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Interdisciplinary Field Methods in the Study of Byzantine Landscapes
The Land and the Sea in Rough Cilicia

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Abstract This paper presents an archaeological case study exemplifying the efforts to integrate methods, such as airborne LiDAR, Cosmogenic Nuclide Exposure Analysis, and Artificial Intelligence for the study of a Late Antique islandscape in Rough Cilicia/Isauria. The extensive limestone quarries on Dana Island (Pityoussa) may have functioned as an industrial settlement servicing the work of the renowned Isaurian builders. In this context, researchers face the challenge of bridging the gap between disciplines like landscape archaeology and architectural history that operate within a framework of fragmentary data and imprecise chronologies, with the premium placed on accurate and precise data acquisition by the fields of engineering.

Keywords LiDAR. Quarries. Isauria. Builder. Remote sensing. Island. Consilience.

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1 Introduction

In the seventeenth International Byzantine Congress in 1986, James Russell (1986), who is among the pioneers of the archaeology of Rough Cilicia (Isauria), gave a talk during a session devoted to the transformation of urban life in the Early Byzantine Empire. At this session five papers covered topics ranging from traditional approaches to methodological discussions that indicated an increasing interest in interdisciplinary studies.[1] His was entitled, "Transformations in Early Byzantine Urban Life. The Contribution and Limitations of Archeological Evidence". Russell commended Byzantine historians for their willingness to incorporate archaeological and numismatic evidence in their interpretation of the disappearance of the *polis*. In Russell's words "the subject is now potentially subject to a refinement that would have been unthinkable a decade ago" (1986, 138). Archaeology, mainly excavations, have enabled historians to find "solutions to the questions that the written texts fail to answer or even address". While attempting to bridge the gap between historians and archaeologists, Russell warned the readers about the limitations of the material evidence which historians may be less critical about. Almost four decades later, the divide between historians and archaeologists is much less problematic as many scholars have been trained in both fields or are involved in collaborative projects, giving them a greater exposure to each other's tools of trade. Since Russell's seminal paper, archaeology has certainly carved for itself a greater niche in Byzantine Studies.[2]

We seem to have reached another turning point as new field and analysis methods promise to take us beyond the interpretations based on historical texts and archaeological evidence in a traditional sense. We owe this to the increasing level of interdisciplinary research in Byzantine Studies, from archaeoacoustics to climate modelling, network analysis, and digital humanities with its diverse sub-fields that offer new ways of collecting, (re)processing, and modelling different types of legacy data, as well as to new means of data collection through new innovative technologies. Byzantine scholars

1 In another paper in the same volume, J. Koder (1986) applied area planning theories of the nineteenth and twentieth century (Location Theory and Central Place Theory) to the study of Early Byzantine cities.

2 In the past two decades, seminal publications appeared on Late Antique and Byzantine archaeology. *The Late Antique Archaeology* series edited by L. Lavan has been published annually since 2003. K. Bowes's (2008) overview of the current state of Early Christian archaeology prompted the publication of the first handbook on the topic (Pettegrew, Caraher, Davis 2019). Meanwhile, M. Decker has been working on the first companion on Byzantine archaeology for the Cambridge University Press. For his commentary of recent developments in Byzantine archaeology, see Decker 2018.

are more and more interested in collaborating with a wider range of disciplines, such as remote sensing, computer science, landscape architecture, and paleoenvironmental sciences, the last mentioned being at the forefront of interdisciplinary endeavours in Byzantine archaeology and history (Izdebski, Mulryan 2019). This interest is reciprocal as researchers in non-humanities fields are equally inclined to produce, analyse, and present historical material. The bright new future promised by new technologies has already prompted self-reflection not only about the boundaries but also about the future of our field, our educational process, and the manner in which we assemble archaeological projects. Keeping our distance from the digital revolution does not seem to be a viable option anymore, especially after the Covid-19 pandemic. Instead, we need to be active participants in the redefinition of what we do, how we do it, and where we go from here. How does Byzantine studies, a notoriously old-fashioned field, adapt to these sea changes? What will be the contribution of Byzantine scholars to bridging the gap between disciplines and to making new connections?

Russell had underlined that historians, as non-specialists in archaeological and numismatic evidence, often relied on published conclusions rather than on the data that formed the basis of said conclusions, thereby overlooking the inherently interpretative quality of the results. Three decades later, this concern has assumed greater imperative as Byzantinists attempt to collaborate with scholars in disciplines that employ a contrasting range of methodologies, terminologies, research design, and publication culture. Archaeology has, time and again, incorporated methods from other disciplines. As such, one might argue that all archaeological projects are multidisciplinary by nature, regardless of whether they engage with sister fields, such as art and architectural history, numismatics, epigraphy, or with more distant disciplines, such as geology, remote sensing, or archaeometry. However, the fact remains that true interdisciplinary research is a goal that we often aspire to, yet seldom achieve. The concept of consilience, or the integration of the research methods of different disciplines to investigate similar questions, was addressed comprehensively by Adam Izdebski (Izdebski et al. 2016), John Haldon (Haldon et al. 2018), Michael McCormick (2011) and others, in the context of the relationship between climate and cultural change. Their interdisciplinary collaborations with paleoenvironmental scientists is significant not only for the results but also for the recommended guidelines for a successful collaboration between scholars and scientists of different research traditions and cultures.

