Set in stone: the role of natural resources in building culture in civilizations

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1 Introduction

Availability of natural resources facilitates state investment into public goods and culture either via indirect financing from the revenues of selling the resources, or directly using the resources themselves to build infrastructure.

This study investigates how access to natural resources in the ancient Mediterranean region may have played a role in cultural investment and enforced state presence. The primary natural resources in question are stones from stone quarries, a type of open mines built to extract rocks and minerals. I hypothesize that spatial variation in the presence of stone mines is connected to presence and spatial distribution of cultural infrastructure, such as theatres, temples, churches, sanctuaries, and amphitheatres in Roman world.

Control over natural resources has long been a cornerstone of state power, serving as both an economic asset and a tool of political authority. The extraction and distribution of stone not only funded public works but also projected state legitimacy through monumental construction. Quarries functioned as hubs of economic activity, employing labor, stimulating trade, and enabling the state to commission architecture that symbolized its dominance. In this way, resource wealth was not merely a passive advantage but an active instrument of statecraft, consolidating territorial

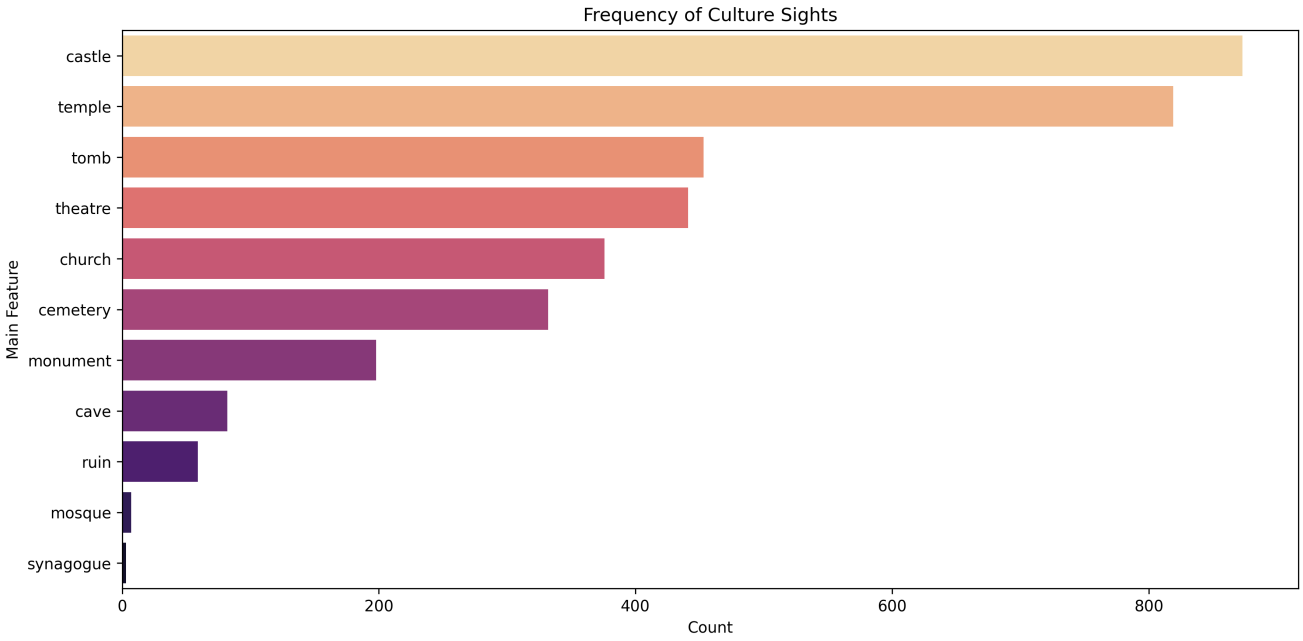

Figure 1: Types of culture sights in the ancient Mediterranean region

control, fostering civic identity, and displaying imperial grandeur. By examining the link between quarries and cultural infrastructure, this study sheds light on how material resources underpinned the geopolitical and ideological ambitions of ancient states.

2 Data

The dependent variable is the number of cultural sites defined as theatres, amphitheatres, churches, temples, and sanctuaries located in a given region. These cultural sites are derived from the Pleiades (2025) dataset, a collaborative project of the Institute for the Study of the Ancient World at New York University and the Ancient World Mapping Center at the University of North Carolina at Chapel Hill, which provides a comprehensive database of the ancient ancient world. The main independent variable is the quantity of stone quarries, it is taken from B.J. Russell's Gazetteer of Stone Quarries in the Roman World (Russell (2013)), a systematically compiled database documenting Roman-period extraction sites. Overall data information concerning the Ancient Mediterrain region is taken from Project Mercury (2025) collecting data for computational modelling in Roman Studies.

