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Multi-scalar Geological Models of Shelters: Developing Techniques that Connect the Geological scale with Human Habitation

Abstract

This research seeks to bridge a perceived gap of representation and comprehension between the scales of the geology of the territory and that of human habitation. The various elements that make up a landscape have always acted as shelter to civilisation, and geological features in particular often held a key role. Factors such as small populations, the limits of building technologies, mild climates, or nomadic lifestyles made suitable local geological features a viable choice. Despite such a close relationship, and the dominance of geology in our environments, the geological scale remains abstract in modern literature and thought, whether in size, materiality or timescale, from its solid strata to its eroded form (Montgomery 2007).

Through the recent consolidation of spatial digital geological models in Australia and elsewhere, it is now possible to spatially represent the geology of a territory with surface details such as habitation. The Seamless Geology project of NSW in particular allows new opportunities to understand the geology of the territory (Phillips 2015). The surface features have been captured through the application of terrestrial and aerial photogrammetry, which captures the nature of the geological textures and environmentally exposed state. The technical aspects of conversion, synthesis and visualisation are a key part of this research.

A scanning technique has been applied to a case study site, in order to propose application to a site in NSW:
Landscape-architectural remnants and survey in the Bavona Valley, Southern Alps, Ticino, Switzerland, for possible applications at the Baiame Cave, Milbrodale, New South Wales, Australia, a heritage listed Wonnarua site in the Hunter Valley.

There exists a wealth of anthro-archeoogical research in a similar technical vein, which often stops short of a contemporary statement on the human-geological scale interface. Through the juxtaposition with various research expeditions to the Nawarla Gabarnmang.

There is clear significance of this research to a greater understanding of the geological scale and its relation to habitation, as well as resource extraction

within contemporary themes of the anthropocene. The didactic and public discourse has the potential to benefit from the ability to visualise and understand such processes in a multi-scalar manner, and influence the interaction of inhabitants with their territory.

Introduction

The grounds for this research are the perceived gap of representation and comprehension between the scales of human habitation and the geology of the territory. The interface of this research is on the interaction between these two scales, geological scale and human scale, whether spatial or temporal. In order to establish the ground for a premise that has both a clear technical and a theoretical aspect, it is important to define the limits of discussion within an extremely broad set of topics. The various elements that make up a landscape have always acted as shelter to civilisation, and geological features in particular often held a key role.

Aside from the imperatives of survival, the act of human interaction with geology holds many compelling elements. Aside from simple imperatives of shelter and lack of alternate technologies or resources, the appropriation of such geological features could be argued to be a instinctive act of self preservation.[1] Factors such as small populations, the limits of building technologies, mild climates, or nomadic lifestyles made suitable local geological features a viable choice. Despite such a close relationship, and the dominance of geology in our environments, the geological scale remains abstract in modern literature and thought, whether in size, materiality or timescale, from its solid strata to its eroded form.[2]

The comparison of the projects marks the first in a series of research documents, formulating a multi-scalar understanding of anthro-geological interaction. A meaningful spatial representation of the connection between the geological scale with human habitation and associated land use and interaction has the potential to reassess our relationship to all geological formations, and the terrain and extrapolated territory underfoot.

The Anthropic and the Geologic

This anthropic projection onto geological forms was pervasive in the 19th century, and forward-projecting, as demonstrated by the quote from Jospeh Gandy from 1838:

> ".. the future history of architecture was already written in the landscape, merely waiting for human civilization to catch up."[3]

In the same document the primeval hut is contrasted in a primitive light to the geological form of the cave; the latter superior in its closer adherence to the built architectural norms of the time.[4] It can be seen that The various elements that make up a landscape have always acted as shelter to civilisation, the most permanent and enduring of these being geological formations, although these often pre-dated the mobile, nomadic structures also depicted, which arguably involved relatively advanced technologies in material understanding, tool use, and iterations of development.

