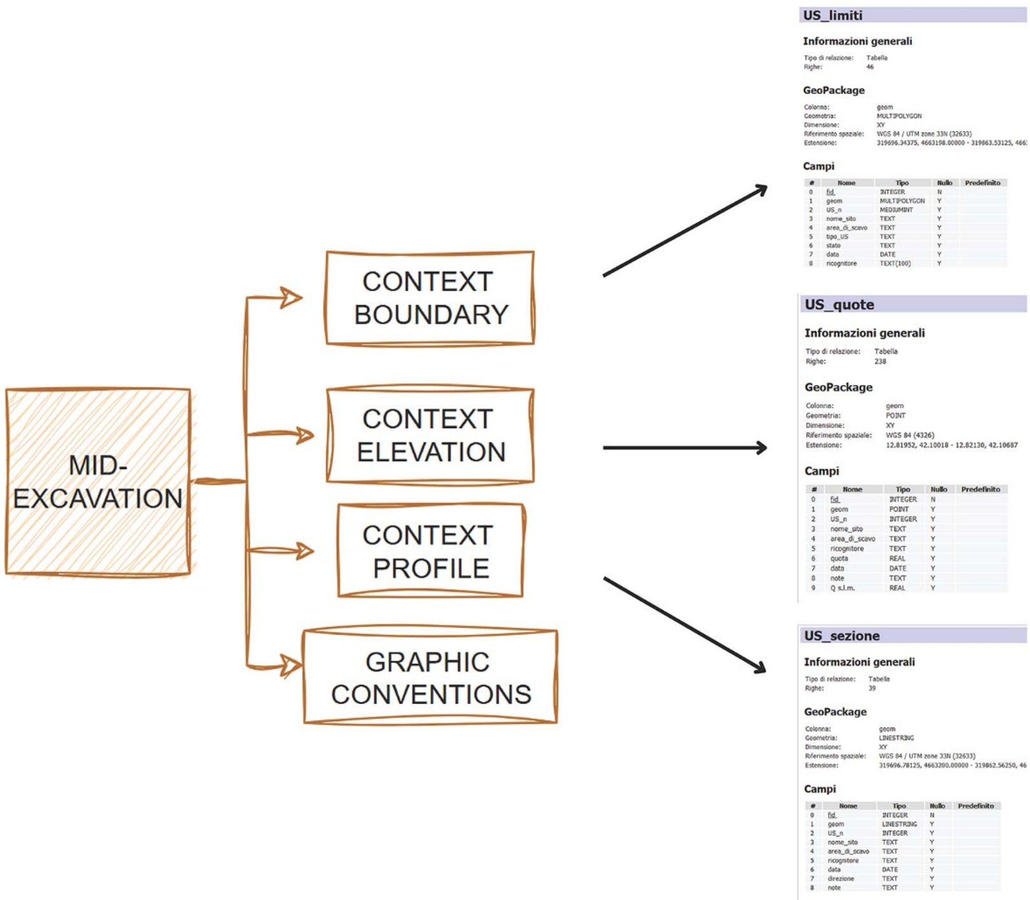

Figure 4. The mid-excavation entities and their defined attributes used for the spatial documentation of contexts.

Associated with **Context_Boundary** are three additional spatial layers:

1. **Context_elevation** (**US_quote**): a point layer used to register elevation data, with key attributes including ellipsoidal height (Quota) and geodetic height (Quota s.l.m.)
2. **Context_profile** (**US_sezione**): a 3D-line layer used to draw context profiles, which are stored as 3D lines and used as a backup to desktop-based photogrammetric documentation
3. **Graphic_conventions** (**US_caratterizzazione**): a 2D-polygon layer used to document specific internal characterizations of the context, such as the presence of big inclusions as stones or blocks

The *Post-Excavation* group encompasses nonspatial entities associated with the written documentation phase of an archaeological excavation—specifically, the completion of context sheets. Typically, once the spatial documentation has been completed and the context physically removed, the final step is to compile the relevant context sheet. In our excavations, we used two distinct types of sheets: one for deposits and cuts (**scheda_US**) and the other for structural remains (**scheda_USM**).

The structure of our context sheets is based on the official Italian model provided by the Central Institute for Cataloguing and Documentation (ICCD; Anichini et al. 2012:9–11). However, users are free to adapt and customize the format to meet the specific needs of their project. Although a detailed examination of each attribute is beyond the scope of this discussion, the use of the Italian language in context sheet attributes and throughout the entire database structuring reflects my choice to produce data that can be immediately submitted to the Italian Ministry of Cultural Heritage without requiring further postprocessing and translation work. Doing so contributed to the production of

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analysis-ready data, not only enhancing the immediate efficiency of excavation recording but also ensuring that datasets would remain reusable in future research contexts, in line with the FAIR principles.