In the study of Byzantine landscapes, the robust tradition of art and architectural history (not to mention, philology, history, and historical geography) inevitably gears the collaboration towards the humanities and social sciences, as opposed to the hard sciences or engineering. My paper is intended to offer a relevant case study of recent efforts to integrate novel methods to our small-scale archaeological survey investigation of a Late Antique islandscape in Rough Cilicia. In the long run, we aspire to be an example – hopefully a successful one – for the intellectual merger of survey archaeology and architectural history, with geology, remote sensing and Artificial Intelligence. The challenge before us is to actualise the consilience of fields like landscape archaeology and architectural history that operate within a framework of fragmentary data and imprecise chronologies, with the premium placed on accurate and precise data acquisition and processing by the field of engineering.

2 Byzantine Landscapes of Rough Cilicia. Remarks on the State of the Field

Field research in Rough Cilicia has witnessed a slow but steady growth since the 1960s. Elisabeth Alföldi-Rosenbaum's survey in coastal western Rough Cilicia was followed by her excavations at Anemurium (1962-67), which continued until the auspices of James Russell in 1971-87. Excavations have been carried out at urban centres both coastal (e.g. Antiochia at Cragum, Celenderis, Elaiussa-Sebaste) and inland (e.g. Diocaesarea, Olba); rural settlements (e.g. Kilisetepe); pilgrimage centres and churches (e.g. Alahan, Aphrodisias, Meryemlik). Archaeological surveys assumed different forms, including intensive and extensive pedestrian survey (e.g. Western Rough Cilicia, Göksu River valley), the documentation and mapping of settlements, watchtowers, churches and early Byzantine houses, architectural sculpture, inscriptions, and olive presses. By 2021, Rough Cilicia is no longer the *terra incognita* that it was a few decades ago.[3] However, despite the lively archaeological research and the rich Late Antique architectural heritage of the region, publications remain lagging even for a subject as commonplace to Byzantine architectural history and archaeology as churches. On the other hand, systematic landscape surveys – especially intensive pedestrian survey – are scarce.[4] While the body of knowledge obtained in Rough Cilicia dis-

3 A 2018 colloquium focused on Early Christianity mainly in central parts of Cilicia (Cortese 2020). The conference (2007) that had brought together specifically scholars of Rough Cilicia is already more than a decade old (Hoff, Townsend 2013).

4 The 2015 legislation of the Turkish Heritage Authority has initially banned, then severely restricted the collection of surface material, which has deeply affected field methodology. It should also be noted that survey permits have been mostly held by researchers trained in the old tradition of Classical Archaeology or Byzantine art history, which rarely include the theoretical framework and methodology for the study of landscapes in their curriculum or field practice. With the exception of a few international

plays geographical and material breadth, its chronology remains irksome, in large part because survey pottery, especially locally produced common and coursewares, and architectural features such as masonry, sculpture, and church forms lack the necessary stratigraphic *comparanda*. Furthermore, the scholarship on Rough Cilicia still needs an accurate and comprehensive documentation of settlements and their architecture, high-quality photographs, detailed descriptions of sites and landscapes, printed catalogues or preferably digital (geo)databases with comprehensive metadata.[5] Finally, novel methods of field documentation and analysis, and interdisciplinary collaboration beyond the usual partners such as archaeometry and geophysics remain limited in the scholarship of Rough Cilicia.[6]

3 Case Study. A Landscape Between the Coast and the Sea

The case study I will discuss in this paper is the Boğsak Archaeological Survey (2010-19, 2021) under my direction, that has investigated closely two coastal islands of the Taşucu Gulf, namely Boğsak (Asteria) and Dana (Pityoussa), and their mainland hinterlands **[fig. 1]**. The livelihood of these island communities deprived of water or significant agricultural resources was contingent upon their connectivity to nearby and/or distant places. Their most robust period of settlement activity occurred during late antiquity following the foundation of Constantinople. Our intensive pedestrian survey and architectural study on the small Boğsak Island (c. 7 hectares) suggests dense inhabitation from the late fourth into the late seventh/eighth centuries. Settlement seems to have survived in some form until the ninth or tenth century CE, or even into the twelfth century, although the latest phase may represent renewed activity on a drastically reduced scale (Rauh, Wohmann, Varinlioğlu forthcoming). Dana Island, the largest island of Rough Cilicia (c. 260 hectares) presents a more complex picture. The earliest occupation may go back to the sixth century

projects, scholarship on Rough Cilicia continues to be a traditional field with limited interdisciplinary collaboration.

5 The online pottery databases, initiated and led by Nicholas K. Rauh, first for the Rough Cilicia Archaeological Survey Project (RCSP), then for the Boğsak Archaeological Survey (BOGA) are the only examples of raw data made digitally accessible for Rough Cilicia: Autret et al. 2019; Varinlioğlu et al. 2020; Varinlioglu, Rauh, Pejša 2020.

6 The Rough Cilicia Archaeological Survey (RCSP) stands out with its paleoenvironmental research on deforestation and human occupation in the Roman period. See Akkemik et al. 2012; Karlıoğlu et al. 2016. More recently, two survey projects (including ours) in Rough Cilicia joined the interdisciplinary collaboration for the application of Optically Stimulated Luminescence (OSL) profiling for dating agricultural terraces, see Turner et al. 2021.

