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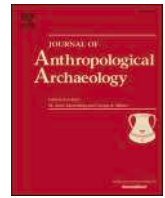


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## Earth construction from past to present: Initial results of the ethnoarchaeological program in the Gobaad Basin (Republic of Djibouti, Dikhil region)

Emmanuel Baudouin<sup>a,\*</sup>, Quentin Aubourg<sup>b</sup>, Xavier Gutherz<sup>c</sup>, Ibrahim Osman Ali<sup>d</sup>, Asma Youssouf Aden<sup>d</sup>, Mariam Abdoukader<sup>b</sup>, Jessie Cauliez<sup>e</sup>

<sup>a</sup> University Paris Nanterre, UMR 8068 TEMPS, MSH Mondes, Bâtiment René Ginouvès, 21 allée de l'Université F-92023 Nanterre Cedex, France

<sup>b</sup> University Toulouse Jean-Jaurès, 5 allée Antonio Machado 21058 Toulouse Cedex 9, France

<sup>c</sup> University Paul-Valéry Montpellier 3, 71 rue du Professeur Henri Serre 34080 Montpellier, France

<sup>d</sup> Centre d'études et de recherches scientifiques de Djibouti, Route de l'aéroport BP 486 Djibouti Ville, Djibouti

<sup>e</sup> Centre National de la Recherche Scientifique (CNRS), UMR 5608 TRACES, Maison de la Recherche, 5 allée Antonio Machado 31058 Toulouse Cedex 9 France

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## ABSTRACT

Architectural studies are of great interest in considering variations in social phenomena. This ethnoarchaeological program therefore focuses on the evolution of building techniques, both in relation to the recent prehistory of Western Asia, and the current context through field surveys carried out in Djibouti. The aim of this article is to present the results of our study conducted in the Gobaad basin (2022–2023) among the Afar and Issa entities by documenting the techniques (materials, layout techniques, morphology of the buildings), referencing practices and socio-cultural context, identifying the networks involved in the dissemination of practices and defining the learning processes in earth construction.

The results of this research show three scenarios. The architectural diversity among the Afar reflect a certain fluidity of social practices, which translates in the architecture into a diverse range of techniques. On the contrary, the standardized architectural traits observed among the the spread of moulded mud brick indicate social compartmentalization and a closed identity. Finally, the adoption by the two communities of an architectural type exogenous to the Gobaad basin allows to formulate a demic diffusion with the adoption of an "Ethiopian style". These results contribute to our research on the Neolithic of Western Asia by providing socio-cultural, economic and historical interpretations.

### 1. Introduction

Architecture offers important insight into the history of a society and its evolution. In studying architecture, we are able to gain a better understanding of social dynamics, because standardizations and innovations develop on a slow time-scale, over the long term (Deffontaines 1972; Leroi-Gourhan 1945). Houses are "built according to the norms of the group, for the group" (Coudart 1998: 18), and they involve a set of social and cosmological principles implied in the concept of a "house" (Rapoport 1969). How one dwells and lives within one's built environment is deeply rooted in the community, and it represents social practices that actively shape group identity. For Bourdieu (Bourdieu

1980), architecture embodies social and cultural norms, and the built environment has a strong value in individual and group identity. As such, architectural variations within social groups (involving the choice of materials, the methods used for building the walls, and the shape of the buildings and roofs, for example) can serve as indicators of technical exchanges within or outside the community (Coudart 1994: 249; Chétima 2019: 7; Pelmoine & Mayor 2020: 374).

Architectural studies are of great interest in considering variations in social phenomena. In order to gain insight into Neolithic architectural traditions in the Near East and its margins, we developed an ethnoarchaeological program on building techniques in the Republic of Djibouti. The objective of this article is to present our

\* Corresponding author.

E-mail addresses: [ebaudouin@parisnanterre.fr](mailto:ebaudouin@parisnanterre.fr) (E. Baudouin), [quentin.aubourg1@gmail.com](mailto:quentin.aubourg1@gmail.com) (Q. Aubourg), [x.gutherz@orange.fr](mailto:x.gutherz@orange.fr) (X. Gutherz), [qsabra@yahoo.fr](mailto:qsabra@yahoo.fr) (I.O. Ali), [deka\\_asma@hotmail.fr](mailto:deka_asma@hotmail.fr) (A.Y. Aden), [jessie.cauliez@cnrs.fr](mailto:jessie.cauliez@cnrs.fr) (J. Cauliez).