The secondary entities within the QGIS-based excavation database are organized into two main categories: *Positioning* and *Others*. In the *Positioning* group can be found the **Reference_Marker** (**Picchetti**) layer, which consists of point features marking the physical reference markers placed on-site, each with associated positioning data. In the *Others* group, the point-based **Context_draftbook** (**Bozza_US**) layer functions as a digital draft book used for the preliminary spatial documentation of contexts during fieldwork, and the **Special_finds** layer is a point layer used to record significant artifacts, providing detailed attributes such as context reference, object type, and precise spatial coordinates.

Defining Relationships: From Flat Tables to a Relational System

The relational structure of the excavation geodatabase was systematically formalized within QGIS through the definition of 32 distinct relationships, primarily based on the classic *local key / foreign key* model, with the unique context number serving as the central linking attribute (Figure 5). Although QGIS natively supports only one-to-many (1:N) relationships, these form the backbone of the database architecture and ensure logical consistency and full interoperability between spatial and nonspatial data.

All the relationships are defined in the project property panel under the section "Relations" (Figure 6). Once the relationships are settled, they are continuously stored within the QGIS project file (.QGS), ready to be synchronized through the QFieldCloud plug-in in QField.

As illustrated in Figure 5, the recording system is centered on the **Context_Register**, which functions as the main entity for linking all documentation related to each individual stratigraphic unit. This core entity is directly connected through the context's unique numeric identifier to spatial layers such as **Context_Boundary, Context_Elevation, Context_Profile**, and **Graphic_Conventions**, as well as to nonspatial entities like the **Context Sheets**.

Going beyond simple 1:N relationships, more complex relational patterns such as one-to-one (1:1) and many-to-many (M:N) can be modeled through the strategic use of intermediate tables and QGIS project widgets, thereby enhancing the system's expressiveness and adaptability to diverse excavation workflows. Two notable examples illustrate this complexity:

1. Many-to-many (M:N) relationships exist between the **Context_Register, Context Sheets**, and the **Physical Relations** tables. These are implemented through dedicated join tables, enabling each context to participate in multiple stratigraphic relationships. This is especially effective for modeling complex stratigraphic sequences.
2. One-to-one (1:1) relationships link each stratigraphic unit in the register to a single polygon in **Context_Boundary**; in addition, each **Context_Boundary** polygon records a single finalized **Context Sheet**. This ensures that each stratigraphic unit is uniquely mapped and documented, preserving consistency between geometric representation and descriptive data.

Finally, the **Site** and the **Excavation_Area** layers are also directly linked to the **Context_Register** and the **Physical Relations folder**. These relationships allow for efficient post-excavation filtering and postdocumentation GIS visualization of the recorded data.

Widget and Forms Customization: Optimizing the Qfield User Interface

The final stage in the customization of the excavation geodatabase involves the configuration in QGIS, through the layer properties panel, of all the widgets, input forms, and display labels. This phase is crucial to enhancing both the reliability of the data and the accessibility of the system, making it easier for archaeologists with varying levels of GIS expertise to work effectively with the QField application.

Using the attribute form panel, it is possible to select the different widgets for all the entities in the geodatabase. Four types of widgets were strategically employed to support and optimize the documentation process:

