

Scientific infrastructure and landscape First developments of the "Laboratory of Architecture and Territory" of the ETIC project

Carlo Atzeni - Università degli Studi di Cagliari, Cagliari, Italy, carlo.atzeni@unica.it

Stefano Cadoni - Università degli Studi di Cagliari, Cagliari, Italy, stefano.cadoni@unica.it

Massimo Faiferri - Università degli Studi di Cagliari, Cagliari, Italy, massimo.faiferri@unica.it

Stefano Mais - Università degli Studi di Cagliari, Cagliari, Italy, stefano.mais@unica.it

Silvia Mocci - Università degli Studi di Cagliari, Cagliari, Italy, silvia.mocci@unica.it

Marco Moro - Università degli Studi di Cagliari, Cagliari, Italy, marco.moro@unica.it

Fabrizio Pusceddu - Università degli Studi di Cagliari, Cagliari, Italy, fabrizio.pusceddu@unica.it

Abstract: This paper illustrates the first search results of a complex and ambitious initiative named Einstein Telescope Infrastructure Consortium, which is part of Mission 4 of the PNRR (National Recovery and Resilience Plan), coordinated by the Italian MUR (Ministry of University and Research). ETIC's objective is to support the Italian candidacy to host the latest generation gravitational interferometer in Sardinia (Lula, NU). This scientific project is of major and strategic interest for Europe as well as for the local territory turned into a privileged site for the contamination of knowledge, where innovation runs in parallel with a model of inclusive society. The Laboratory of Architecture and Territory—whose members are all architects and researchers from the Department of Civil, Environmental Engineering and Architecture of the University of Cagliari—investigates the relational dimension inherent with the science-research-territory triad through a rigorous methodology, based on analytical readings of the context, and resulting in a set of design strategies and interventions. The main topics developed so far, which are also the focus of this paper, are fundamental to describe a state of the art and to explore a critical approach structured on three thematic focuses: relationship between innovation and historical cultural heritage; landscape as a stratified palimpsest; the research campus as a design-cultural model to interpret scientific infrastructures in their hybrid and renewed iterations.

Keywords: landscape, environmental regeneration, territorial stratification, scientific infrastructure, Einstein Telescope

1. Introduction. Research framework

This paper aims to present the framework and methodology of the extensive research related to the ETIC project (Einstein Telescope Infrastructure Consortium), then to discuss the first developments in the research work carried out by the team from the DICAAR (Department of Civil, Environmental Engineering and Architecture) of the University of Cagliari [1], with a disciplinary focus on architectural technology. ETIC is a project supported by Mission 4 of the PNRR (National Recovery and Resilience Plan), coordinated by the MUR (Ministry of University and Research). The proponent and leader of the project is the INFN (National Institute of Nuclear Physics) [2], with the collaboration of universities and national research

centers. The general objective of the ETIC project is to support the Italian candidacy to host the latest generation gravitational interferometer—Einstein Telescope (ET)—in Lula (Nuoro), Sardinia. This is the major research infrastructure of strategic interest for Europe, and in fact, one of the most experimental and ambitious projects in the ESFRI roadmap (European Strategy Forum on Research Infrastructure). Since early 2023, ETIC's multidisciplinary research structure has given its primary support to the preparation of the formal documents for the EU tender bid for the Technical Economic Feasibility Project (PFTE) aimed to run the gravitational waves observatory Einstein Telescope in Sardinia. In particular, the preliminary studies are aimed at the construction of a next-generation interferometer and research laboratories focused on the study of gravitational wave signals, able to observe a volume of the universe at least a thousand times larger than current research infrastructures. The preliminary studies are focused on the site already selected for hosting the Einstein Telescope, that is, the abandoned mining site of Sos Enattos located between Lula, Bitti and Onanì. These studies concern geological investigations, environmental impact aspects, engineering solutions and technologies for the construction of underground infrastructures, assessments in reference to the relationships between the historical heritage, natural landscape and the new infrastructures—both underground and overground—as well as economic and safety considerations related to the construction process and methods. In the context of these preliminary phase, the role and contribution of the disciplines of architecture and landscape are fundamental to understanding the transformative potential of ET within a system of interconnected nodes and values tied to the specificities of the territory and the local communities.