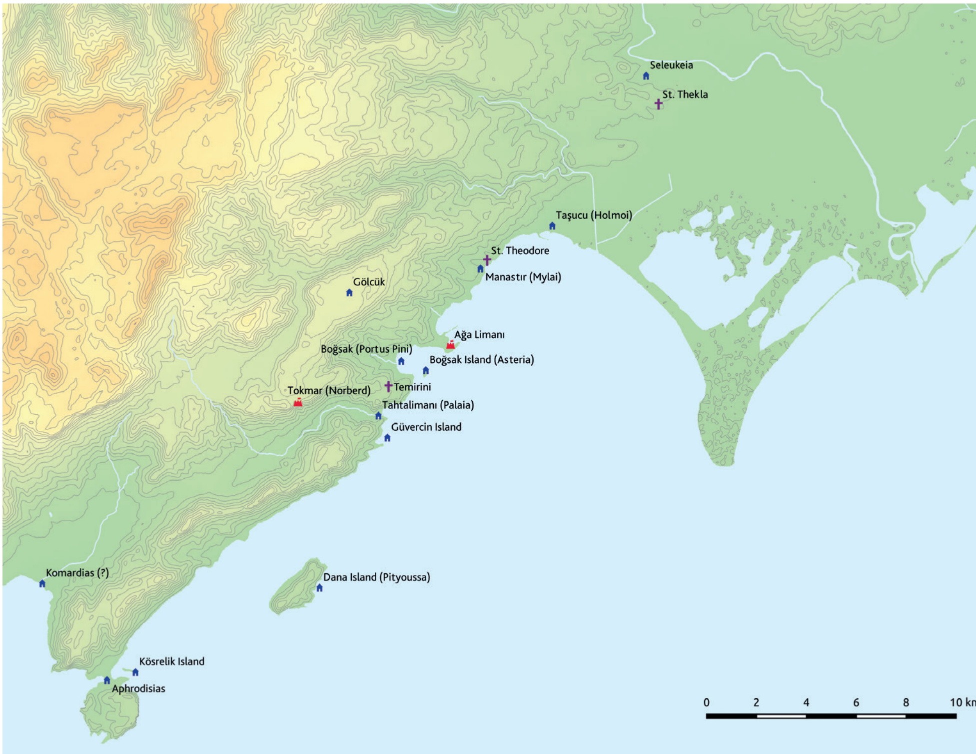
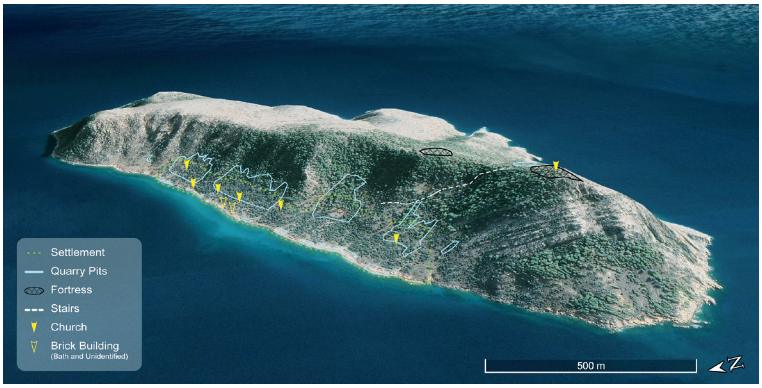


Figure 1 The Taşucu Gulf in Rough Cilicia (map: Kıvanç Başak)

BCE when two Iron Age ring forts, possibly serving as temporary military outposts, were built on its crest (Kaye, Rauh, Varinlioğlu 2020) **[fig. 2]**. The southern fort was reoccupied and modified in late antiquity when a church with a subsidiary chapel (perhaps added in a later phase) was built within the preexisting fortifications. The main settlement developed along the western shore and slopes of the island, which witnessed limited occupation in the Early Roman period, yet grew into a large maritime settlement (c. 10 hectares) during late antiquity, with a peak period of activity in the fifth and sixth centuries, contemporaneous with the settlement on Boğsak Island. Across the lower settlement, dozens of stone-built structures, including a coastal bath, houses, six churches (probably fifth-sixth centuries) were organised on wide terraces. For other nondescript structures, we may infer general functions that one would expect to find at a maritime community site, including hostels, shops, and warehouses (Varinlioğlu et al. 2017).



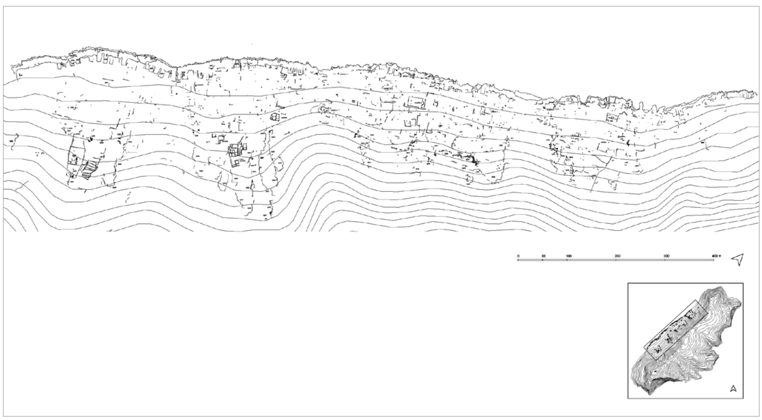


Figure 2 Google Earth Image of Dana Island showing the two settlements, quarry areas, and major buildings (church, bath, residential complex) (image: Hilal Küntüz)

Figure 3 The plan of the lower settlement and quarries on Dana Island (drawing: Nihan Arslan, 2019; image: Hilal Küntüz)