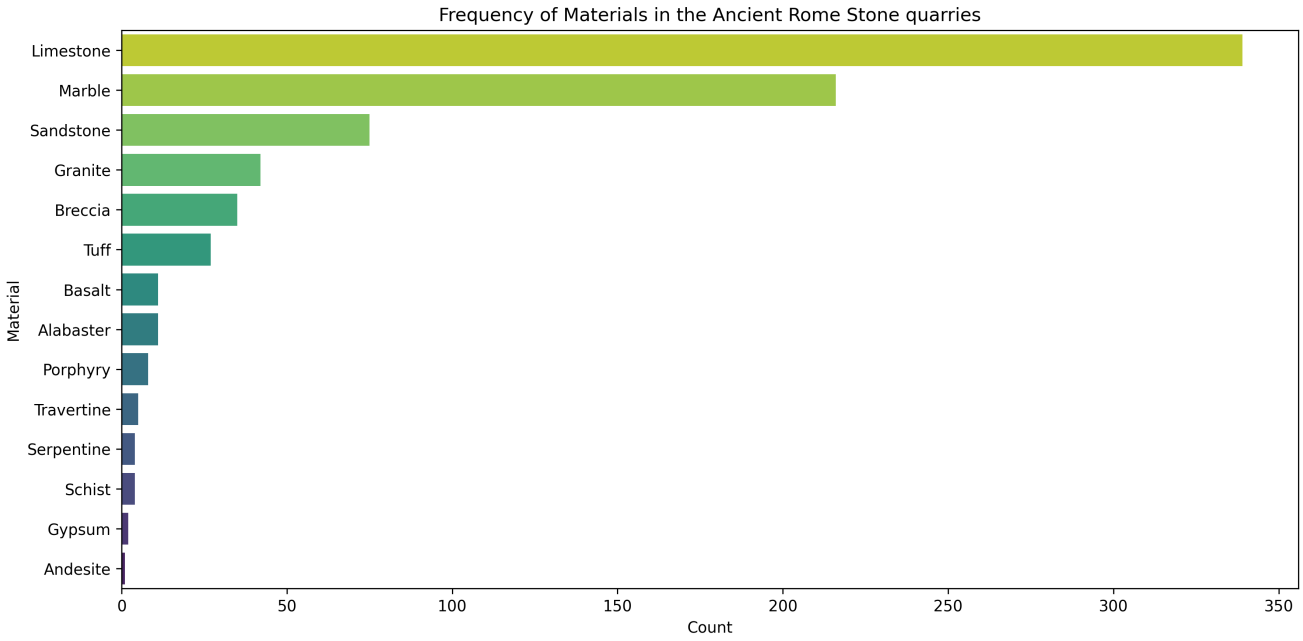

Figure 2: Types of natural resources in stone quarries in the ancient Mediterranean region

Figures 1 and 2 show what types of culture sights and stone materials are present in the data. Maps in Figures 3 and 4 illustrate geographic distribution of resources and cultural objects.

Figure 5 shows the locations of stone quarries. Figure 6 overlays settlement sites on top of quarry locations. Figure 7 adds cultural sites such as temples, sanctuaries, amphitheaters, and churches. Figure 8 integrates all three elements of resources, settlements, and cultural infrastructure into a single map.

The figures illustrate a central concept of the study: access to natural resources can reinforce economic activity, attract settlements, and empower states. In the Roman context, the ability to extract and mobilize stone facilitated monumental architecture, which not only showcased the state's presence and administrative control but also embodied imperial ideology. Infrastructure and identity co-evolved with access to material resources, offering a spatial account of how resources can shape civilizations.