2. The laboratory of architecture and territory - ET

The design proposal for the Einstein Telescope consists of two distinct systems, although closely related: the underground infrastructure and the overground infrastructure. The first is the technological and scientific heart of research activities, the second is a great opportunity to rethink the territory. It is the project of a physical and immaterial network, an apparatus that is able of making the invisible visible through architectural and landscape interventions where concentrate spaces for scientific dissemination—with related services—and for the everyday life of researchers. A widespread and complex system which operates as the interface between the scientific world underground, the territory, and the communities. This kind of relationship, that is the connection between the place where knowledge is produced and the society, is the cornerstone of the most important European funding programs for research as they recognize the strategic potential of creating large, highly specialized research infrastructures and their opening outwards to promote the contamination of knowledge. This is a key element for the growth of human capital in order to address the challenges of the future where innovation should run in parallel with an inclusive society. It is evident, in fact, that the large international research centers are already projected into a new dimension of openness and permeability, in opposition to the imagery of closed and confined places at the service of scientific research. Most of the centers of excellence in this field are nourished by physical, social, environmental and economic relationships with the territory in which they are located.

Within the ETIC framework, the DICAAR's Laboratory of Architecture and Territory-ET aims to investigate this relational dimension which can be summarized in the science-research-territory triad. In fact, due to ET project's distinctive characteristics of complexity and innovation, any kind of pre-feasibility or preliminary design document requires an in-depth analysis of the direct and indirect implications related to spatial, functional, technical,

environmental, and technological aspects which are preliminarily identified by the Laboratory of Architecture and Territory-ET and must be taken into close consideration in the subsequent phases of the project. Within the broader organizational structure of the ETIC project, the laboratory is an active part in the development of *Work Package 6* - overground research infrastructure and socio-spatial relations. The specific objective of the laboratory is to advance studies on the territory, the landscape and the network of material resources, and thus, to build new contexts for generative ecosystems originating from scientific research infrastructures on gravitational waves, new habitats of knowledge that accommodate spaces and facilities for researchers involved in the activities of ET in accordance with the environment they will be part of. Indeed, the research work is focused on producing and testing a range of spatial possibilities that could facilitate the integration between scientific research and territories, that is, defining the guidelines for integrating scientific research on gravitational waves with the development of the local territory and its specificities. Against this backdrop, it is intended to start a first experiment in the territory of Lula by proposing a set of interventions—of different scale and gradients—meant to activate new relationships between physical-social spaces and research infrastructures. In other words, reactivating the territory through a knowledge-based model, and stimulating the transition from material production (mining products) to immaterial production (knowledge and learning processes that reverberate on the territory).

3. Research methodology

The research methodology is developed around a framework of analytical surveys concerning with the reading of the stratified context and the identification of design strategies:

- surveys, analyses, mapping of the territory for a comprehensive understanding of the context, definition of strategic guidelines for the recovery and reuse of the built environment now abandoned, of the cultural heritage and those sites of landscape-cultural relevance, as well as the refurbishment of those artefacts belonging with the heritage of industrial archeology of local mines and their environmental system;
- planning and design of physical spaces, coordinated and interdisciplinary, which accommodates any kind of specialized environment related to scientific research both for permanent and temporary workers involved in the context of international cooperation, but also any kind of public facilities devoted to socialization and scientific dissemination;
- modular, multilevel and incremental strategies—economically and technically sustainable—for the transformation of urban spaces connected to the system of scientific infrastructures, by promoting new uses and activities and also providing alternative forms of management, innovative design or recovery tools. The challenge is to take action in the territory through advanced devices and technologies—in the field of ICT for example—making the case of Lula a pilot project;
- evaluations and design hypotheses that identify Lula as a new model for co-habitation for ET operators, researchers and visitors, that is, a rare opportunity for renovating a small-scale village and stimulating new rituals of everyday life.

Another set of actions is addressed to establish connections and reinforce involvement with the local communities:

- analyses, surveys and research on the social and institutional impact of the scientific infrastructure in the territorial context of Lula;

- promotion of innovative forms of knowledge production and dissemination such as living labs/community hubs/visitor centers that will integrate and reinforce the existing fabric of services and facilities starting from the research in the field of gravitational waves, by developing systemic solutions for a knowledge-based economy and emerging technological sectors;

- development of a catalog of interventions and strategies that allow the various stakeholders to plan activities of mediation between communities and places, able of triggering coordinated and synergistic processes with particular attention to the context in which these activities take place.