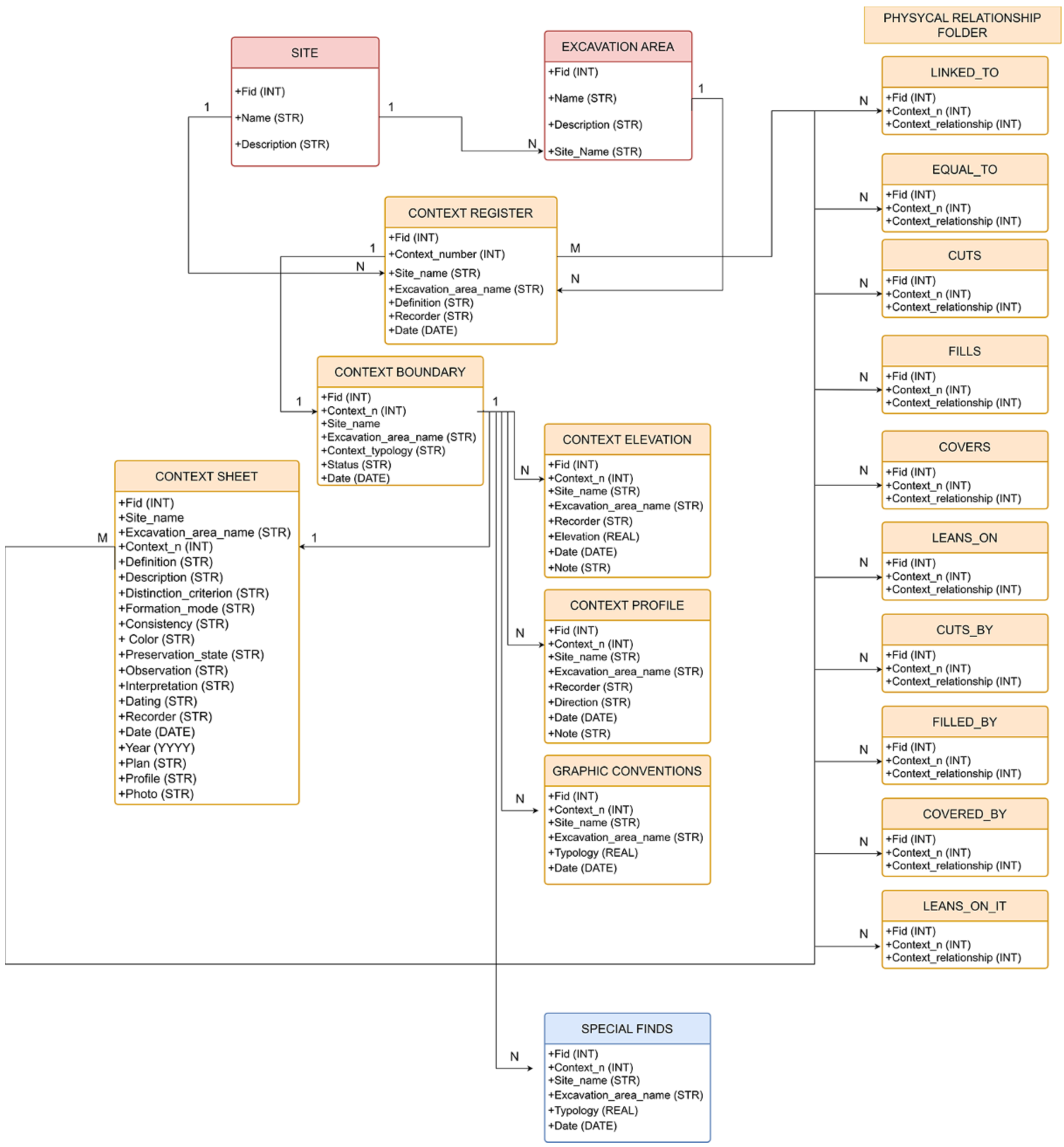

Figure 5. Relational architecture of the excavation geodatabase showing links between spatial and nonspatial entities via the unique context number.

1. **Relation Reference**: This widget allows users to populate attribute fields in a child table by selecting values from a parent table, as defined in the project's relationship settings. It is particularly useful for managing the hierarchy between **Context_Register** and **Context Boundary**, guiding users through the documentation workflow in QField. This ensures that no geometry can be created unless a corresponding context number has first been registered in the context register (Figure 7).
2. **Value Relation**: This widget allows users to populate attribute fields by selecting values from an external reference table without requiring a formal relationship definition. It is particularly useful for fields that recur across multiple entities, such as the recorder's name, thereby promoting consistency and reducing the use of redundant project relationships (Figure 8).

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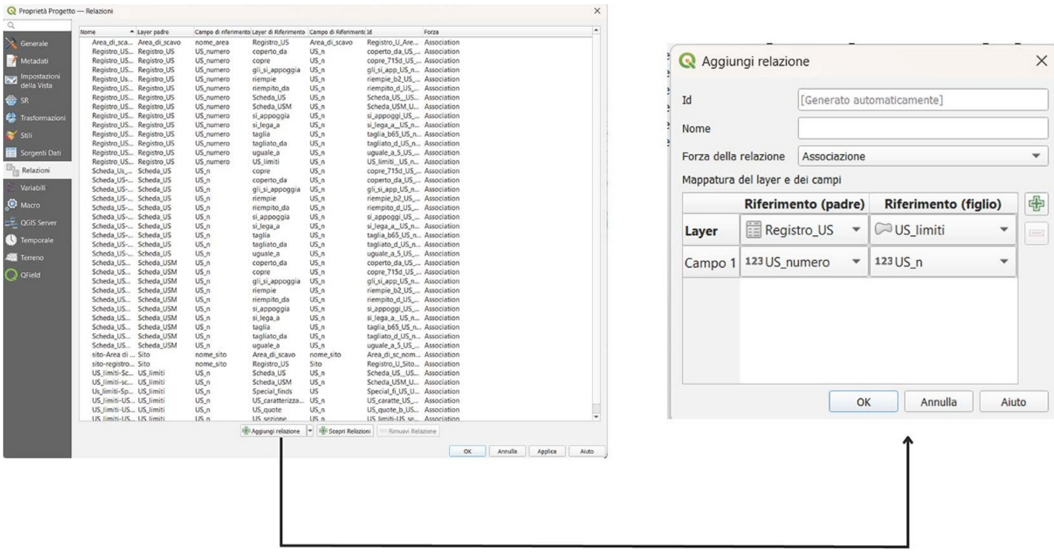

Figure 6. QGIS project property panel showing the configuration of geodatabase relationships.