The most noteworthy characteristic of the island is its immense limestone quarries cutting directly through building remains along the shore and extending inland through the settlement to the slopes behind **[fig. 3]**. Still other quarry cuts have been identified preliminarily on the eastern side of the island below the summit (c. 250 metres above sea level) but not far from the upper settlement. Along the shoreline of the settlement, are several rectangular, sloped surfaces located side by side (Jones 2021). These rock-cut areas extending to the water's edge may have been used as loading ramps to slide stone blocks down to the shore where they could be loaded onto boats. This is not the only coastal quarry landscape in the region, but it is the largest and the only one undeniably associated with a settlement. Supported by the island's connectivity, the settlement of Pityoussa on Dana Island presents itself as a rare example for the study of the quarrying industry of utilitarian building material.[7]

4 Isaurian Builders. From Texts to Remote Sensing

In his article entitled "Isaurian Builders", Cyril Mango (1966) introduced our scholarship to the existence of construction workers who probably originated from Isauria (Rough Cilicia), yet, who were identifiably the builders of choice across the Byzantine empire during the latter part of the fifth century (from the 490s to the 560s CE). He underlined the recurring mention of Isaurian architects, masons, construction workers, and workshops active in North Syria, Palestine, and Constantinople.[8] Scholars have subsequently searched for the handiwork of these builders in architectural remains at home and abroad.[9] The Basilica A in Resafah-Sergiopolis and Qalat Siman in North Syria (Castelfranchi 2007), the church at Tomarza in Cappadocia (Hill 1975), and Theoderic's mausoleum in Ravenna (Deichmann 1974, 230-3) were tentatively associated with the presence of Isaurian builders and pilgrims. Isaurian building know-how seems to have also been put into use in the Byzantine army (Procopius, *The Wars of Justinian* 5.9.11-21, 6.12.6, 6.27.5-8 [transl. Dewing and ed. Kaldellis 2014]; Elton 2000). As the most skilled master builders on the market, Isaurians were known to charge exorbitant fees for their services (Zanini 2007). The emergence of Isaurian crews as experienced construction specialists coincided with the ambitious building activity across Isauria after the fourth century CE, and especially during the fifth and sixth centuries. The epigraphic record from the province has also revealed a wide range of wealthy architectural professionals, such as architects, (master) builders, stone-cutters, contractors, carpenters, and marble workers (Trombley 1987). The

7 Our rough calculation suggests that quarry pits covered at least c. 7.5 hectares, while the industrial area (including work surfaces, spoil dumps, ramps) reached at least 16 hectares. This brings to mind other industrial sites such as the Early Byzantine marble quarries of Aliki on Thasos, or the much larger and more complex Roman imperial quarries at Mons Claudianus and Mons Porphyrites in Egypt.

8 In *The Life of Saint Sabas* two Isaurian *architektones* were responsible for the construction of the saint's lavra between Jerusalem and the Dead Sea (494-550). The *Life of St. Martha* and *the Life of St. Symeon Stylite the Younger* (541-58) describe the work of Isaurian quarrymen, masons, architects, workshops, and unskilled workers, employed or volunteering in building projects in and around Antioch. Isaurians were also mentioned in the reconstruction of the dome St. Sophia after its partial collapse in 558. For detailed discussion of textual evidence, see Mango 1966; further elaborated in Magoulias 1976.

9 The vast settlements with their churches across Rough Cilicia may represent the work of Isaurian builders at home. For examples, see Dagron, Callot 1998.

ateliers that were responsible for these stone-built structures comprised skilled artisans who excelled in the construction of arches, vaults, and domes, such as those we have documented on Boğsak and Dana Islands. These workshops must also have included unskilled or low-skilled labourers, employed in tasks such as digging trenches, cutting quarry channels, removing debris, mixing mortar, and transporting stone blocks. The necessary building material was quarried directly at or in the vicinity of the construction site, or more rarely, it was transported from further afield.[10]

In this context, the limestone quarries on Dana Island pose the question whether or not the island functioned as an industrial settlement servicing the work of Isaurian builders. The study of Dana Island presented two main challenges: First, how does one model a terrain heavily modified by human action via quarrying and building? Second, how could one date the quarries? The preponderance of the material evidence for quarrying and stone transport, and the low visibility of the remains due to dense vegetation pose major impediments. Even though a considerable number of quarry faces are visible along and through the slope behind the settlement **[fig. 4]**, except for the remains along the coastline, the settlement itself cannot be studied short of the removal of several hectares of dense vegetation that hides the remains.[11] To calculate the total area and volume of quarrying, to entangle the spatial and temporal relationship between quarry zones and the settlement, and to understand the transformation of the natural terrain into a highly-modified industrial area, methodologies such as traditional mapping, aerial photogrammetry, Terrestrial Laser Scanning (TLS) – all of which we had successfully deployed on both islands – simply proved inadequate. Our logistical, environmental, labour-intensive, and financial challenges necessitated new tactics employing novel methods of data collection, analysis, and modelling. Given the availability of more advanced technologies, we knew that we could raise more cogent questions about the transformation of the terrain, the capacity of the quarries, and the energy consumption required by quarrying activities. To this end, our collaborator, Professor Nicholas K. Rauh of Purdue School of Languages and Cultures, was able to connect our project with the ROSETTA Ini-

10 Ordinary materials such as lime and sandstone often travel regionally. Stone transport exceeding 20-30 kilometres distances is significantly cheaper than land transport, especially on the difficult terrain of Rough Cilicia. Cargoes of ordinary stones have not yet been discovered along the south coast of Asia Minor. For Late Antique Eastern Mediterranean, the existence of stone trade in building stones (not marble) is attested by the fifth–sixth century Dor 2001/1 wreck off coastal Israel carrying sandstone (Mor, Kahanov 2006) Stone transport in the Roman period has been thoroughly studied by Russell (2013a; 2013b).