The anthropomorphisation of such existing geological features can function rhetorically in both directions, with built, architectural structures being described as “cavernous”, “cave-like” or as “sheer”, and program organised into “strata”. In a 1992 guidance paper that defines the correct scientific procedures and protocols to describe the geological sciences, authors Irvine and Rumble outline correct writing, grammar, word choice and context to be used in the sciences of Geology. In doing so, they address common issues of geological discourse - beyond grammar and terminology, specifically the common tendency for Anthropomorphise geological formations and processes.[5] It could be argued that an Anthropic characterisation of geology, geological processes and surface formations may be a likely and inevitable byproduct of an extremely long cultural and symbolic interaction between humans any their geological context.

In current contemporary theoretical discussion on such themes is invariably dominated lead directly to a discourse of the (post-) anthropocene period and its broader implications is a common topic in current research at this moment in on spatial design, planning and society in general.[6]

Scales of Time

The various modes of what can culturally be termed “western” concepts of time certainly privilege the current and technological progress of civilisation, as well as the empirical linear mapping of time, and its clearly discernible traces.[7] This concept of time is difficult to reconcile with other cultural concepts of time, including many of the indigenous Australian perspectives and connection of narrative with temporal conception.[8] The concept of time for the geological sciences is another level of abstraction, stretching from speculations on the origins of the planet, mineral accumulation through external elements entering the atmosphere, permutations of geological strata and the trajectories of future tectonic shifts, erosion and emergence.[9]

In writings about the effect of the anthropocene and post-anthropocene discourse, the human / geological spatial and temporal scales have often called to attention to the

discrepancies of inhabitation and intervention, and specifically what we build now and anticipated futures of the built environment; between assurances and uncertainty.[10] In addition to the common anthropocene discussions of contemporary and future oriented temporal comparison of geological anthropic scales, the (pre-)historical periods demonstrate an additional interface of interaction - a direct human interaction with the inert geological strata, linked to its existing physical and material characteristics. It is important to acknowledge pre-extraction and resource consumption anthropic relationships to geology, which invariably relate to a specific local geological context, understanding and contact.

This is perhaps not surprising, given the close relationship between geology and the species, tracing back to the earliest still existing evidence of its origins. Symbolically, this is likely also due to the shelter that such structures provide, both physically from external elements, and creating stable climates, potentially slowing processes of erosion, dispersal and decomposition.

The concept of “Geological Memory” is useful here to further counterpoint conventional scales of time and its codification. This abstraction of scale, in this case of time, implies a general abstraction of the concept of scale, ie. whether temporal, spatial, or conceptual. The implications on particular for an abstraction of a geological spatial, and material scale are particularly relevant here.[11]

> “It is that the confrontation with geological time, with the temporalization of the Earth itself, brings into relief elements and forces that do not sit comfortably in the category of `life’, `body’ or `organism’.”[12]

Through this confrontation, they allow by extension a recontextualisation of the categories surrounding the body, such as scale, context, dependancy and coexistence. The potential to experiment with the physical modelling and representation of this confrontation is the key aim of this research.

Geological and Surface Models

Through the recent consolidation of spatial digital geological models in Australia and elsewhere, it is now possible to spatially represent the geology of a territory with surface details such as habitation. The Seamless Geology project of NSW in particular allows new opportunities to understand the geology of the territory.[13]

The surface features have been captured through the application of terrestrial and aerial photogrammetry, which captures the nature of the geological textures and environmentally exposed state.

The combination of geological surface modelling with photogrammetry and laser scanning does have many precedents[14], however these tend to focus on the identification recognisable large scale surface signifiers for underlying geological traits. While the author has published articles on processes of the analysis of such landscape features, this research is more focussed on the linking of fine-grained, small scale geological details with the territorial geological scale.[15]

While 3D geological models are not a new concept, they are often stored in custom formats designed for proprietary geological modelling software. As a result they are not readily combined with design software data, and survey information.[16]

The following examples from Australia and Swizterland, each with their strengths of application, serve as proof of research concept for the Baaime, Hunter Valley site.

Case Studies

The case study sites contrast existing research by other authors of geological structures in Arnhem Land, NT, with two sites, one already scanned by the authors of this paper, and the Baaime site, in the Hunter Valley, NSW, proposed especially for its potential to interface with the ‘Seamless Geology Project’ of NSW.