3. **Value Map**: This widget provides predefined dropdown menus populated with fixed lists of options. It is especially effective in supporting the standardization of data entry and vocabulary for context sheets. Attributes such as layer consistency, color, and other qualitative characteristics can be rapidly entered via user-friendly selection menus, enhancing the efficiency and accuracy of field documentation (Figure 9).
4. **Default Value**: This widget is used to automatically populate fields using QGIS default or customized expressions (Table 2). It is particularly important for the automatic extraction of spatial coordinates and the entry date on geometry creation. Additionally, default values are used to reduce repetitive data entry by automatically retrieving information from parent records. For example, when populating layers such as **Context_Boundary, Context_Elevation**, or **Graphic_Conventions**, attributes such as *Site* and *Excavation Area* are automatically inherited from the **Context_Register**, ensuring consistency and reducing the cognitive load on the user.

Once the widget customization is completed, the next step is to configure the input forms using QGIS's *drag-and-drop* designer. This phase allows for the customization of the form's layout, thereby streamlining the data entry process and enhancing the user experience within the QField application. QGIS enables the creation of intuitive forms using custom labels and nested subfolders that are designed to help and guide the user in the data entry process. For example, I structured the **Context_Boundary** input form into six subfolders (Figure 10):

1. General Info (Informazioni Generali)
2. Elevations (Quote)
3. Profiles (Sezione)
4. Graphic Conventions (Caratterizzazione)
5. Deposit/Cut Sheet (Scheda_US)
6. Structural Remains Sheet (Scheda_USM)

The *General Info* subfolder contains all the core attributes of the **Context_Boundary** entity. The subfolders *Elevations, Profiles*, and *Graphic Conventions* manage the relationships with the child tables **Context_Elevation, Context_Profile**, and **Graphic_Conventions**, respectively. These allow

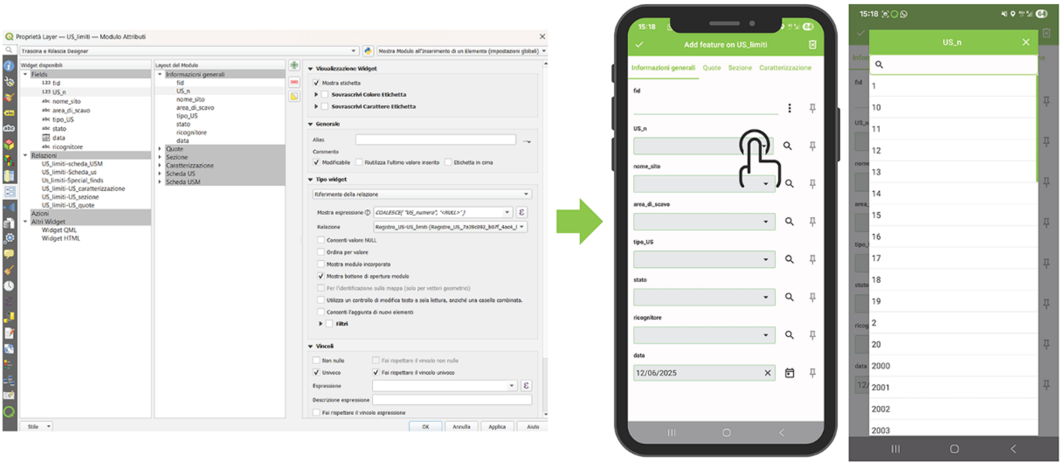

Figure 7. *Left:* Setting the Relation Reference widget for the *US_n* attribute in the *US_limiti* layer in QGIS; *right:* QField interface showing the widget used to link geometry creation to registered stratigraphic contexts.