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ethnoarchaeological results and demonstrate how they can elucidate archaeological patterns described in detail elsewhere. The aim of this article is to present the initial results of this second part of our research, the archaeological part having already been addressed elsewhere (Baudouin 2019, 2021, 2022; Baudouin et al. 2022).

Clarifying the archaeological questions underlying this program and the findings of the research conducted on the architecture of Mesopotamia and the Caucasus during the 6th–5th millennia BC is crucial as a starting point. This region was chosen because, among the different categories of habitat, earth construction is a universal, transhistorical heritage, dating back over eleven thousand years (Sauvage 2009). In Western Asia, the invention of houses, and by extension of the first Neolithic villages, represents a new structuring of the inhabited space and marks a turning point in the way of life of emerging agro-pastoral communities. Its appearance therefore plays an integral part in the different stages of neolithization. The technological evolution that took place over several millennia (12,000–6,000 BCE) according to the traditionally accepted sequence of wattle-and-daub/cob/shaped mud bricks/molded mud bricks, reflects the progressive complexity in the knowledge and skills involved in building practices (Sauvage 1998).

Over the long term, breaks in technical traditions reflect major social changes, which can be perceived in typo-technological analyses of the architecture, focusing on the materials, construction methods, and forms of habitats (Baudouin 2021: 15). Among the main outcomes of this research, is the identification of a northeast/southwest technical divide from the end of the 7th to the middle of the 6th millennium. On one hand there were communities engaged in a local exchange network, in which the diversity in construction methods reflects technical skills mastered by a significant part of the community, while on the other hand there were communities in which the architecture was highly standardized, indicating the emergence of construction specialists (Baudouin 2022). In the latter case, the spread in the use of molded mud bricks from the Middle Euphrates to central Mesopotamia at the end of the 7th millennium, can be directly correlated with the introduction of standardized constructions (Baudouin 2021: 217). These findings have allowed for broader reflection on the connection between standardizations and specializations (Costin 1991) and the status given to builders within a society. These archaeological results therefore offer new avenues of thought on the evolutionary phenomena involved in the invention, dissemination, and adaptation of architectural techniques and the transmission of technical knowledge.

The archaeological approach alone does not resolve questions of socio-cultural, economic and historical interpretation however. Following this initial work, two questions need to be addressed. The first concerns the dynamics behind the introduction of new techniques and their possible relationship with other elements of the material culture. The second concerns the diversity of techniques and the question of whether they reflect socio-cultural or economic differences. In other words, are technical frontiers the result of deep social or economic divides? The aim of this ethnoarchaeological program on the earthen architecture in Djibouti<sup>1</sup> is to answer these research questions as well as to contribute to the development of a technical reference base, which is indispensable for studying architectural practices and *chaînes opératoires*.

The program involves unprecedented work that has never been carried out in the Horn of Africa despite the extensive research in West Africa. In this context, two field surveys were carried out from 2022 to 2023 as part of the program “*Premières Sociétés de Production dans la Corne de l’Afrique*” [First Food-Producing Societies in the Horn of Africa], led by Jessie Cauliez in collaboration with the *Centre d’Étude et de Recherche de Djibouti* [Djibouti Center for Study and Research]. The current scope of this program is the eastern sedimentary basin of Lake

Abhe in Djibouti in the southwest of the country. In this basin, known as the Gobaad basin, the program questions the role of lake ecosystems in the emergence and consolidation of societies that have adopted a food-producing economy. It also considers the connections between these environmental components and the development of new population dynamics, forms of mobility, social interactions, value systems and innovations (changes in techniques, cultural choices, and new economic models), from the end of the Pleistocene to the present day (Cauliez & Gutherz 2021; Cauliez et al. in press). This is an interdisciplinary program combining archaeology, paleoclimate studies, modern climate studies, hydrology, ecology and ethnology.