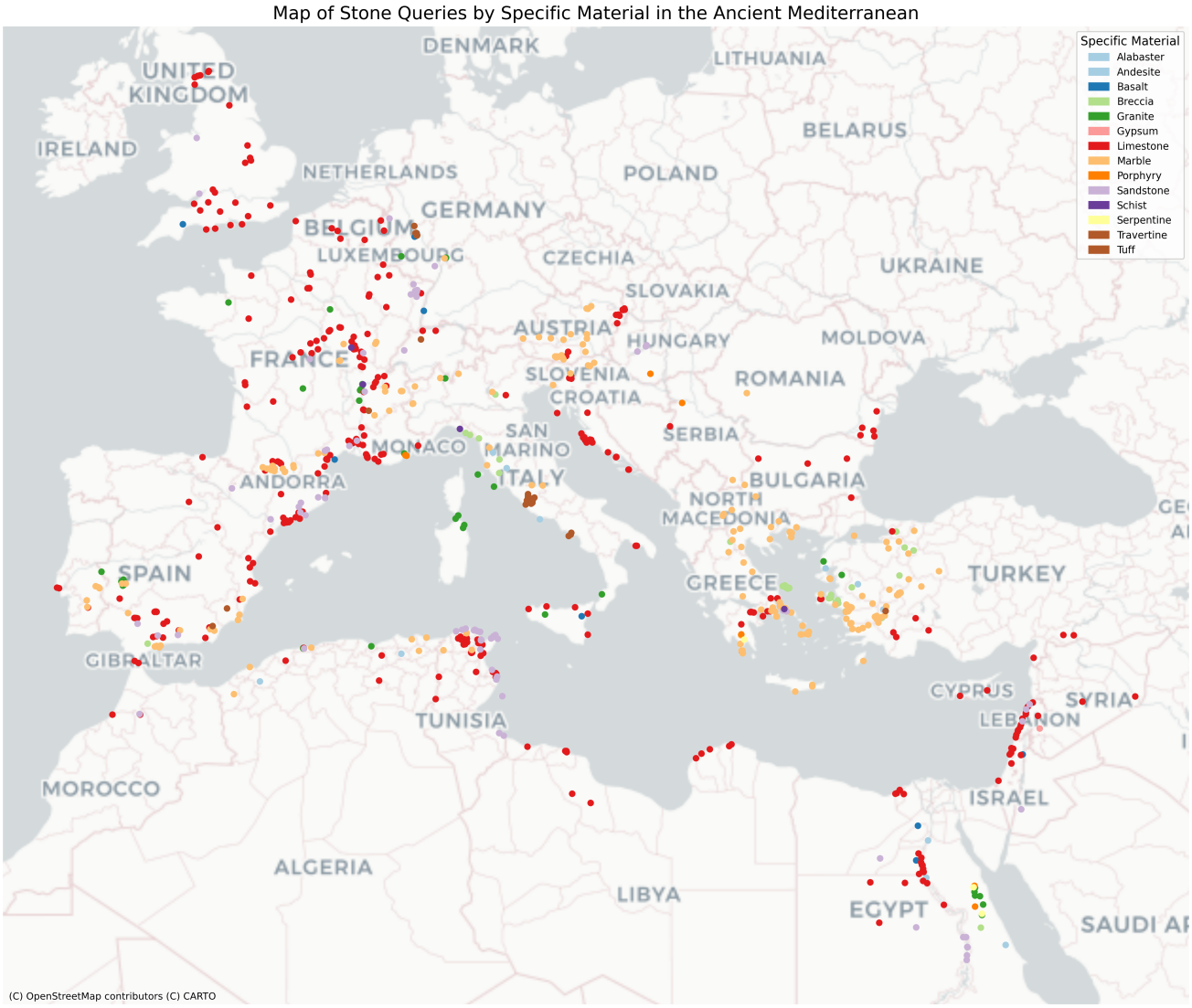

Figure 3: Map showing location of different resources

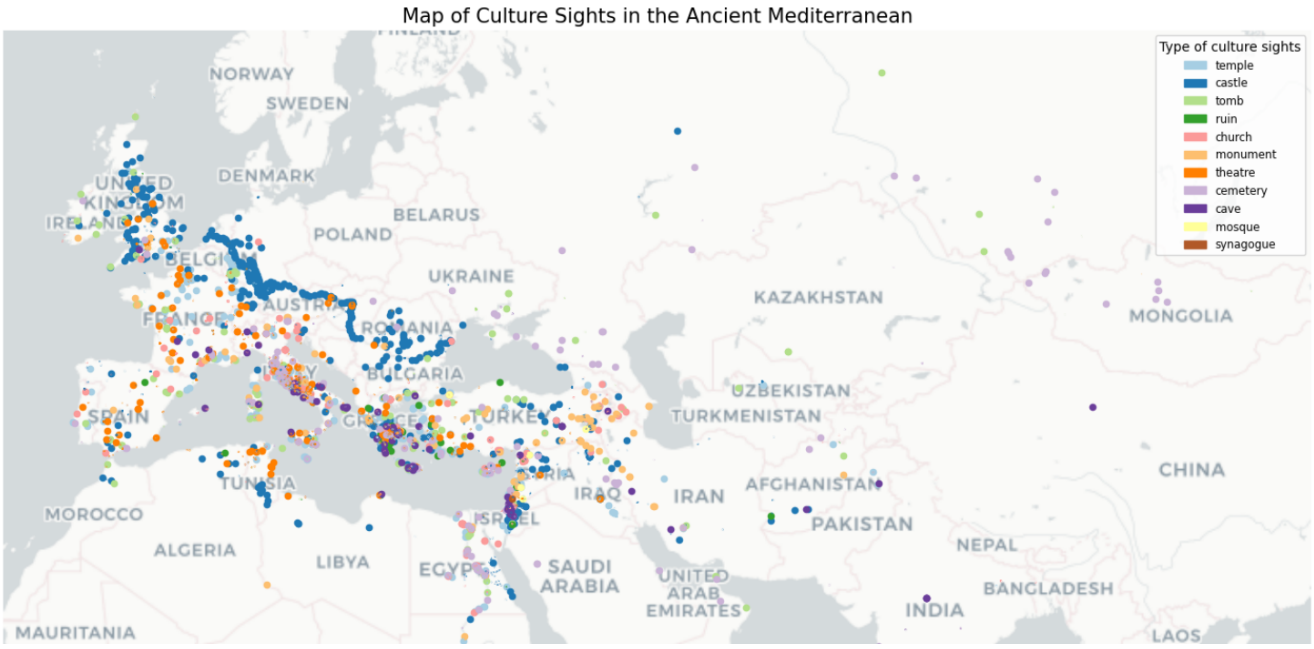

Figure 4: Map showing location of different culture sights

3 Research methodology

To examine the relationship between access to construction resources and the spatial distribution of cultural infrastructure in the Roman world, I employed a grid-based geospatial analysis. First, I divided a map into square cells measuring from 5 km × 5 km to 50 km × 50 km. Using this grid, I counted the number of cultural sites and stone quarries in each cell. I then estimated an OLS regression model where the count of cultural sites per cell was regressed on the number of stone quarries, with robust standard errors, to assess whether access to local building material correlated with higher investment in cultural architecture. Figure 9 shows an example of a geospatial grid approach.

$$\text{Quantity of culture sights}_i = \beta_0 + \beta_1 \cdot \text{Quantity of stone quarries}_i + \varepsilon_i \tag{1}$$