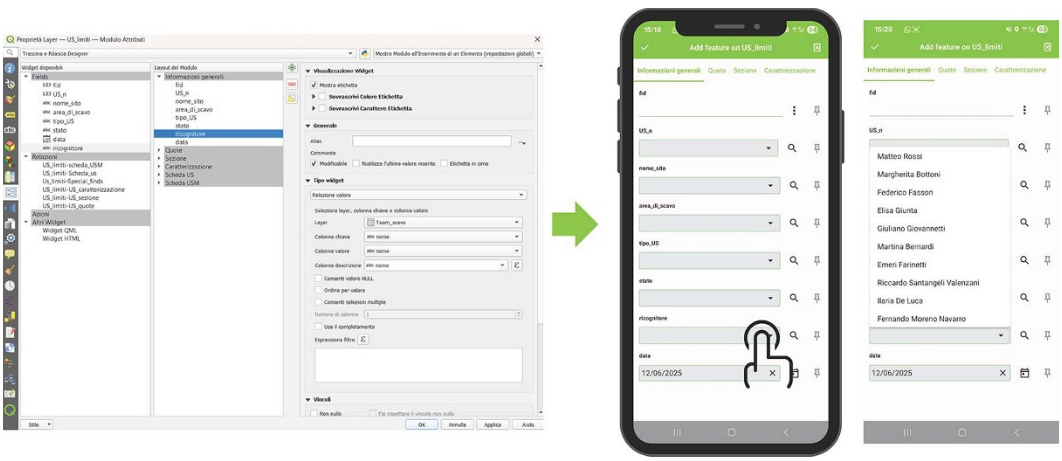

Figure 8. *Left:* Setting the Value Relation widget for the *recorder* attribute in the *US_limiti* layer in QGIS; *right:* Use of the widget in QField to select values from the excavation team reference table.

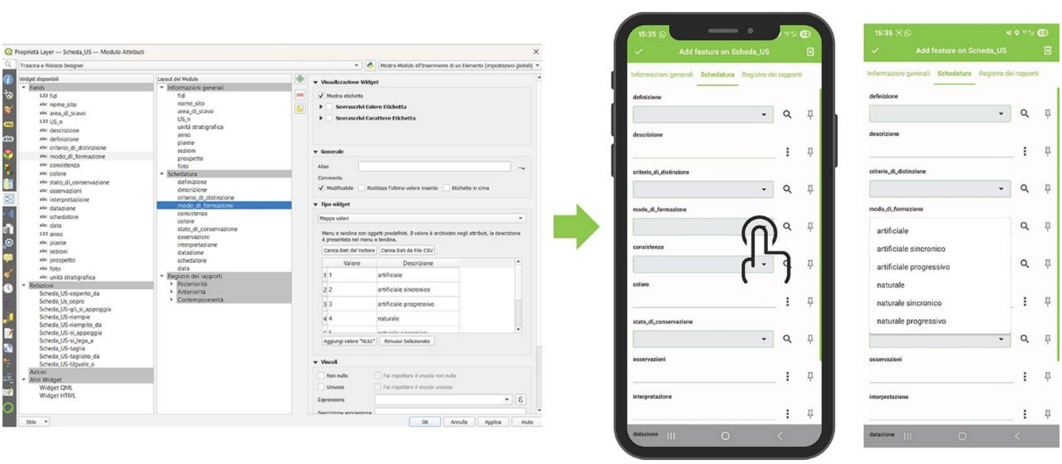

Figure 9. *Left:* Setting the Value Map widget in the *Scheda_US* layer in QGIS with predefined options; *right:* dropdown menu in QField enabling standardized attribute selection during context sheet completion.

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Table 2. Examples of QGIS Expressions Used in the Default Value Widget.

Expression syntax	Returned value
$x	Extract longitude value
$y	Extract latitude value
$z	Extract altitude value
now()	Extract entry date
attribute(get_feature('Registro_US', 'US_numero', "US_n"), 'Sito')	Extract the value of "Sito" from the Context Register entity.
attribute(get_feature('Registro_US', 'US_numero', "US_n"), 'Area_di_scavo')	Extract the value of "Area di Scavo" from the Context Register entity.