## 2. Geographical, historical and economic context

Located in the center of the Afar depression, at the junction between the Nubian, Arabian and Somali plates (Fig. 1), the Gobaad basin is a graben, i.e. a depressed tectonic trough around ten kilometers wide, bordered by basaltic horsts: to the north, those of Ay Silo and Dakka, and to the south those marking the Ethiopian border. This basin is fed by the Awash River, which descends from the Ethiopian highlands to the west, forming Lake Abhe. During the African Humid Period (AHP: 10 ka BP), Lake Abhe was at its highest, covering the entire Gobaad basin, which flowed from outlet to outlet to the Red Sea. Today, lake levels are at their lowest. Since entering a phase of extreme aridity around 5 ka BP, there has been a progressive reduction in the surface area of the lake (320 km<sup>2</sup> compared to 6,000 km<sup>2</sup> during the AHP), leaving the sedimentary basin bare (Khalidi et al. 2020; Mologni et al. 2021, in press). Four wadis cross this basin: wadi Dagadle, Gobaad, Sankal and Cheykheti.

Around the lake (from which the ichthyofauna has disappeared) and in the basin, the animal and plant species are characteristic of a semi-arid environment. The animal species include warthogs, gazelles, spotted hyenas, jackals, antelopes, and ostriches (Laurent & Laurent 2002), while the vegetation is a grass and shrub steppe, composed of *Cymbopogon schoenanthus*, *Acacia asak*, *Acacia tortilis*, *Balanites aegyptiaca*, and *Salvadora persica*. Around the wadis, the vegetation consists of tamarisk (*Tamarix nilotica*) and a few doum palms (Newton et al. 1996). The climate involves two seasons: a dry season in which temperatures reach over 50 degrees, and a wet season characterized, due to recent climate change, by episodes of extreme rain and flooding of the wadis. Djibouti, and more broadly the Horn of Africa, is considered one of the most sensitive hotspots on the planet, a region where the rise in temperatures will be above the global average over the next 50 years, accentuating the risk of severe drought, loss of biodiversity and extreme flooding. Desertification affects more than 90 % of the country and is the most serious environmental issue in rural areas (Moussa Ibrahim et al. 2010). The communities living in the basin have gradually adapted to this increasing aridity by adopting a semi-nomadic lifestyle based on small-scale goat farming (previously cattle) and a caravan trade based on camels. Two native ethnic groups are settled in the basin: the Afar and the Somali.

The Gobaad basin to the east of Lake Abhe is mainly populated by Afar communities who have historically been under the customary rule of the Sultan of Gobaad. This sultanate is one of Djibouti’s three Afar sultanates and was created in the late 18th or early 19th century (depending on the authors). Its geographical location offers a strategic position, because it controls the caravan route towards Ethiopia and has an important resource within its bounds – the salt of Lake Assal. It was created by the Debne, a tribal war confederation originating from the Mabla mountains, north of the Gulf of Tadjourah. The Debne settled in Gobaad following a conquest during the war between the sultanates of Awsa and Tadjourah. Several different interpretations can be found in the oral tradition regarding the circumstances of the sultanate’s origin however. The Debne are said, among others, to have played a major role in the repression of the Oromos (Omar 2011; Soulé 2011; Rahem 2001). The sultanate is also made up of a second, seemingly subordinate tribal group, the Adorassou. The geographical proximity of Somali Issa

<sup>1</sup> The traditional domestic architecture of the region’s nomadic populations will not be detailed in this paper.