Figure 5: Location of stone quarries

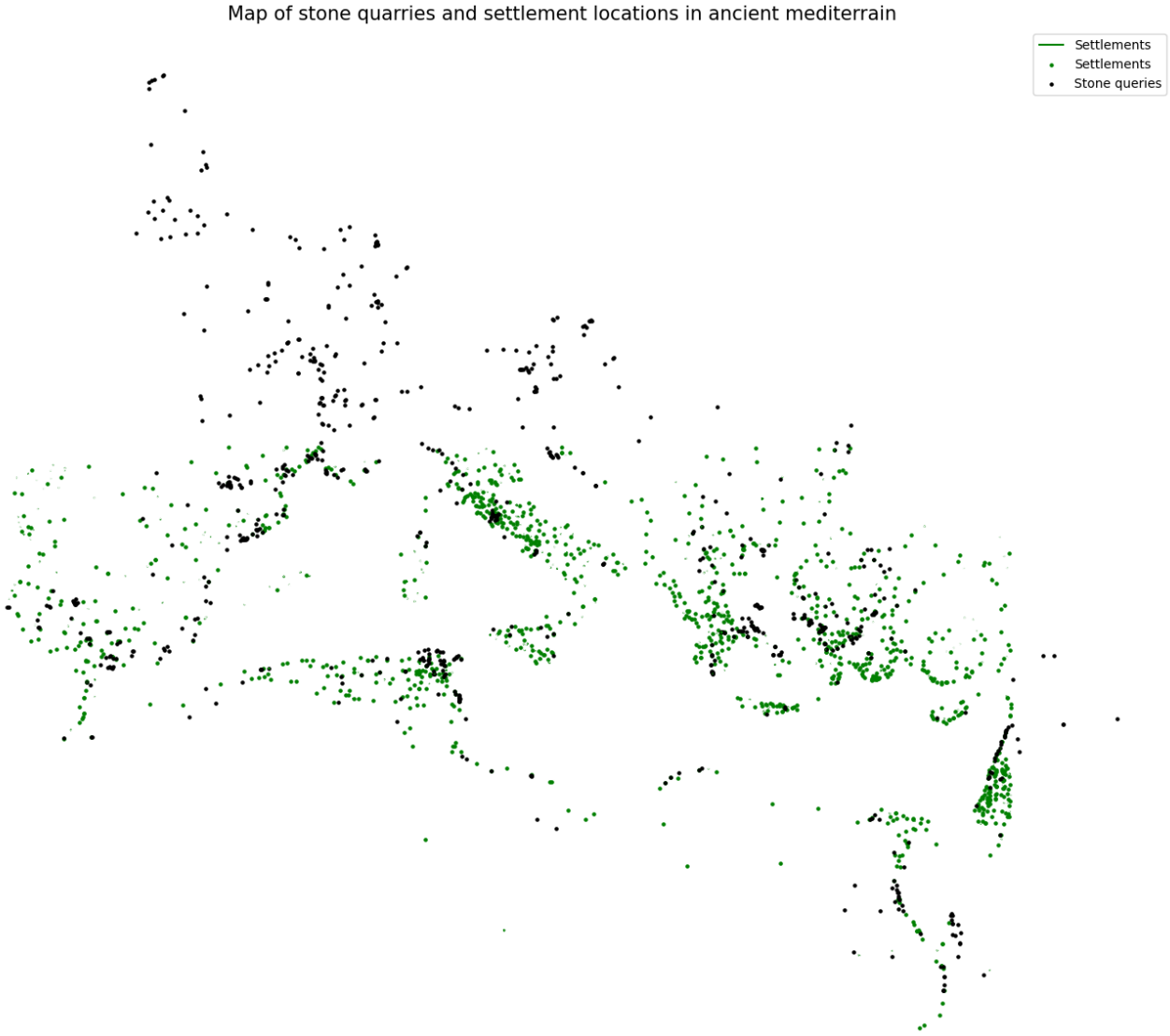

Figure 6: Location of stone quarries and settlements locations

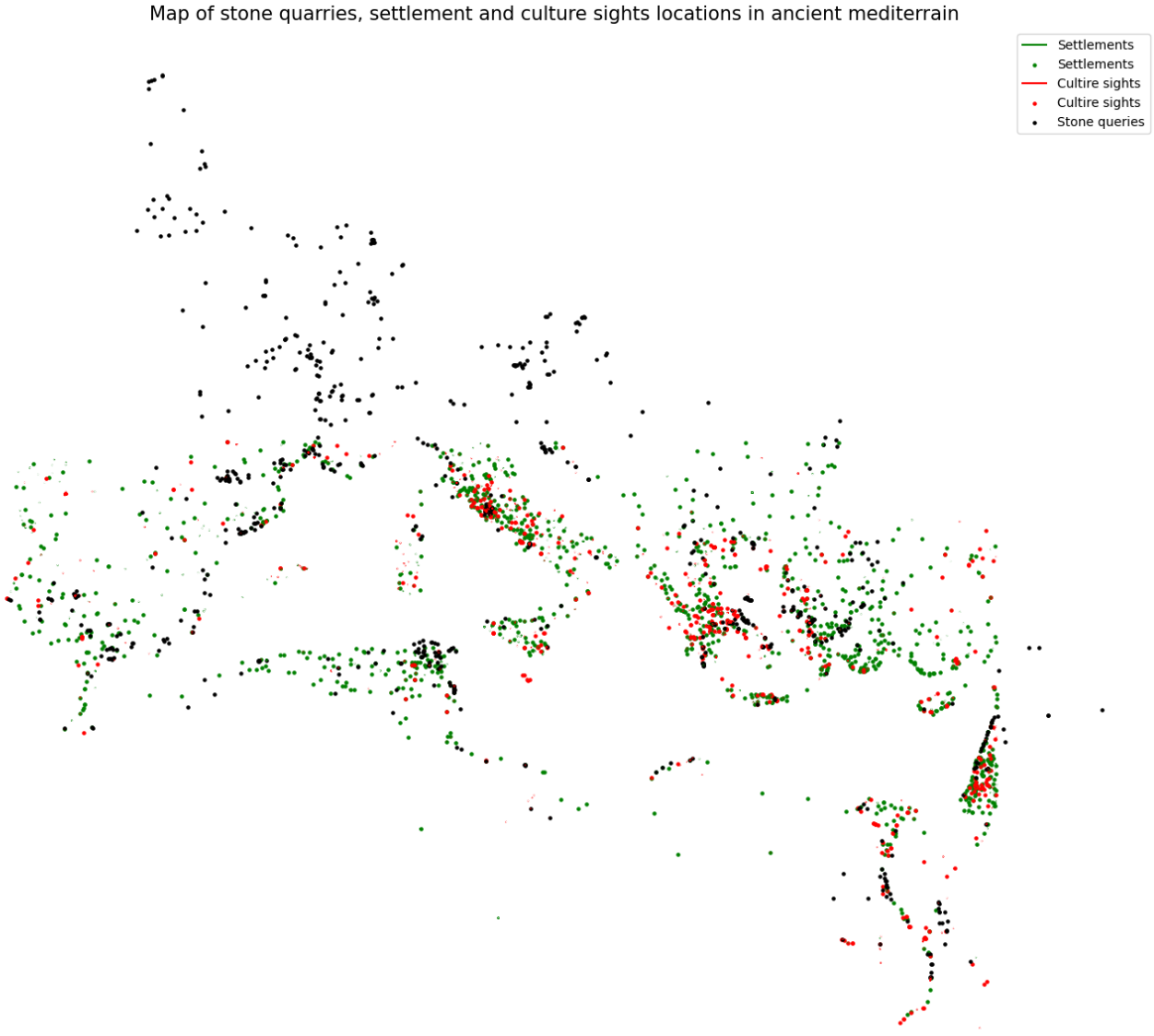