Therefore, all tasks and actions undertaken by the Laboratory of Architecture and Territory-ET contribute in the first instance to supporting the preliminary feasibility studies for the design of ET overground infrastructure and landscape works in Sardinia; in the second phase, the DICAAR's team will be responsible for supervising and supporting detailed design choices in terms of architectural, civil, and environmental interventions.

4. Research framework. Three thematic focuses

In order to establish a research framework as a consequence of a rigorous methodology that is attentive to specific objectives and outputs, a thematic approach is being developed for circumscribing questions and framing them within cultural paradigms and design perspectives. For this reason, each phase of analytical study and activity planning was preceded by the accurate delimitation of three thematic focuses in order to build a state-of-the-art and to stimulate a critical dimension on the main topics, that is, (a) the relationship between innovation and historical-cultural heritage, (b) the landscape as a stratified palimpsest, (c) the research campus as a design-cultural model to interpret scientific infrastructures in their hybrid and renewed perspective.

a) Territorial connections between science and cultural heritage. A crucial aspect in considering design options is that ET infrastructure represents a unique opportunity to create a scientific hub for the promotion and dissemination of scientific knowledge accessible to all, with laboratories and educational spaces, to be systematized and connected with the cultural assets that characterized the project site. This is a strategy that links the gaze towards the future with the awareness of the present and past of local territories, with their own material and immaterial presence. Within a radius of a few tens of kilometers from the mining site of Sos Enattos di Lula, in a sparsely anthropized area, there is a concentration of artefacts and infrastructures which over time have stratified the identity of place with their uses and traditions, still present today. Among these, we find a remarkable quantity of nuragic sites (two of which are currently candidates for the Tentative List of UNESCO heritage [3], along with thirty other regional nuragic sites), remains of industrial mining archaeology, sanctuaries and medieval routes, water infrastructures and villages that still maintain traditional architectures and buildings. The consideration of this multifaceted heritage within a complex geography of territorial connections, in relation to ET and its great potential, offers an unprecedented opportunity to promote widespread tangible and intangible values at the global scale, and to make local communities and their territories protagonists of this epochal changes. Therefore, this thematic focus aims to highlight these value qualities in a detailed and synthetic way through analytical inquiries that are the common ground of historical, architectural and urban studies of the territory, and are indispensable for planning actions consciously related to the context.

b) The depth of the landscape: Perspectives, directions, and design methods towards complex stratifications. This thematic focus reflects on the crucial role that the cultural-historical landscape is called to play, as a whole, within the major processes of change in the contemporary world. The complexity of the very notion of landscape intersects both historical values and natural systems that involve geographies, territorial forms and long-lasting spatial articulations. Indeed, the very essence of a place sits in those inescapable relationships between recent and historical settlements, between ecosystems and infrastructural networks which have guaranteed functionality and stability over the centuries, between the deep-seated cultural and social realities. It is in this particular notion of stratified landscape, understood as a palimpsest of material and immaterial forms, that the possibilities of transformation are rooted. And it is in the depth of this rootedness that we can imagine and foster new processes and dynamics of change in strong synergy with the specificity of places and the inhabiting communities. Against this backdrop, the ambitions of a large-scale territorial project can only align with a landscape-based approach. Which is not a simplistic jump in scale from the object to the landscape, but a possible strategy for the future development of the whole territory driven by a sustainable and environmental perspective. In this sense, both the design of underground infrastructure and overground architectures becomes a privileged place for the production of new meanings and values for the territory and its communities.