The Nawarla Gabammang in Western Arnhem Land, Northern Territory, Australia

The Nawarla Gabammang, one of thousands of sites in the Arnhem Land plateau, documented in collaboration with the local Jawoyn people by researchers from ANU and several other international research bodies.[17] (David et al., 2013) It is well documented, both in discrete archeological and anthropological research, and in the documentary interviews with the local Elders and guides. The site is specific in its composition, with a slow process of dissolution of the cave rock leaving a grid-like pattern of pillars. The spaces have further been rendered ‘anthropic’ through the removal of specific pillars, and evidence of the removal of eroded materials, increasing the scale of the space and its usability.[18]

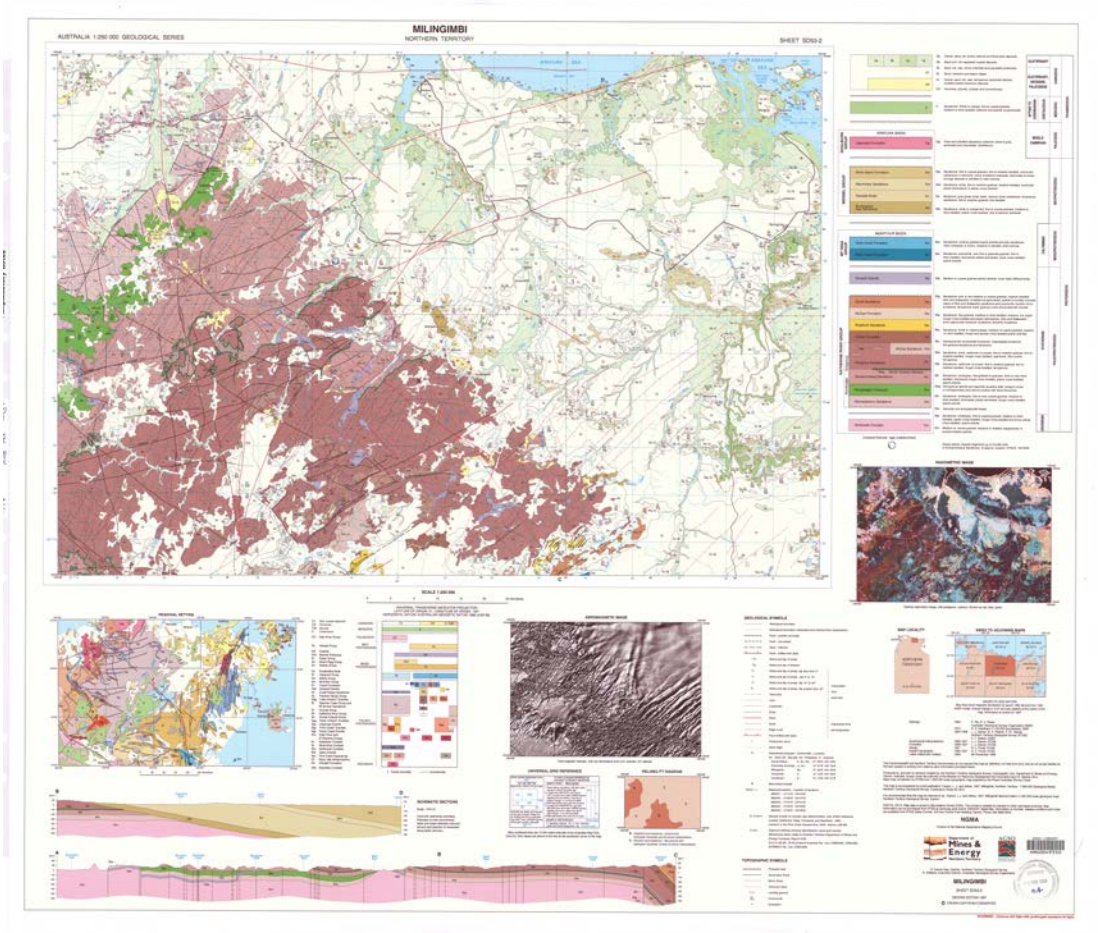

Figure 1. The large scale 1:250,000 Milingimbi geological map of the Nawarla Gabammang demonstrates the clear directional fissures in the Marlgowa sandstone, the dominant geology of the exposed geological features. [19] (Carson 1997) The digital version is the same data, traced into vectors.