11 The island is a protected archaeological and natural site.

Figure 4 Orthophoto of one of the major quarry zones on Dana Island (orthophoto: Kıvanç Başak, 2018)

tiative under way at the College of Liberal Arts at Purdue University. Initiated by Dr. Sorin Matei, Associate Dean for Research, ROSETTA stands for Remote Observation and Sensing Technologies and Techniques in Archaeology or AI enabled humanities.[12] The first and main component of this collaboration entailed airborne LiDAR and aerial photogrammetry, carried out during the 2019 field season by a team led by Professor Ayman Habib of the Purdue College of Engineering. The processing of this data will also entail AI inverse modelling and design in collaboration with a team led by Professor Daniel Aliaga of the Purdue College of Computer Science. A second collaboration concerned geological sampling to date the quarries, a project undertaken by Professor Darryl Granger and his PhD student Angus Moore at the Purdue College of Earth, Atmospheric, and Planetary Sciences.[13]

5 Airborne LiDAR. Modelling the Industrial Settlement and Its Quarries on Dana Island

LiDAR (Light Detection And Ranging) is a non-invasive remote sensing technology that uses laser scanners to collect 3D geospatial data to map natural and man-made features and landscapes. Widely used since mid-1990s in geosciences, it has gained ground in archaeological projects in the past decade, especially in landscape archaeology.[14] Terrestrial Laser Scanners (TLS) mounted on a tripod, a platform, or a vehicle, are commonly used to generate 3D documentation of architectural remains as these offer better spatial resolution and accuracy than aerial systems. Airborne LiDAR mounted on airplanes or more recently on Unmanned Aerial Vehicles (UAV)'s, are employed for mapping sites and landscapes which have larger spatial coverage. The ad-

12 The ROSETTA Initiative may be reached at https://www.cla.purdue.edu/research/rosetta-initiative/index.html.

13 This collaboration would not be possible without the support of Sorin A. Matei, Associate Dean of Research at the College of Liberal Arts at Purdue University. The 2019 and 2021 fieldwork was financed by the following grants: Seed Grant of the Office of the Vice President of Research at Purdue University (2019); Koç University GABAM Fieldwork Grant (2019); Mimar Sinan Fine Arts University Research Fund (2019); Mary Jaharis Center Project Grant (2021); Mersin Metropolitan Municipality Fieldwork Grant (2021). The LiDAR analysis is currently supported by Purdue University's Humanities without Walls (HWW) Seed Grant (May 2021). The AI project received the grant of the NSF Division of Computer and Information Science and Engineering (no. 2032770, July 2020), "EAGER: Minimal 3D Modeling Methodology, Modeling Ancient Settlements in South Coastal Anatolia" (D. Aliaga, PI; N.K. Rauh and G. Varinlioğlu, co-PI's).

14 For a comprehensive overview of the history of air and space-based remote sensing methods used in archaeological research, see Luo et al. 2019. The use of LiDAR in archaeology is beyond the scope of this paper but the following publications may be consulted for technical introductions for non-specialists: Opitz, Cowley 2013; Chase, Chase, Chase 2017; Crutchley, Crow 2018.

vantage of the latter lies in its capability to cover large swaths of terrain and to enable the discovery and/or mapping of features through dense vegetation cover and even underwater. The laser pulses emitted by the scanner penetrate the foliage; thus, measuring every single surface they hit, including the canopy, archaeological features and the terrain that lies underneath, provided, that is, that the foliage is sufficiently patchy. Airborne LiDAR produces a point cloud that must undergo enhancement procedures of filtering and classification, followed by visualisation in order to be useful for archaeological interpretation.[15] While the analysis and visualisation of the data is often carried out by remote sensing professionals, the archaeologists familiar with the terrain and the subject matter are expected to judge the validity of the featural results revealed by the analysis. The visual interpretation by the archaeologist – often aided by GIS – is a method that is still considered more reliable than (semi)automatic detection techniques such as image enhancement; however, the knowledge, capability, and biases of the archaeologist also play a significant role in the final results (Luo et al. 2019, 22-3). Meanwhile, research on machine-learning methods to increase the accuracy and reliability of automatic identification has also made significant advances, offering the potential to reduce the amount of human effort, and hence the cost to evaluate big data that are measured in terabytes and occasionally even in petabytes. At the same time, machine-learning, in which “digital device and/or technological agency is to exceed human agency” (Huggett 2021, 427) might be the most extreme form of black boxing as archaeologists have limited capability to comprehend or control its techniques.[16]

The remote sensing survey on Dana Island used a mobile mapping system custom-built at Purdue University and mounted on site on a high-end drone.[17] The mapping system consisted of a high-resolution topographic laser scanner, a Global Navigation Satellite System/Inertial Navigation System (GNSS/INS), and a high-resolution, full-frame DSLR camera for Red-Green-Blue (RGB) 2D imagery.[18] The

15 Filtering methods and classification parameters are determined based on the characteristics of the territory scanned with the LiDAR. Archaeologists often depend on various visualisations of these numerical datasets, which make them human-readable. About the visualisation of the raster data, see Kokalj, Hesse 2017.