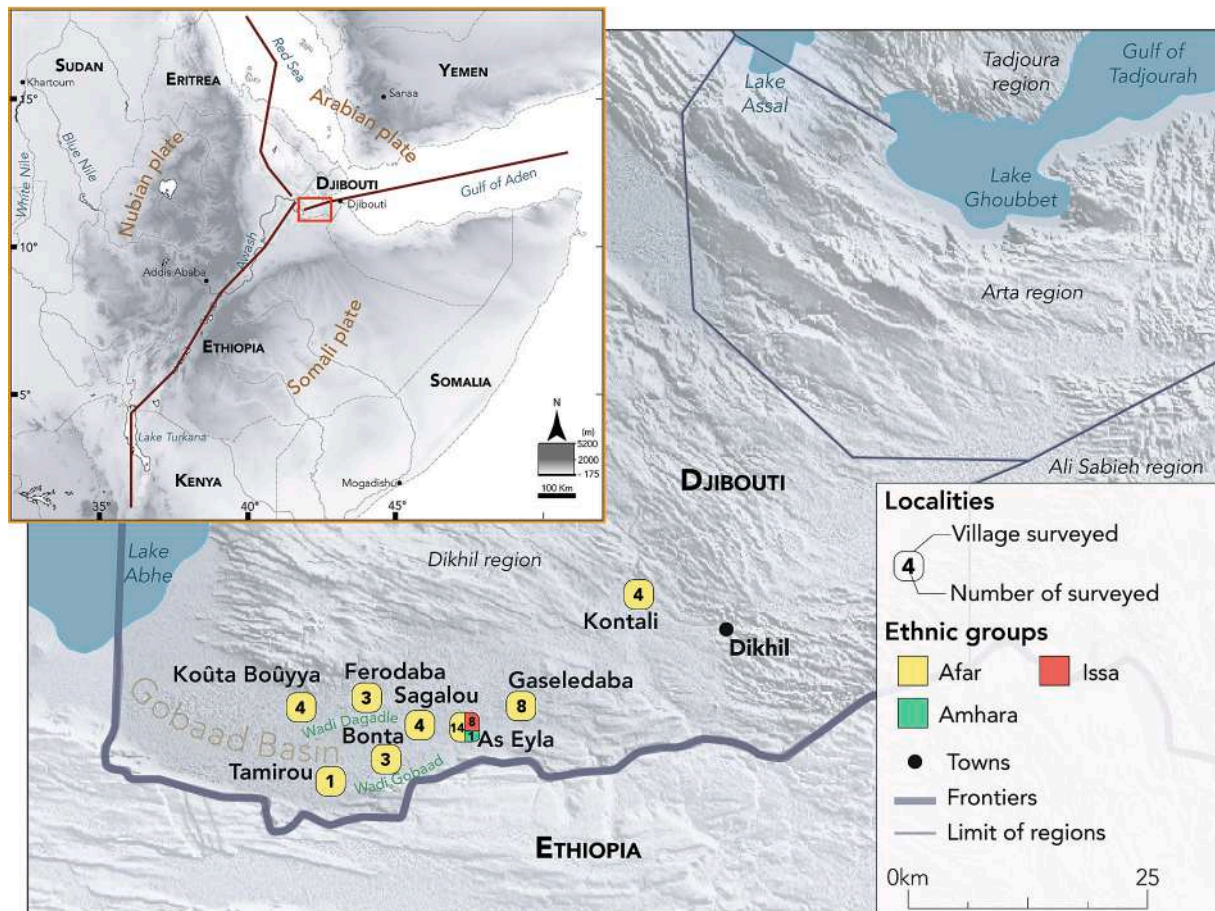


Fig. 1. General map and location of the earthen buildings surveyed in the Gobaad basin (Dikhil region, Djibouti) between 2022 and 2023 – CAD: E. Baudouin.

communities in the mountains south of the basin has always led to a tense dynamic which has resulted in numerous, and at times violent, conflicts. These days, despite some episodes of tension regarding the use of wells and disputes over pastures in a context of repeated droughts, these two populations, which are two of the main groups in the Republic of Djibouti, comfortably coexist in the town of As Eyla, although with a specific residential sector for each of them.

The sultanate underwent several important events during the colonial era. The first treaty with the French was signed on March 11, 1862 by the sultan Loïta. It was a Treaty of Friendship establishing close ties with France. His son Hummad Loïta then played a major role in preparing the Treaty of Ambado, which was signed in Obbock in 1885, allowing France to extend its presence into the southern part of the country. Relations between the sultanate and the French administration became conflictual from the early 1900s, however, and in 1930, Sultan Loïta the younger was deported to Madagascar at the same time as Vizier Houmed of Tadjourah. He died there in 1932. The sultanate was then abolished by the colonial authority, but this decision was never recognized by the Debne, who continued to designate new sultans. Since the creation of the Republic of Djibouti in 1977, it has been agreed that sovereign powers be shared between the customary rule of the sultan and the prerogatives of the State.