To modern eyes, the potential of such spaces perhaps beyond anthropic, rather tending towards the ‘archi-thropic’ - the signifiers of the grid, the column/pillar, ceiling, floor and cave walls being so recognisable, despite only minimal intervention through anthropic means. The resulting paradox of the ancient, yet anthropomorphically recognisable architectural space, through the subtle yet fundamental interventions of past occupants, produces a hybrid of geology and constructed human shelter, as related in the university lecture series of Prof. Desley Luscombe, UTS.

Documented with surface laser scanning and detailed, marker-scaled photography, the research project nonetheless is physically de-coupled from the larger geological context, seen in Figure 1. While there is unfortunately no three dimensional data of the underlying geology, the territorial 1:250,000 geological maps in this case demonstrate a similar dominant geometrical direction, running between SW and NE, shared across scale levels in the Marlgowa sandstone, as can be seen in the comparison with the original figures in the research article (publicly available) for comparison and juxtaposition.[20]

With first occupation of the site dated in the same research at 50,000 years ago, the site also shares the additional significance of many other indigenous Australian sites as coming the closest to a geological timescale, within traceable human interaction with the environment.

The exposed, largely homogenous nature of the geology lends itself to the typical planar geological mapping technique, employed consistently over the last decades. The contrast to the Baaime site geological features (Figure 5) clearly separate the two sites, and the specificity of their representation.

An individual boulder structure in the village of Sabbione, Bavona valley, Ticino, Switzerland

The landscape-architectural remnants in of the village of Sabbione in the Bavona Valley, in the Southern Alps, Ticino, Switzerland, consists of the anthropological interaction with an erratic granite boulder. The village consists of many such enclosures created in spaces created between the massive granite stones and the local rock and soil deposited through centuries of erosion, as shown in Figure 2.

Figure 2. The setting of the Bavona boulder, in the town of Sabbione, Ticino, Swizterland. The geological formation (right in image) matches that of the sheer granite walls of the valle, seen in the background. Indicative recent fragmentation site of the valley geology circled, see Figure 4. Source: Author.

A local exhibition and research project from 2004 documents many of the structures in the

Maggia valley in Ticino, Switzerland. Through the surveying of their context, detailed physical form, and historical use, the various practical aspects of their implementation are revealed, cool air, climatic stability, as well as fissures and gaps providing ventilation and forming chimneys. The nature of many these structures matches the human scale to the geological feature, each invariably involves the excavation under the features of the malleable valley soil in order to adapt the context for human use. While there is evidence of early habitation in the valley since the late Bronze age, most evidence of usage and habitation in the valley is being.[21]

In the case of the site chosen for this research, which does not seem to have been previously documented beyond a single photograph, there is no evidence of an existing cave or hollow, rather the monolith was tunnelled under to create the space of use, in this case a mixture of habitation and storage, the use likely changing over time. As can be seen in figure 2, the site is one of many structures carved out underneath existing massive geological fragments. Among the fractured sheer granite walls of the valley towering above the site, many clear signs of detached geological material can be detected, a recent, less weathered one marked in the figure and documented in figure 4.

The sloping site of the Sabbione village, its topography owing largely to the sedimentary processes of gradual landslides and material deposit for the gullies and cliffs above, demonstrates a clear material connection to its geological context, the smaller building materials also fashioned from smaller fragments of the same granite, often requiring no additional treatment or refinement.