Figure 7: Location of stone quarries, settlements and culture sights location

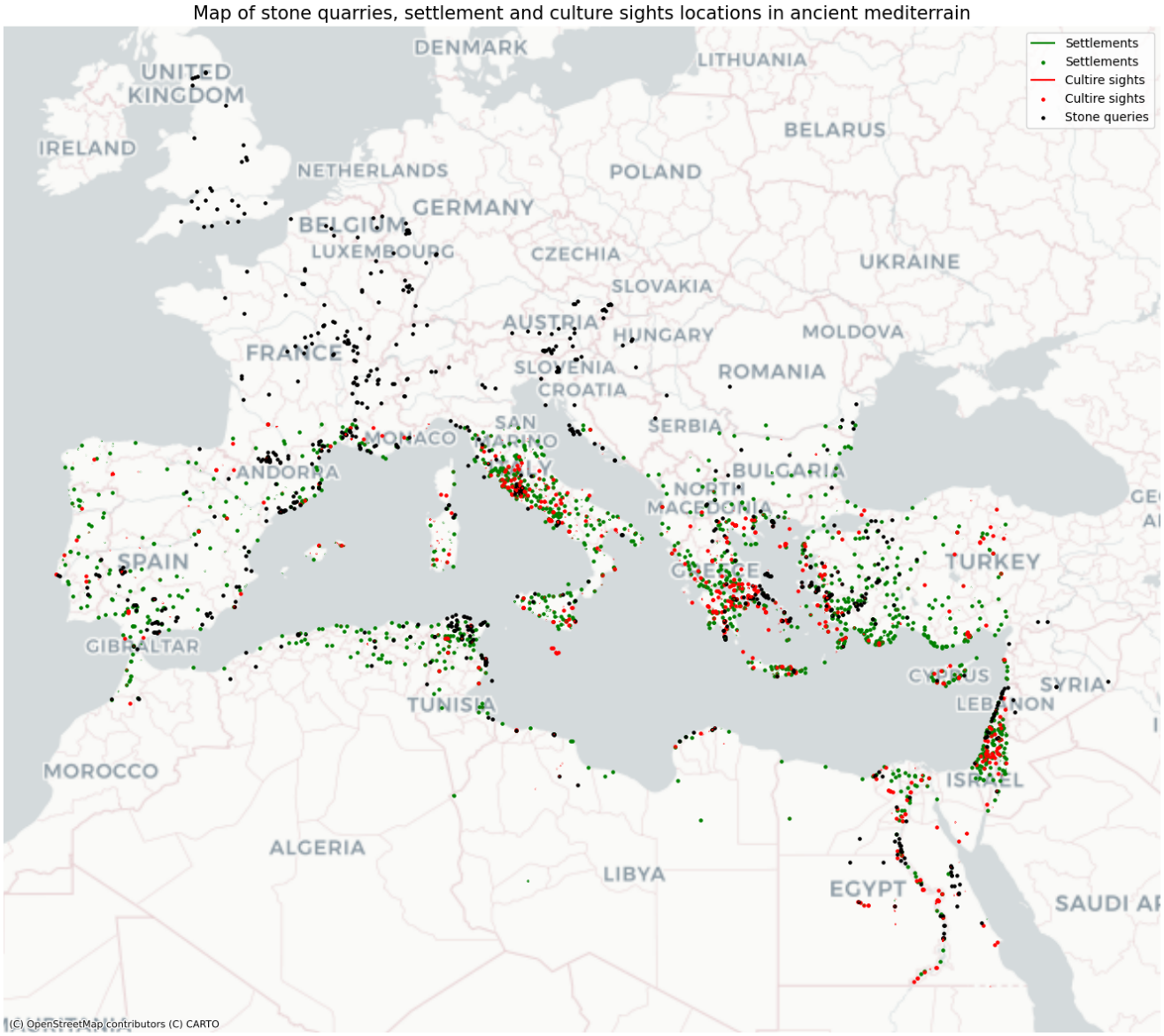

Figure 8: Location of stone quarries, settlements and culture sights location relative to a map of ancient mediterrain