c) The Form of Science: archetypes, figures, and images of the territories of knowledge. In the last 20 years, the repertoire of scientific infrastructure has expanded and the discourses in which it is inscribed have changed. As posited by O’Grady, Smith, and Hughes [4], although philosophical speculation, the aesthetics of design, and the affective register of sociality are outside of the scientific method, all these aspects have become essential to fulfilling its ambitions. Oscillating between the dream of total isolation and the current need to make the production of knowledge accessible to the general public, scientists themselves are recast as experimental subjects inhabiting workplaces designed with the aim of inducing specific responses. Against this backdrop, the Einstein Telescope represents a unique opportunity to rethink forms, figures and images associated with scientific progress. Especially today, with knowledge intended as a crucial agent in guiding the ecological transition. What is the role of architectural and urban design in reshaping the space of scientific infrastructures, its porosity of boundaries and the powerful connections with their hosting territories? And then: what about its role in cultivating potential relationships with historical landscapes and heritage, both material and immaterial? In this spirit, this questions interrogates both the notion of “scientific infrastructure” and the typological notion of a “research campus”, old and new, through the lens of its architectural formations and landscape interventions that connect people to services of knowledge production and its dissemination. From the pastoral image of scientific communities pleasantly immersed in isolated and verdant scenarios, to the metropolitan turn of scientific districts colonizing prominent urban sites to induce creativity and convey prestige, questions arise on the possibilities of a third way: scientific infrastructures as paradigm of a new territorial project that overcomes long-established dichotomies and breaks new ground.

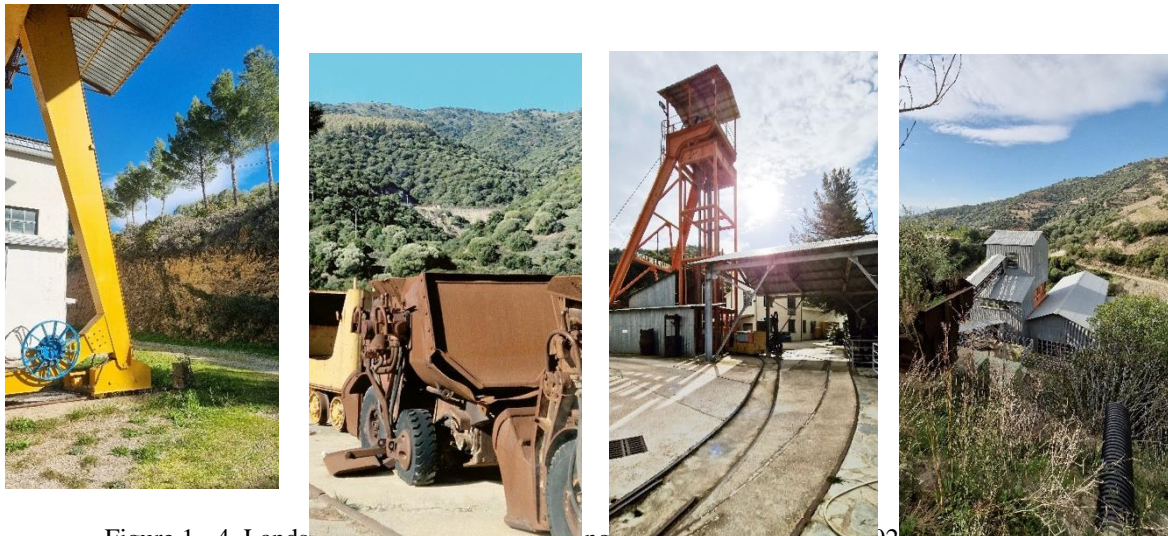


Figure 1 - 4. Landscapes of Sos Enatus mining site, Lula (Nuoro) - © 2024, Mocci/Cadoni



Figure 5 - 8. The historic center of Lula (Nuoro), forms and characters of the place - © 2024, Mocci/Cadoni

5. Layering as interpretative reading

The three thematic focuses frame stratification as the structural materialization of the landscape's complexity, that is, its material and immaterial cultural aspects as well as its design and strategic projections. On a methodological level, stratification is not summarized in the diachronic perspective, nor in a census of present values, nor in those actions like superposition and sedimentation, but rather, it coincides with a critical interpretative reading. The stratigraphic approach on a methodological level differs from its archaeological counterpart in terms of design perspective, which defines the potential of the latter as a critical and interpretative tool in a synchronic dimension. Acting on a stratified landscape with such an approach means recognizing the existing system of values before intervening on it, and then, relocating the pre-existences in a system of contemporary meanings through design.