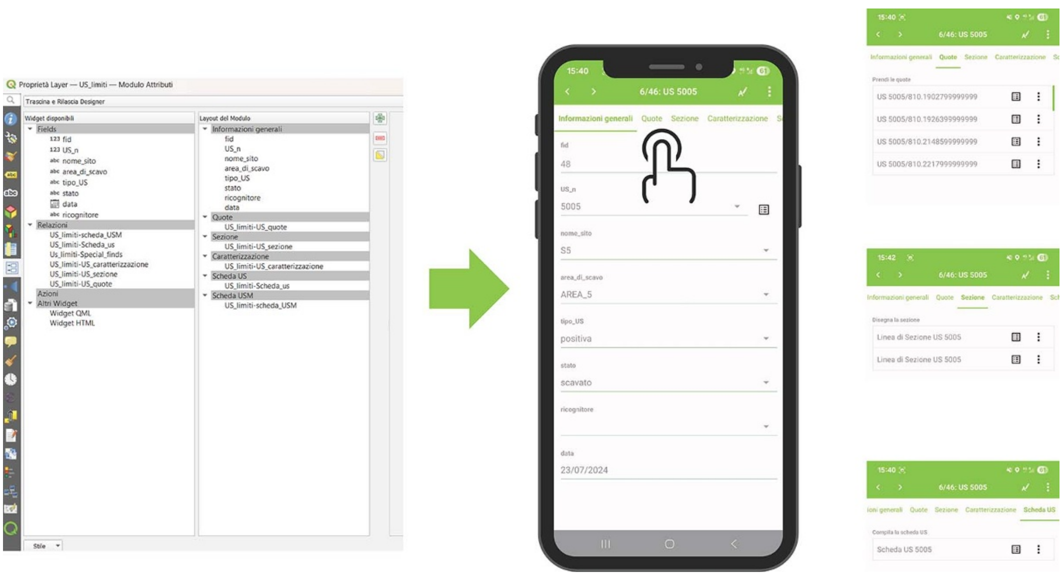

Figure 10. Custom layout of the *US_limiti* input form in QGIS, structured into nested subfolders to enhance usability.

users to directly access and edit these related child tables from within the **Context_Boundary** parent form. Similarly, the context sheet relationships are handled through the subfolders *Deposit/cut Sheet* and *Structural Remains Sheet*. However, in this case, the visibility of each subfolder is controlled by expressions based on the value of the field *Context_type* (*tipo_US)* (deposit/*positiva*; cut/*negativa*; structural remain/*verticale*), which is part of the **Context_Boundary** attribute table:

- *"tipo_US" IN ("positive," "negative")* → displays the **Deposit/Cut Sheet** subfolder.
- *"tipo_US" IN ("vertical")* → displays the **Structural Remains Sheet** subfolder.

This logic ensures that only the relevant documentation subfolders appear in the form (Figure 11).

This configuration forms the backbone of the system, establishing a self-guided workflow in which spatial and nonspatial data are contextually linked through the unique context number as the primary reference key. It supports a coherent and logical documentation process by allowing users to seamlessly navigate between interconnected layers, ensuring consistency and completeness during data collection in the field.

Once the project configuration is done, it is finally possible to upload the project file (.QGZ/.QGS) and the GeoPackage file (.GPKG) in QField using the QFieldCloud plug-in (for more detailed information about project synchronization, visit https://docs.qfield.org/it/get-started/tutorials/get-started-qfc/).

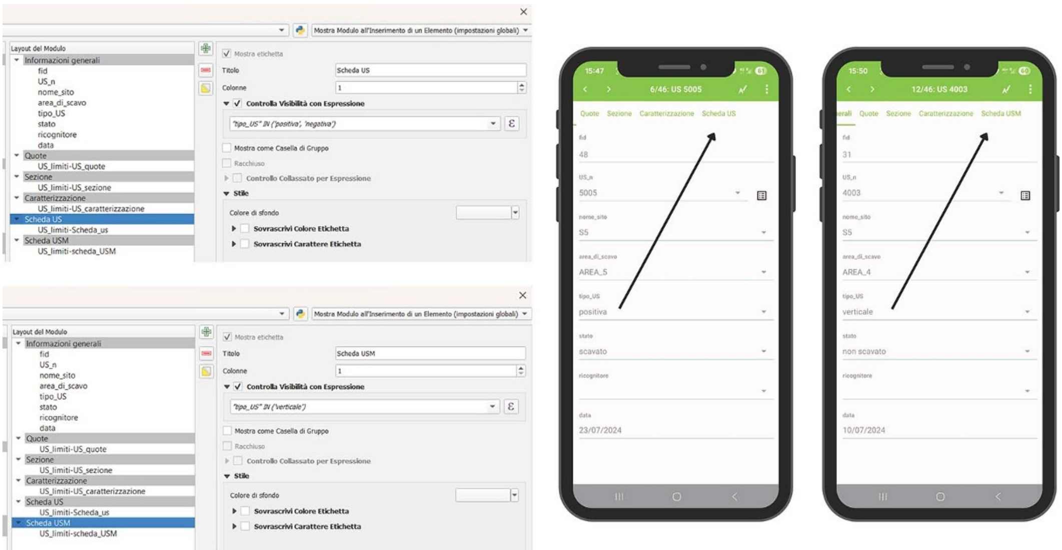

Figure 11. Conditional display of context sheet subfolders based on the context type (deposit, cut, or structural feature).