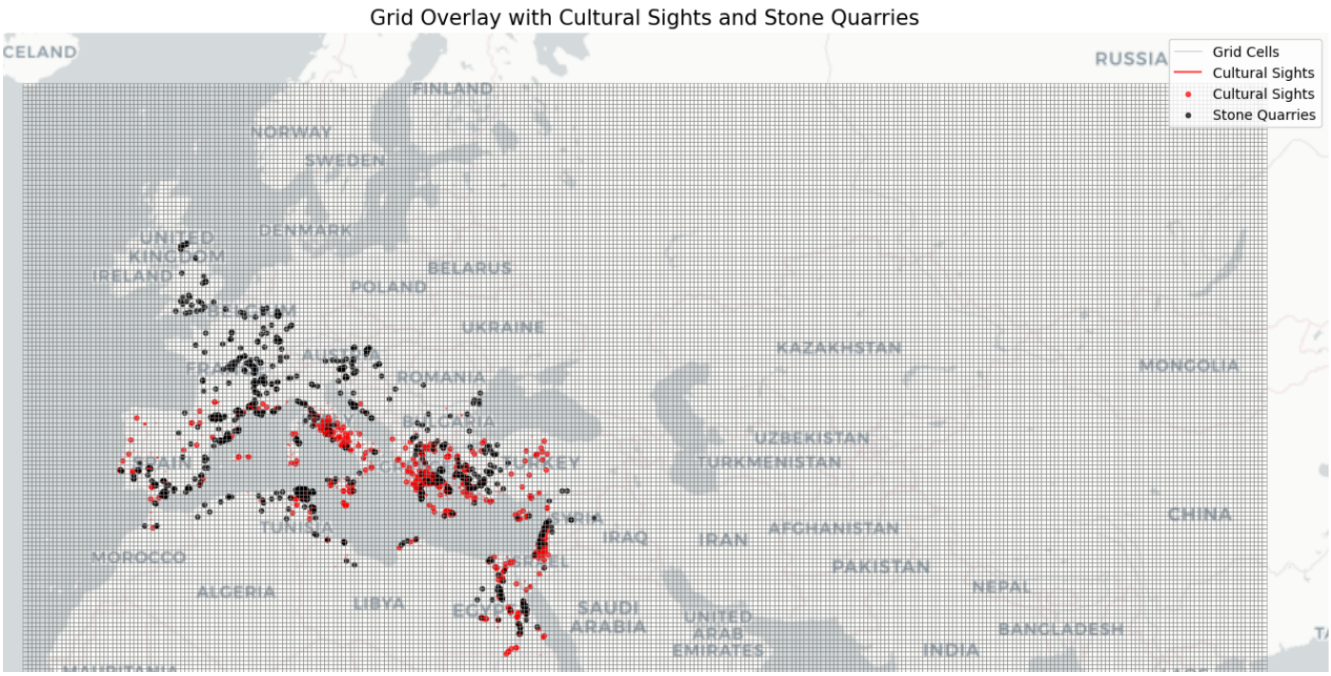

Figure 9: An example of a grid geospatial approach. A number of culture sights and stone mines are counted within grid squares of 5 and up to 50 kilometers. Calculations are automated.

4 Empirical findings

The regression results suggest a significant positive relationship between the presence of stone quarries and the occurrence of cultural sites. Specifically, Table 1 shows that for each 5 km increase in proximity to stone quarries, the quantity of cultural sites increases by approximately 0.21 (column 1), and this trend remains statistically significant across all distance intervals. For instance, at the 50 km distance (column 8), the quantity of cultural sites increases by 0.90 for each additional stone quarry, with the effect remaining statistically significant at the 5% level.

Table 2 presents the log-odds coefficients from a logit regression examining the relationship between the presence of stone quarries and the likelihood of cultural sites being present. The coefficients are statistically significant and positive across all distances, indicating a positive relationship: as the number of stone quarries increases, the probability of a cultural site being present also increases. The coefficients represent log-odds, which can be translated into probabilities. For example, at the 5 km distance (column 1), a coefficient of 3.315 means that for each additional stone quarry, the odds of a cultural site being present increase by approximately 27.5 times. To get an estimate of the probability change, we use the logistic function. At the 50 km distance

(column 8), the coefficient of 1.086 implies the odds increase by approximately 2.96 times. This still represents a notable increase in the probability of a cultural site being present, but the effect is less pronounced at greater distances. These results suggest that the presence of more stone quarries significantly increases the likelihood of finding a cultural site, with stronger effects at shorter distances and a diminishing effect as the distance increases.