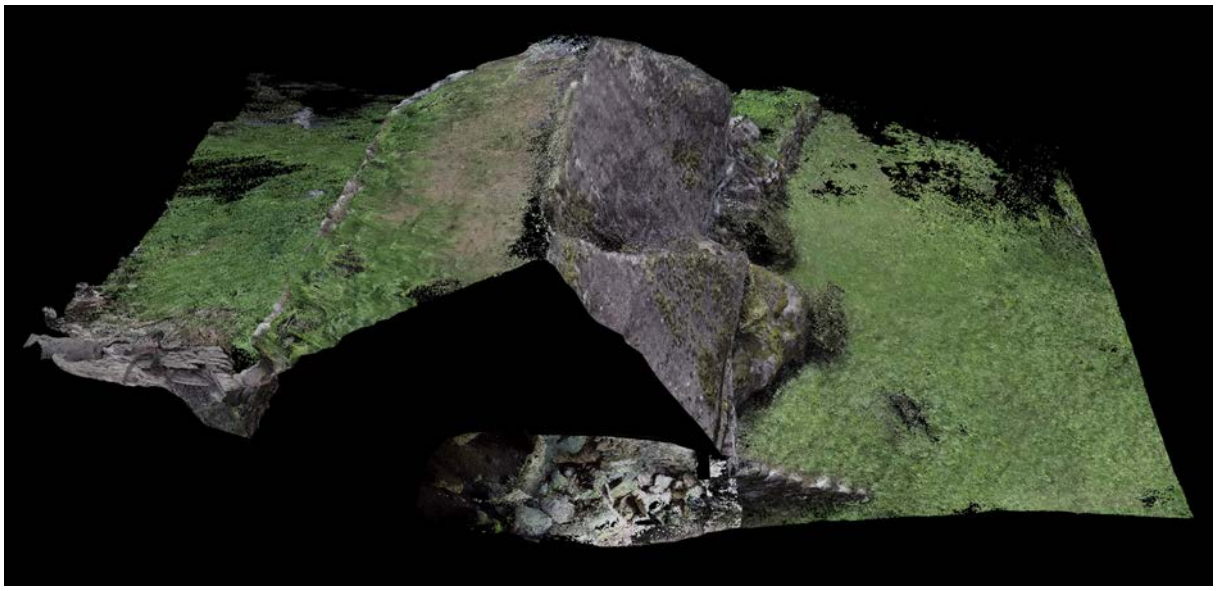

Figure 3 a&b. A view of the pointcloud data (a) of the geological formation and section (b) showing interior, at Sabbione, Bavona Valley, Ticino, Switzerland. Source: Author.

A detailed photogrammetric scanning campaign captured the site in its context, interior, as visible in figure 3. The scan reveals the transversal section of the stone, the angular nature of its fractures, and scale that the monolith would have had in the landscape, before the space below was hollowed out and adapted to anthropic use.

The scanning process combines in this example the texture, materiality, and geological information specific to the granite material from which the site composes, as well as the small fragments of the same stone material, which form the Anthropic building elements added to the site to further enclose and render the structure usable. Analysis of the site of mechanical erosion on the valley walls can yield similar information of the geological specificity of the individual boulders throughout the valley floor.

The sheer granite valley walls were scanned as well, to understand in detail the manner of detachment and fracture that cause such monolithic stones to cluster in this particular area of the valley. The detailed scan of an indicative scan of an example site of a recently detached boulder (not specifically linked to this feature) on the steep granite valley walls, can be seen in Figure 4. Clear evidence in colouration as to the nature of the recent detachment is visible.