Figure 9. Ex-Rimisa building at Sos Enattos, Lula (Nuoro), waiting for renovation as a research laboratory and visitor centre of the future Scientific Park - © 2024, Mocci



Figure 10. Santuario di San Francesco, religious complex in the rural landscape of Lula (Nuoro)
- © 2024, Mocci



Figure 11. The woodland and pasture landscape at the foot of Monte Albo (Nuoro)
- © 2024, Mocci

THE DEPTH OF LANDSCAPE

Perspectives, directions and design methods
towards complex stratifications

Università degli studi di Cagliari, DICAAR

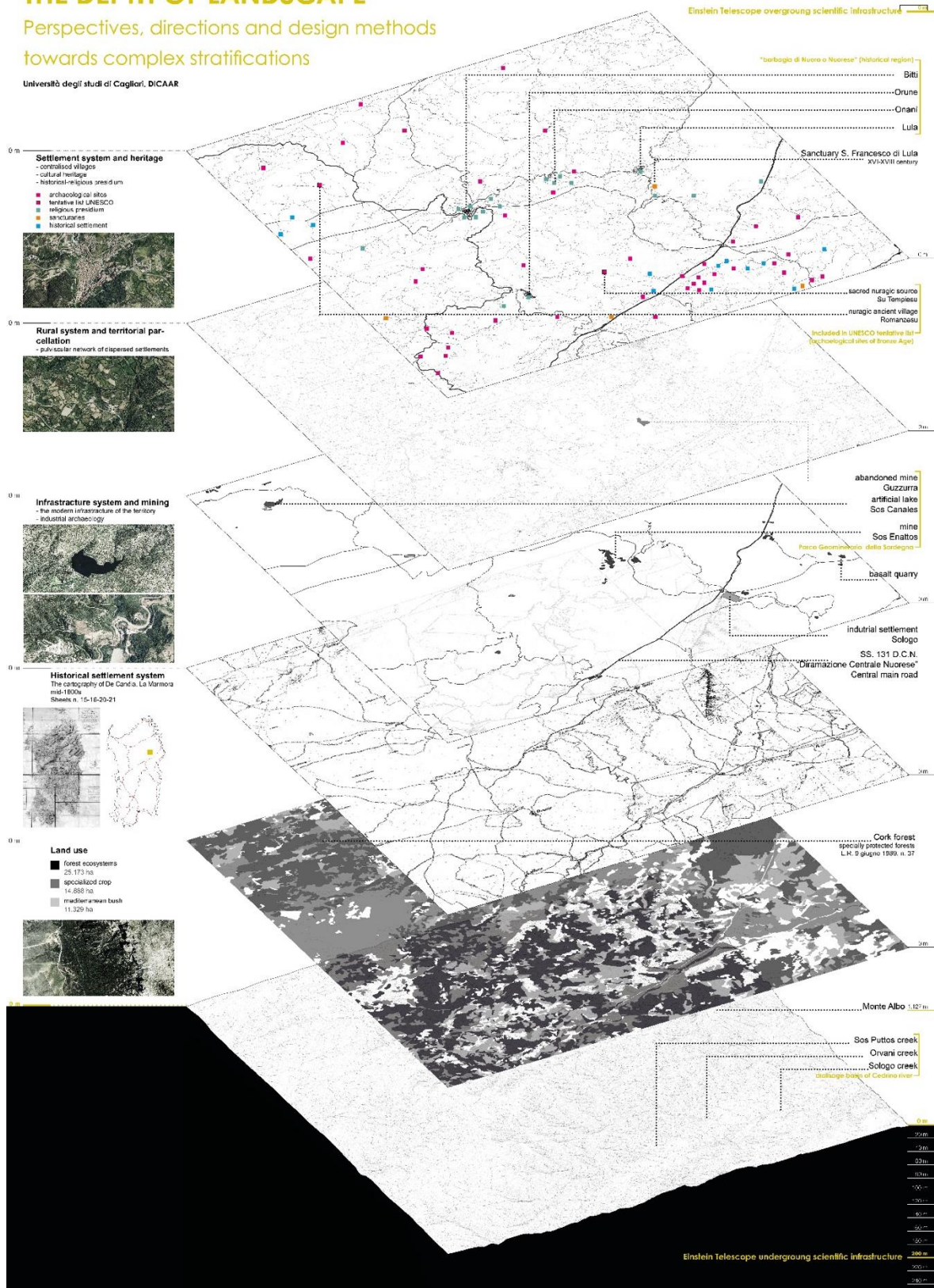


Figure 12. The depth of landscape, interpretative layering -

- © 2024, Cadoni/Mocci

The critical reading of the existing palimpsest and the scientific infrastructure design experiences identifies the inhabited center of Lula as one of the main references of the territorial system. Especially, if considered within the relational network that includes other municipalities (Onanì, Bitti and Orune) which defines the settlement system arranged on the slopes of Monte Albo. Based on this structural character of the territory, it is useful to identify the rural village of Lula as a focal point of the environmental-scientific-productive park instead of a peripheral or marginal one, in a double mirrored perspective: integrating the communities and their living spaces into the project to encourage participation and ensuring active involvement in the life of the places; avoiding the reiteration of those vulnerabilities congenital to isolation, as in the cases of theme park systems that are inexorably self-referential and confined like enclaves. If conceived in this exclusive way, ET project it wouldn't be different from mining interventions that have been superimposed in the last two centuries, with profound and still visible traces awaiting for reading, understanding, and strategic views. The vast and depopulated territory, in fact, has demonstrated a remarkable capacity to welcome external episodes—even those of great environmental impact—which have stratified over time. And it is precisely this ability to dilute critical events that could easily distribute the instrumental potential of the overground infrastructure connected to the Einstein Telescope without compromising its scientific objectives. So, the main goal is to develop a strategic view around key themes and places in the area, supporting this view with small-scale devices without restricting the premises of the *Einstein Telescope* project to the buildings and infrastructures only necessary to satisfy scientific research requirements.