Field Testing of the Qfield Documentation System

Research Contexts, Hardware, and Software Setup

The QField recording system was tested in two archaeological excavations during 2024 (Figure 12). The first took place in Italy in July 2024 as part of the MoLuLaP Project conducted by Roma Tre University at the medieval site of Montefalco Castle (Bernardi and Farinetti 2024). The second test occurred in Greece in October 2024 during the excavation of the Marmara Sanctuary under the auspices of the WeMALP Project, a collaborative effort led by Roma Tre University, Scuola Archeologica Italiana Di Atene (SAIA), and the Greek Ephorate of Antiquities (Farinetti and Avgerinou 2023).

During the MoLuLaP campaign, QField version 3.3.5 "Darien" was used. For the WeMALP excavation, version 3.4.2 "Ebo" was deployed. The application was installed on two Samsung S9+ tablets, each connected via Bluetooth to an E-Survey E300 PRO DGNSS receiver. This configuration enabled simultaneous data collection across multiple excavation areas. When necessary, QField was also operated by personal smartphones, offering additional flexibility in the field. The excavations were conducted under different connectivity conditions: the MoLuLaP campaign took place in an area with no phone signal, whereas the WeMALP campaign was carried out in a location with mobile data coverage. Nevertheless, in both cases, data synchronization with QfieldCloud was intentionally postponed until the end of the working day, when a strong and reliable internet connection was available. This approach took advantage of QField's capability to operate fully offline using the tablets' internal memory and was adopted to minimize the risk of data loss and ensure the integrity of the recorded information.

Qfield On-Field Recording Workflow

Once the QGIS project is fully synchronized with the QField app, the system is ready for use in the field. A GitHub repository with a demo project has been created to allow everyone to test this system and its recording workflow (https://doi.org/10.5281/zenodo.17492524). It can be summarized in five key steps (Figure 13).

(1) *Initializing the system.* The field documentation process begins by launching the GIS project on the mobile device and establishing a Bluetooth connection with the high-precision GNSS receiver. This setup will turn your GNSS pole into a georeferenced drawing tool. To set up an external antenna in the QField app, first pair your mobile device with the GNSS receiver via Bluetooth. This step enables the app to detect other Bluetooth connections. Then, open the QField app settings, navigate to the

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Figure 12. The two field testing locations of the QField system: on the left, Montefalco (Italy) and on the right, Marmara (Greece).

Figure 13. The on-field QField recording workflow.

Positioning section, and tap the green button to select the external receiver from the list of available Bluetooth devices.

(2) *Register a new stratigraphic unit.* A new stratigraphic context is initiated by creating a new record within the **Context_Register** layer. Through the attribute table, it is possible to assign the context a unique identifier and a brief descriptive definition. Using the table banner, it is also possible to access the **Physical Relationship Folder** directly from this table, allowing the operator to immediately record the context's physical relationships.

(3) *Complete the spatial documentation.* Using the **Context_Boundary** layer, the operator draws the context's boundaries by physically moving the GNSS pole along its perimeter. Once the geometry is captured and the related attribute form is completed, through the parent table **Context_Boundary** users can easily access all other documentation layers (**Context_Elevation, Context_Profile, Graphic_Conventions**) for completing the context spatial documentation.

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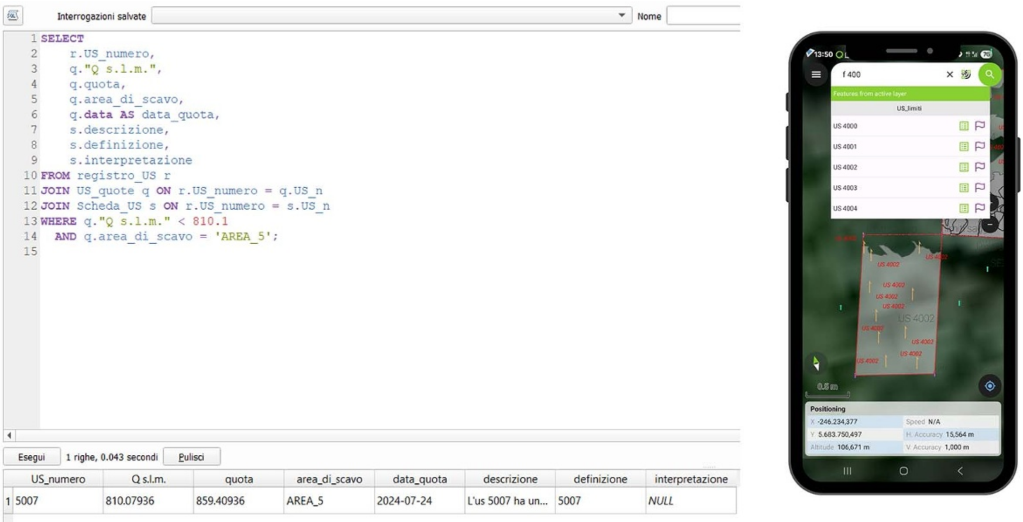

Figure 14. Example of QField's built-in search and filter tools (right) and advanced SQL query execution in QGIS desktop for post-excavation data interpretation.