16 Regarding automation in remote sensing, see Opitz, Herrmann 2018; for an earlier discussion about automation versus manual interpretation, see Bennett, Cowley, De Laet 2014.

17 The LiDAR team carried out five flight missions in three days during the 2019 campaign. The team members were, Ayman Habib (PI), Evan Flatt (drone operator), Günder Varinlioğlu and Nicholas Rauh (field consultants).

18 The models of the equipment are as follows: DJI Matrice 600 Pro hexacopter (UAV), Velodyn VLP-32C Ultra Puck (Laser scanner), APX-15 UAV V2 (GNSS/INS), Sony Alpha ILCE-7R camera (36.4 MP resolution) with a fixed lens. For a detailed discussion

LiDAR and imagery data, collected simultaneously by this system, were georeferenced using the coordinates provided by the on-board GNSS. Thus, it was possible to match details in the photographs with those acquired by the laser scanner and vice versa.[19] Airborne photographs serve two purposes: first, high-resolution, georeferenced, and accurate (1 centimetre) orthophotos can be created for each flight; second, the point cloud created by laser scanning may be coloured using the RGB values recorded in the photographs. The result of the latter is a colour-coded and georeferenced Digital Surface Model (DSM) that looks very close to what the eye perceives **[fig. 5]**. Laser beams are mostly reflected off the vegetation, which means that the point cloud data documents foremost the canopy itself. For Dana Island, however, because the tree and shrub cover are relatively patchy, LiDAR collected a considerable amount of data about the terrain and the archaeological remains below, enabling the production of a reliable Digital Terrain Model (DTM) and as many profiles as we may need **[fig. 6]**.

One of the common misconceptions about LiDAR for the general public is that it functions as a sort of X-ray which automatically removes the canopy impeding clear sight. In fact, the different types of data collected by the field team on-site and the detailed knowledge of the landscape are crucial for interpreting the settlement and the features that lie under the vegetation as well as for reconstructing the topography of the island at high resolution. After several campaigns of extensive survey and mapping on the island (2016-19, 2021), our field team has acquired an intimate knowledge and record of the terrain, the vegetation, and the archaeological remains. Our dataset on physical features (buildings, quarries, ramps) was obtained through various formats and scales, including plans, elevations, and sections drawn by hand on paper and measured by GNSS-CORS units, tape measures, laser metres; a comprehensive photographic documentation; Structure-from-Motion data for quarries and select objects, TLS data for a single building complex, and field notes. The airborne LiDAR point cloud and georeferenced 2D imagery complement and contextualise in 3D the data already acquired through field survey and will help to resolve the discrepancies between different types and scales of data.

of the technical aspects of the equipment, the LiDAR survey and preliminary results, see Lin et al. 2019.

19 The I-LIVE software, currently under development by a team led by Ayman Habib, allows users to have simultaneous access to photographs and the coordinates measured by the scanner.

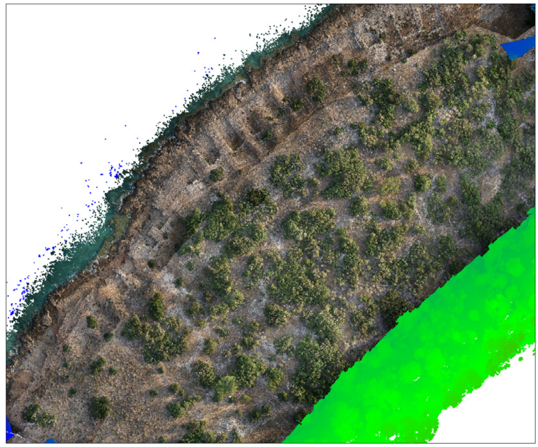


Figure 5
Digital Surface Model (DSM) of Mission 1 on Dana Island, colour-coded using the RGB data from the orthophoto (image: Yi Chun Lin and Ayman Habib; drone operator: Evan Flatt, 2019)

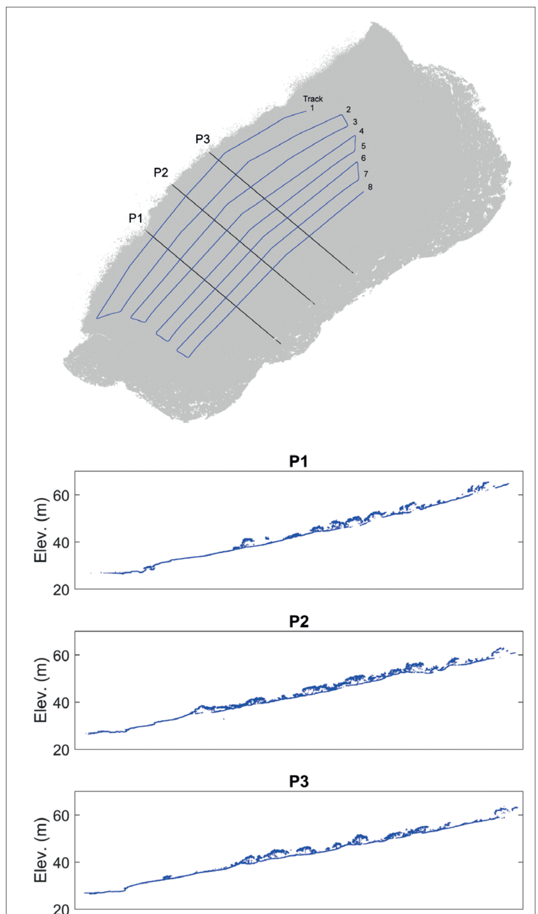


Figure 6
Surface profiles created using the LiDAR point could for Mission 1 on Dana Island (image: Yi Chun Lin, Ayman Habib)