These small-scale devices, preferably made out of natural materials and in accordance to the principles of the circular economy, should not be exclusively conceived in terms of design but also in terms of process. In fact, these devices can be more or less permanent; more properly, they should be conceived in terms of programmed durability, adaptable to specific sites and changeable programs through reconfigurable modular units. The design experience itself can be part of the process of understanding and approaching the territory and the landscape, organized through competitions, participatory design micro-events (interdisciplinary workshops) developed in concert with the University and other institutional partners. The circularity of the economic process can translate into a general preference towards low-cost technologies, that is, not the result of *a priori* ideological choices directed towards a pauperist aesthetic, but in adherence with a principle of necessity that innervates the construction culture and the long-lasting processes that have shaped the historical settlement in the area. Furthermore, the low-cost option must be understood not in terms of the use of raw materials or the result of production processes that are distant in space and expensive in terms of ecological and social footprint. On the contrary, it means stimulating development of technologies, production and transformative processes that are already present in the area of intervention, so that the effects of the investment are fully procedural and not only restricted to the physical outcome. Such an approach can be considered in a low-carbon strategy, though it should be carefully examined in technological terms and with respect to the construction materials, seeking a balance between the materials itself and the production and transformation process necessary for their use.

If these minimal devices could animate the territory following a procedural dynamic, the dimension of living can be re-established in urban polarities based on its values of permanence. The historical-traditional building heritage of Lula, today largely uninhabited, constitutes a great reservoir of knowledge of the building and residential culture of identity, that is, a starting point for a recovery program in the village which traces the values of

reconciliation in the peculiar and specific characters of the places with future communities of inhabitants.