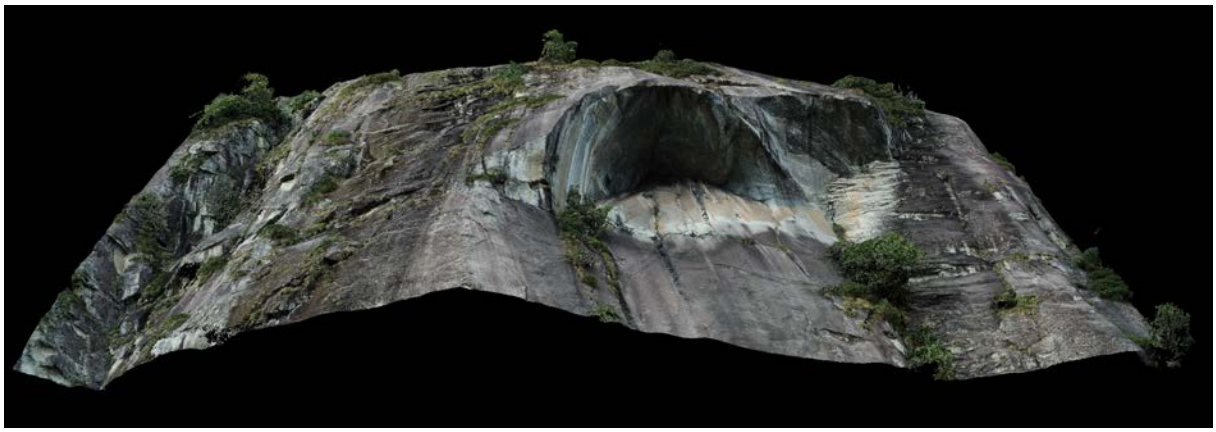

Figure 4. Example of the site of detachment of a granite boulder from the granite valley walls (indicative), perspective view from below, scanned by UAV platform in 2019, 100m above the valley floor. The location of the feature is marked in Figure 2. Source: Author.

It is feasible to believe that the inhabitants of the valley were mindful of the source of these stones and their proximity, even danger of rockfalls. As detailed in the *Vivere tra le pietre* book and exhibition, the surrounding valleys contain many hundred such sites, and have been the sites of tragic rockslides. The coincidence of risk and opportunism seems however to have formed a balance in the favour of the anthropomorphism of these elements and their context.

Similarly to the Northern Territory example, a model representing the larger geological formation, in both spatially and in depth, would yield context to the specificity of this site, where other such sites exist, and the layers of similar previous occupation that may have been erased by further erosion processes.

The Baaime site

The nature of the Baiame Cave, Milbrodale, New South Wales, Australia, a heritage listed Wonnarua site in the Hunter Valley, differs from the other sites in a key aspect, its lack of anthropic intervention. Aside from the paintings adorning its surface, there is little evidence of transformation of the site and its context, save for a contemporary accessway and platform, added to limit the damage caused by visitors.

The site, managed together with the local community, holds a larger local significance, depicting at least one figure that has huge regional and even territorial significance and scale. The somewhat unassuming site signifies a potential both for a reinforcement of its specific geological link to the landscape and unique geological form, and also a similarly territorial conceptual symbolism. While access is encouraged by the original custodians of

the land, it may be possible to codify the significance of the site, its stories, and large scale symbolism without the further physical degradation of the site.