6 Dating Quarrying Activity on Dana Island

Dating quarries is notoriously difficult. First, quarrying technology shows a remarkable continuity until the introduction of modern industrial practices. Toolmarks occasionally help with general periodisation, such as the festoon-like marks created by the heavier pick introduced at the end of first-beginning of second centuries CE. These are actually quite common across Dana Island. The entire range of tools used in stone extraction can rarely be identified because quarries were used either over sustained periods of time or intermittently during different eras, thereby, eliminating the evidence for earlier phases. Furthermore, extraction and working techniques depend heavily on the physical properties of the stone, such as its stratification, hardness, and splitting patterns, all of which make periodisation even more challenging. The debris resulting from the quarrying activity is not stratified; thus, datable material such as potsherds demonstrate only that the quarry was functional at a particular given time. Mason marks and graffiti inscribed on the quarry faces or on the extracted material may also provide chronological *termini*. Similarly, the destination of the material extracted from a particular quarry may help date the quarrying activity (Waelkens, De Paepe, Moens 1990; Fant 2008; Russell 2013a, 81-2).

Dating the quarries of Dana Island is further complicated by the fact that the extracted material was suitable only as ordinary building stone and simple architectural sculpture like those preserved in the churches of the island. We have not come across any inscriptions, graffiti or other symbols at any of the quarries. The dates suggested by the intensive pedestrian survey, also correlating with the Christianisation of the landscape, provide a rough chronology for the development of the settlement but the question how this relates to the quarrying phases does not have a straightforward answer. The buildings, if datable, would provide *termini ante quem* for the quarries lying directly underneath or in very close proximity. Unlike Boğsak Island where almost all the structures employed mortar-bound small stonework of roughly hewn, rectangular stones (Varinlioğlu, Esmer 2017), the buildings on Dana Island display a variety of masonry styles. Larger stone blocks bound with little or no mortar are more common across the lower settlement. This does not necessarily suggest a different chronology (such as Early Roman as opposed to Early Byzantine); instead, this might reflect the practices of the quarrying industry on the island and the properties of the native stone types (Varinlioğlu, Esmer 2019). The rocky outcrops rising above and extending beyond the settlement consist of true limestone like in Boğsak. This is a denser, hence heavier stone that is hard to cut into large pieces as it may easily break along natural fractures and bedding planes. However, the quarries themselves and the building blocks of the structures often belong to a geological formation known as clastic limestone or limestone alluvium. This type of limestone has significant porosity and is lighter in weight than true limestone.[20] As such, it is easier to cut, lift, and move large blocks of clastic limestone. In addition, the existence of a quarrying industry with experienced quarrymen and lifting equipment and know-how may have facilitated the production of larger blocks.

Operating within the limits of the survey places, we have sought alternative methods that might help us understand the phases of quarrying on Dana Island. Darryl Granger suggested the method of Cosmogenic Nuclide (^{36}Cl) exposure analysis that is used elsewhere to date geomorphic features (e.g. river terraces, fault scarps). This method measures the accumulation of very rare nuclides that are produced by cosmic ray particles passing through mineral grains of the rocks exposed in the upper few metres of the ground surface. By measuring the concentration of ^{36}Cl (according to its recognised calibration), it is possible to determine the length of time surfaces, such as quarry faces, have been exposed to cosmic rays. In ideal conditions, the precision of the dating is +/-250 years. During the 2019 campaign, Angus Moore collected twenty-six samples from nine quarries, four along the coastline, and the remaining five inside and beyond the settlement. So far, we have the preliminary results of the analysis of a single coastal quarry near the southern end of the industrial area of the island (DA-250), which gave a mean quarry age of -1600 +/- 1950 (1σ) before present. Following a Bayesian inference of probability, this large temporal interval may be constrained using two types of priors independent of the dates provided by the analysis. In the first model, since the quarries were excavated before the present day, one may give all ages in the past uniform probability, while assigning zero probability to future ages. In the second model, one may use the overall chronological span of the pottery recorded by the intensive pedestrian survey, as a way to render uniform probability to all the periods between 1200 BCE and 1400 CE. The Bayesian interpretation (using either model) furnishes a narrower probable date range between 550 and 1180 CE. In the second model which relies on the pottery prior, the median probability age would be 760 CE and the mean age 570 CE (Moore, unpublished research report).

The results of these preliminary analyses have, thus, introduced our team to the sampling, analysis, and interpretative methods used

20 Alluvial fans are geologically younger than the limestone bedrock of Dana Island, which may be observed at higher elevations. Through erosion, the exposed bedrock accumulated and cemented by secondary calcium carbonate (caliche) in alluvial fans (Moore, e-mail to Varinlioğlu, 23 September 2019).

by two vastly different disciplines. Although the dates obtained by archaeologists using pottery, masonry, architectural sculpture, church forms, and texts may lack precision and complex statistical models, as we come to understand the analytical and interpretive methods of these other disciplines, we should be able to combine the different types of data into a more rigorous statistical model, one capable of placing our suggestions for the dating of the quarrying and the settlement on Dana Island on firmer ground.