6. Conclusions

The depth of the historical landscape of the site selected to host the Einstein Telescope in Sardinia alludes to the underground dimension of the former mining settlement and the future scientific infrastructure. According to the stratigraphic approach, this transition materializes in the thickening of that line that is commonly associated with the zero level of the mine, that is, the most dense area of the territory where all the human events have concentrated over time by expressing their potential, in terms of points of transition and contact, or even friction and contrast. The ET project might be a unique opportunity for territorial and environmental redevelopment on the one hand, but also for repairing and taking good care of material and immaterial productions on the other. All of this provided that, unlike what happened in the past, the “world below” is able to meet the “world above”. From this point of view, the territory can really be interpreted as an intermediate space on a large scale, with its own characteristic and dense thickness. The depth of the landscape lies in fact in the value of its stratifications, which must be read and recognized in order to identify the relationships between different parts and the potential for intervention on them, according to a non-cumulative system vision. This approach intends to avoid, programmatically, any projection of futuristic imageries that appears too similar from those from the past, that is when the monocultural episodic nature of extractive industry superimposed its own logic which ignored—if not deliberately opposed—the agro-pastoral production of land and the environmental and historical-cultural resources of the whole territory. The soil becomes the common ground between above and below, but also between before and after, between the submerged and the saved, where still survives a possibility of recovery and repositioning of what has been lost—or it is only latent—if it will be rediscovered in a contemporary value system. This line between the “above” and the “below” acquires its own characteristic dimension depending on the potential for future projection. Its relational density increases between the stratified resources, that is, where different layers interact; on the contrary, it becomes more rarefied when one of these layers is prevalent. In conclusion, the fundamental objective of this research and those design operations deriving from it is to identify contact zones, or marginal areas that stimulates interaction between the submerged and the emerged. In a broader and more general way, it should also be the prime objective of the territorial strategies and policies in support of the ambitious ET project, so that the wounds that define a present of suffering of the territory are ultimately replaced by the scars testifying a process of redemption; a process that reaffirms a project as identity and not as a regret. From this point of view, potential of relationships resides precisely in the depth and stratifications of landscape which constitutes the premise and the resource for it to be transformed into an interscalar matrix of knowledge, able of supporting and nourishing new forms and methods of exploration and understanding of reality.

References

[1] Il gruppo di ricerca del DICAAR è formato da ricercatori afferenti a diversi settori scientifico disciplinari: Prof. Massimo Faiferri (responsabile scientifico), Arch. Ph.D Marco Moro e Arch. Ph.D Fabrizio Pusceddu: settore ICAR/14; Arch. Ph.D Silvia Mocci: settore

ICAR/12; Prof. Carlo Atzeni e Arch. Ph.D Stefano Cadoni: ICAR/10; Arch. Ph.D Stefano Mais: ICAR/18. Il gruppo interdisciplinare vanta rilevanti esperienze pregresse nel campo della ricerca e della progettazione di grandi infrastrutture scientifiche –acceleratori lineari e science centre –, condotte entro un quadro di collaborazione consolidato e pluriennale con l’INFN (Laboratori Nazionali di Frascati) e tramite l’organizzazione di workshop e scuole internazionali sul tema. Rilevante, in tal senso, anche la collaborazione con il DADU (Dipartimento di Architettura, Design e Urbanistica) dell’Università degli Studi di Sassari, già descritta in diverse pubblicazioni di carattere scientifico tra cui Faiferri M., Bartocci S., Cabras L., Pusceddu F., *Communicating scientific knowledge, AA.VV., Creativity and reality - The art of building future cities. vol. I*, Edizioni Nuova Cultura, Roma, 2020.

[2] The INFN coordinates the ETIC project with the Sections of Bologna, Cagliari, Genoa, Naples, Padua, Perugia, Pisa, Rome and Rome Tor Vergata, Turin, the National Laboratories of Gran Sasso and the National Laboratories of the South. Among the partners that support the INFN: INAF (National Institute of Astrophysics), INGV (National Institute of Geophysics and Volcanology), Alma Mater Studiorum – University of Bologna, University of Cagliari, University of Genoa, University of Padua, University of Studies of Perugia, University of Pisa, University of Rome Tor Vergata, University of Federico II of Naples, University of Campania Luigi Vanvitelli, Sapienza University of Rome, GSSI Gran Sasso Science Institute, ASI (Italian Space Agency).

[3] A vast project to enhance the Nuragic heritage in Sardinia is in progress for some years. The process of inclusion in the list of UNESCO monuments began in 2021, through the selection of 31 most representative sites of the architectural production during Nuragic civilization: <https://whc.unesco.org/en/tentativelists/6557/> [February 2024]. The project is promoted by the Sardinia towards UNESCO Association with the scientific collaboration of the University of Cagliari: <https://sardegnaversounesco.org> [February 2024]. For further information on the topic, see: Marco Cadinu, Nuragic architecture and proto-urban landscape. Ancient relations and extensive current dimensions, in «Archaeological Restoration», Speciale 2, 2022, pp. 266-271.

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