This pattern holds across different grid cell sizes, indicating that the positive association between stone quarry presence and cultural site occurrence is robust to changes in spatial scale. While the results are significant and suggest an interesting trend, it is important to acknowledge that no control variables were included in this model, so the results could be purely correlational. Nevertheless, these findings may reinforce the idea that the presence of natural resources, such as stone quarries, plays a role in empowering states, potentially influencing the development of cultural and sociopolitical infrastructure. Further analysis with control variables would be necessary to explore these relationships in more depth and confirm the causal mechanisms at play.

Table 1: Effect of Stone Presence on Cultural Sight Count

	(1) 5km	(2) 10km	(3) 15km	(4) 20km	(5) 25km	(6) 30km	(7) 40km	(8) 50km
Quantity of stone quarries	0.207***	0.278***	0.457**	0.421***	0.792*	0.780*	0.776*	0.896*
	(0.0656)	(0.0660)	(0.196)	(0.109)	(0.469)	(0.458)	(0.431)	(0.469)
Intercept	0.000881***	0.00343***	0.00678***	0.0125***	0.0138**	0.0202***	0.0363***	0.0486**
	(0.0000430)	(0.000183)	(0.000603)	(0.000966)	(0.00561)	(0.00782)	(0.0126)	(0.0211)
Observations	1168872	292444	130162	73224	46879	32616	18306	11830

Notes: This regression investigates whether the number of cultural sites defined as theatres, amphitheatres, churches, temples, and sanctuaries, within various spatial cells is associated with the quantity of stone quarries in that cell. The outcome variable is the number of cultural sites, derived from the Pleiades dataset, a project by the Institute for the Study of the Ancient World (NYU) and the Ancient World Mapping Center (UNC Chapel Hill). The main predictor, "Quantity of stone quarries", measures the number of stone quarries listed in the Gazetteer of Stone Quarries in the Roman World (Russell, 2013). The analysis tests whether access to construction materials correlates with the spatial distribution of cultural infrastructure in the Roman world.
Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Conclusion

This study investigates how access to building materials, specifically stone quarries, shaped the spatial development of cultural infrastructure in the ancient Roman Mediterranean. Using geospatial analysis and regression models, it finds a strong and consistent positive relationship between the presence of stone quarries and the density of cultural sites like temples, theatres, and churches. These findings support theories of state formation that emphasize natural resource mobilization

Table 2: Effect of Stone Presence on Cultural Sight Count (Logit)

	(1) 5km	(2) 10km	(3) 15km	(4) 20km	(5) 25km	(6) 30km	(7) 40km	(8) 50km
Quantity of stone quarries	3.315***	2.224***	1.947***	1.508***	1.439***	1.293***	1.142***	1.086***
	(0.177)	(0.165)	(0.146)	(0.133)	(0.126)	(0.115)	(0.0942)	(0.0984)
Intercept	-7.323***	-5.991***	-5.261***	-4.738***	-4.392***	-4.081***	-3.644***	-3.352***
	(0.0358)	(0.0367)	(0.0384)	(0.0394)	(0.0416)	(0.0429)	(0.0464)	(0.0505)
Observations	1168872	292444	130162	73224	46879	32616	18306	11830

Notes: This logistic regression investigates whether the number of cultural sites defined as theatres, amphitheatres, churches, temples, and sanctuaries, within various spatial cells is associated with the quantity of stone quarries in that cell. The outcome variable is the number of cultural sites, derived from the Pleiades dataset, a project by the Institute for the Study of the Ancient World (NYU) and the Ancient World Mapping Center (UNC Chapel Hill). The main predictor, "Quantity of stone quarries", measures the number of stone quarries listed in the Gazetteer of Stone Quarries in the Roman World (Russell, 2013). The analysis tests whether access to construction materials is correlated with the spatial distribution of cultural infrastructure in the Roman world. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

and infrastructure as tools for projecting power and fostering social cohesion. While the results are robust across spatial scales, future research should incorporate control variables to clarify the causal mechanisms behind this relationship, as well as more carefully match the timing between opening each mine and building each cultural object, which now is difficult to process with the data we have.

References

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Russell, B. J. (2013). Gazetteer of stone quarries in the roman world. `http://oxrep.classics.ox.ac.uk/databases/stone_quarries_database/`. Accessed 30 April 2025. Hosted by the Oxford Roman Economy Project. Contains 792 records of quarries with location, stone type, and bibliographic references.