7 Where Do We Go from Here?

Our small research team comprising archaeologists, earth scientists, and remote sensing and machine-learning engineers, is still its initial phases of deploying new field and analysis methods for the collaborative study of (Byzantine) landscapes in Rough Cilicia. In this paper, I laid out the beginnings of an interdisciplinary collaboration that research teams separated by space and time are trying to sustain after a successful field campaign two years ago. The Covid-19 pandemic suspended the lab analysis, access to computer facilities and libraries for over a year. Although this long hiatus is slowly coming to an end, the financial and institutional repercussions of the pandemic will continue to affect interdisciplinary collaboration especially when it involves research partners from multiple countries with different institutional schedules, expectations, and infrastructure.

This is by no means the first instance of a collaboration between archaeology, engineering, and earth sciences, but it is unusual for survey projects in Turkey, likewise, in Byzantine Studies. Landscape archaeologists have already appealed to “break down the boundaries within and between disciplines” (Turner 2013, 139). In Byzantine (landscape) archaeology, novel field methods, new technologies and digital tools, including machine-learning, encourage us to push the temporal, theoretical, and methodological boundaries of our fields. As Byzantinists where do we stand on this matter? Byzantine Studies still abides by the scholarly tradition in which the command of ancient and medieval languages continues to be central, while at the same time, there is an increasing demand for researchers proficient in new technologies and methods. Also, as interdisciplinary collaboration takes a greater share in research agendas and as the data exponentially increases with new field methods, there is growing demand for publishing the raw data and detailed final reports that include a description of the evidence alongside the interpretation of this data (Izdebski et al. 2016, 13; Lavan 2015, 7).

Thirty years ago, Russell had warned us about the need to communicate the limitations of the archaeological evidence:

> For while historians are all too conscious of the fragmented and imprecise character of the literary sources that are their stock in trade, they seem to be less aware, and certainly less critical, of similar failings in the archaeological evidence. Of particular concern is a tendency to invest archaeological and numismatic evidence with a decisiveness, especially in matters of chronology and causation that it cannot provide. (Russell 1986, 138)

To this I would add that the scrutiny we have learned to apply to historical and archaeological evidence must now be expanded and adapted to address the results obtained from our collaborations with new disciplines. In the case study I have presented, archaeologists need a basic scientific literacy, including a working knowledge of remote sensing, machine-learning, geological dating, and statistical modelling, and at the same time scientists must be willing to learn about the uncertainties of archaeological data and the interpretative complexities of humanistic and social sciences. This hurdle is harder to overcome than the one posed by technological or digital infrastructure, because there are fewer resources and less allocated time for the kinds of training, brainstorming, and intensive communication that it requires.

As we try to bridge the gap between disciplines, the gap between practitioners in our fields is widening alarmingly due to the discrepancy in the digital, logistical, technological, and human infrastructure. Small projects and institutions are finding it harder and harder to find the needed financial and technical support as ground-breaking field methods, impressive visualisations in mixed reality, new digital platforms and databases requiring super computers, take over the scholarly landscape and are expected to be available in all projects.[21] Among them, remote sensing and machine-learning receive a lot of attention, as institutions like the National Geographic pump up the hype over the 'discovery' of hidden features which generation after generation of archaeologists supposedly could not achieve (Clynes 2018; response in Smith 2018). In fact, the various methods that we borrow or rather use in collaboration with other disciplines are not magical solutions (Joyce 2012). Airborne LiDAR data does not automatically remove the vegetation; Cosmogenic Nuclide Exposure does not easily provide absolute and precise dates for the quarries. The analysis, whether manual, automated, or by machine-learning, requires archaeological and historical knowledge acquired by field archaeologists following the robust methodologies of their discipline.

21 The critique of digital archaeology has become more vocal in the past five years. My discussion was informed foremost by the following works: Huggett 2015; Caraher 2016; Kersel 2016; Rabinowitz 2016.

Ultimately, we will have to synthesise old and new evidence having different degrees of precision and scale. Isaurian builders recorded in texts offer a chronological precision down to half a century, and a trans-regional geographical distribution, but we are not even sure what the term 'Isaurian' signifies. Architectural data, especially from the churches, may narrow the construction at a certain area of the island down to a few centuries. Surface pottery has a large temporal coverage but little geographical precision, even though it extends the connectivity of the island across the Mediterranean. Although the geological analysis may eventually result in absolute dates down to +/-250 years; for the time being, the probabilistic models need archaeological evidence that are likewise imprecise and uncertain. To interpret the LiDAR data with its empty or obscure patches, we use another kind of incomplete data collected by the field teams. McCormick's (2011, 255) remark on the collaboration between climatologists and historians is valid also for us: "Scientists, it turns out, need historians and archaeologists as much as historians and archaeologists need scientists".

As we use the tools and methods offered by advanced technologies created, mastered, and shared by collaborating disciplines, the necessity for a critical approach to data collection, its manipulation by humans or machines, its representation, and interpretation, ultimately falls upon scholars in the humanities and social sciences. While recognising the challenges posed by the need to balance human and technological agency and autonomy,[22] we still believe that our interdisciplinary collaboration with the Earth Sciences, Remote Sensing and AI science, is crucial to our effort to generate multiple hypothetical models for the transformation of Dana Island into a complex archaeological landscape. Alternative models, created by machine-learning, human agents, and interdisciplinary collaboration will hopefully enable us to write multiple narratives, which can be modified, updated, or refuted through further research and analysis. This might be the hook that will connect architectural history, landscape archaeology, earth sciences, LiDAR, and Artificial Intelligence.

22 I refer specifically to the discussions by Huggett 2021, esp. 428-9. Our team insists upon digital augmentation rather than full automation. Archaeologists are willing to share the agency but not yield the authority to digital technology.

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