(4) *Complete the written documentation.* After acquiring spatial data, written documentation is finalized using the **Deposit/Cut sheet** layer, which is still accessible from the **Context_Boundary** parent table. From the context sheet layer, the user can also return to the **Physical Relationships folder**, enabling the documentation of intercontext stratigraphic relationships via the dedicated modules.

(5) *Synchronize data.* At the end of each fieldwork session, the new records are synchronized with the QFieldCloud platform. This enables immediate access from a desktop GIS environment and eliminates the need for manual data transfer or postprocessing.

Conclusions

The adoption of QField as a mobile GIS solution for archaeological excavation management has significant potential for improving both the efficiency and accuracy of field documentation while keeping the user learning curve and the funding required low. Its ability to support the integrated collection of stratigraphic and planimetric data directly on-site reduced the risk of mapping errors and minimized the need for post-excavation data processing. Moreover, its offline functionality ensured reliability even in remote research contexts. The intuitive interface, the customizable widgets, and its support for both simple and advanced queries made the application accessible to users with varying levels of technical expertise. Throughout the excavation process, recorded data could be reviewed and queried directly within QField using its built-in search and filter tools—a useful feature for quick, on-site context research. However, its real advantage emerged in the post-fieldwork phase, when more advanced queries could be performed within the desktop GIS environment using SQL language (Figure 14). This capability was crucial during the interpretation stage when the relational structure of the database allowed for powerful, targeted data interrogation.

However, several limitations of QField were identified: its optimal use requires a large-screen device, and battery life, mainly when using the device's internal GNSS receiver, can be restrictive during extended field sessions. Furthermore, multiuser collaboration on shared projects relies on QFieldCloud, which requires a paid subscription for full functionality. Looking ahead, areas for future development—enhancing the relational database by simplifying relationships, improving widgets, and including Z-dimension data in the 2D-layer Context_Boundary—will be prioritized. These improvements aim to lay the groundwork for a future 3D GIS excavation ecosystem that will be capable of integrating stratigraphic records with photogrammetric models for even more comprehensive documentation.

Acknowledgments. I thank Margherita Bottoni for her wholehearted support and her valuable feedback on the strengths and weaknesses of the developed system. I also express my sincere gratitude to the WeMALP project director Emeri Farinetti and to the MoLuLaP project directors, Martina Bernardi, Emeri Farinetti, and Riccardo Santangeli Valenzani, for allowing me to use and test the Qfield recording system during their fieldwork. Special thanks go to Fernando Moreno Navarro for assisting with the translation of the abstract into Spanish. Finally, let me emphasize that no specific permits were required for the completion of this work. The fieldwork for the WeMALP project was conducted with permit no. 92YA46NKOT-EH3 (2019, renewed in 2025) issued by the Hellenic Ministry of Culture. The fieldwork for the MoLuLaP project was conducted with permit no. 246 (12/03/2024) issued by the Italian Ministry of Culture. All the images are mine.

Funding Statement. This work was supported by the University of Rome "Tor Vergata" under Grant PNRR DM 118/2023. The research also forms part of the ongoing MoLuLaP and WeMALP projects of Roma Tre University.

Data Availability Statement. The digital data supporting the paper, consisting of a demo of the Qfield recording system, are available in the GitHub repository at https://doi.org/10.5281/zenodo.17492524.

Competing Interests. The author declares none.

Notes

1. The term "GPS" (global positioning system) refers to the US satellite constellation fully released to the public in May 2000 by President Bill Clinton (Chyla and Bulawka 2020:102). Since then, other satellite constellations have been launched into space and fully released to the public by various countries, such as GALILEO (the European constellation in 2016) or GLONASS (the Russian one in 2007). Although the acronym GPS is now used commonly to refer to the satellite positioning system, the acronym GNSS (global navigation satellite system) is preferred.
2. It is important to emphasize that the free QFieldCloud community account makes projects accessible and downloadable by anyone, which may present data security concerns in multiuser scenarios. Nevertheless, for academic users, a discounted subscription plan (€300 per year) provides 10 GB of cloud storage and support for an unlimited number of users, enabling secure collaboration on private projects.

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Cite this article: Rossi, Matteo. 2026. Let's Dig with QField! A F/OSS Mobile GIS Management System for Archaeological Excavation. *Advances in Archaeological Practice* 14(2):341–357. https://doi.org/10.1017/aap.2025.10143.