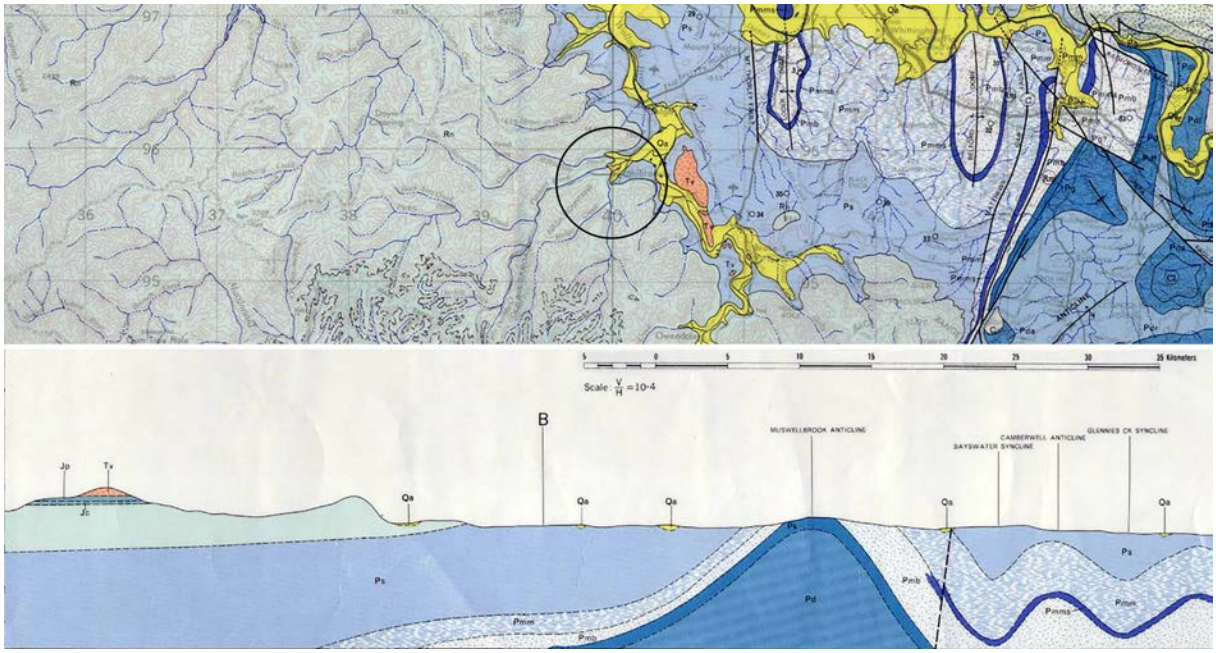

Figure 5. The publicly available geological map of the Singleton area from 1959 is the only publicly accessible document of the Baaime site, and reveals little information. The seamless geological data is available for the site, however in its proprietary format. Detail, Singleton, 1:250,000 Geological Map. [22]

As can be seen by the abstract nature of the 1:250,000 scale map of the area, the site differs from the two proceeding areas of enquiry due to the relative subtlety of the geological formation, especially when represented in the abstract form of plan view, which only refers to its surface-level geological context (Fig 5).

The Baaime site, with its existing underlying available 3 dimensional data, and many sites like it, especially those that are publicly accessible, may signify a potential for another contextualisation of such sites, and their importance for preservation and fundamental link between contemporary culture, ancient culture and the underlying geology. Initial enquiries as to the local interest in such an initiative have been positive, but rely on supporting information and explanatory materials before the research can begin with local support, and demonstrates other forms of local practical use and worth to the community.

Conclusion

There is clear significance of this research to a greater understanding of the geological scale and its relation to habitation, as well as resource extraction within contemporary themes of the anthropocene. The didactic and public discourse has the potential to benefit from the

ability to visualise and understand such processes in a multi-scalar manner, and influence the interaction of inhabitants with their territory.

There are many examples of landscape architecture and architecture which struggle with the issue of representing time in a drawing.[23] Common to these are issues with the static nature of the drawing itself. The exciting aspect of representing geology is its cultural and physical connection to anthropological concepts of time itself, bearing on its surface recognisable marks and incisions, or in the case of sites such as the Valley Bavona, movement and through recognition of the origin of a geological fragment and its current location. Geology also codifies time as literal carrier of fossils, traces and signifiers with which we as researchers and societies identify and map past traces of change, including the cultural and geological.

Further to this is what the author considers an embodiment of time frozen; geological time is at the edge of the ability of the human sensory range of the detection and conceptualisation of what is a constantly, if slowly, evolving and dynamic system.

The extrapolation of geological time includes the acknowledgement of the human role in future geological strata.[24] While dwarfed by the other forms of human produced detritus that are already forming layers of the geological and hydrological systems, it is perhaps poetic that one of the final contributions to the post-anthropocene contribution to the earths environment will be our own remains, the resulting strata forming the space for other processes and habitat for other life in the future.

Through the juxtaposition of human and geological time, habitation, and traces, we can perhaps derive new conceptual models for what a post Anthropocene relationship may become.[25] In the case of the original inhabitants of Australia, the significance of the length of habitation, which in sites such as the Nawarla Gabarnmang now stretch to timespans approaching 50 thousand years, may offer a conceptual bridge between models of short, limited anthopological time and geological time scales, and spatial scales. Even the smallest cultural site such as Baaime Cave has a cultural depth, and physical nature that is an embodiment of a cultural interaction with the geological spatial and temporal scales.

The further stages of this research involve the collaboration with the local land custodians and community. It is through the transfer of this technique that the cultural and geological significance of the site, and their combined and specific stories might further contribute to their enduring significance, preservation and understanding, beyond established concepts of the interaction of time, space and culture.

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