Even if the Issa living in the sultanate bear allegiance to the Sultan of Gobaad, they ultimately refer to a supreme political and religious authority, known as the Ugass. The Ugass is a young man aged between 15 and 20, chosen from the Wardig clan who represents the political and religious power over all the territories populated by the Issa, whether in Djibouti, Somalia or Ethiopia. The main characteristic of this kind of “king” is that he is an impartial mediator between the living to resolve the numerous conflicts between herder communities. The Ugass is also a

mediator between the living and the divine and between the living and the deceased by perpetuating the memory of the ancestors (Djama 2011).

The largest town in the area is As Eyla. It is here that the sub-prefecture is located, which centralizes the region’s medical (health post), educational (nursery school, elementary school, and middle school) and economic (artisan and agroforestry cooperatives) infrastructures. The population of As Eyla is estimated at 5,200 inhabitants, with an average age of around 15–20. The population’s economic and health status is very fragile, with incomes based on a declining activity of semi-extensive livestock farming and collective market gardens which are being degraded by climate change. There are also several small villages in the basin, located near the wadis, namely Katoumbati, Sissalou, Yalhalou, Iyakimbiro, Tewo Dabba, Garaytou, Kada Dalla, Bonta, Sagalou, Ferodaba, Kontali, Tamirou, Koûta Boûyya, Oudoukyia, and Gaseledaba. Finally, there are some, small scattered hamlets, involving single households (extended family units). In total, the basin has a population of nearly 10,000 people. In addition to goat breeding, additional sources of income include the production of charcoal and the sale of fruit and vegetables at markets.

### 3. Materials and method

The evolution of technical practices and the material culture is at the heart of anthropological and archaeological considerations. One way to approach it, masterfully addressed by Cavalli-Sforza and Feldman (1981), is by studying mechanisms of transmission and diffusion. The long-term perspective of archaeology allows us to observe transfers in technical and stylistic features. Interpreting them in sociological and historical terms (for example demic diffusion versus cultural diffusion;

phenomena of acculturation, assimilation, and deculturation; dynamics around the introduction of innovations, etc.) is fundamental in revealing evolutionary trends, however this is only possible by using models or modern-day references i.e. ethnographic references regarding transmission conditions (Valente 1999; Flache & Macy 2011; Roux et al. 2017).

Although these frames of reference are essential in understanding how elements of the material culture reflect social identities, boundaries, and changes in sociological and historical processes (population and depopulation mechanisms, conflicts, economic competition, and demographic pressure), they are still clearly insufficient. In view of this, the ethnoarchaeological project underway in Djibouti aims to build a reference base regarding the conditions of transmission and dissemination of technical architectural features in order to provide answers to the questions of the techno-economic and socio-cultural interpretation of Neolithic archaeological complexes. Earthen architecture is very common at archaeological sites and is still a widespread practice in traditional societies today, allowing us to consider modern-day examples. Technical practices are of particular interest when considering transmission and diffusion, for any technical practice used in construction, be it in the acquisition of raw materials, their preparation, or the choice of building methods, is based on knowledge acquired within a specific social environment. Technical performance arises from conventions that are intricately linked with social networks and always takes place within an environment that is structured by cultural heritage, norms and restrictions. In other words, by taking into account the way in which the materials are used, we can learn more about a society's cultural expression, just as we can with the style and form of the architecture.

Several methodological and theoretical challenges arise in compiling a modern-day reference base regarding the conditions of transmission of technical practices between individuals and social groups and the circumstances under which they are shared. In order to interpret the processes of cultural transfer, we must ask ourselves to what extent the complexity inherent in transfer phenomena and the unique socio-historical context of each modern-day environment allow for the development of transcultural models that have real informative value in archaeology. Gallay (2011) and Roux (2007) have both considered these matters. In their view, it is possible to acknowledge both the unique nature of individual scenarios and the existence of recognizable patterns. Today, several sociologists and psychologists agree that certain universal psycho-social mechanisms are involved in the borrowing of technical and stylistic features (Bril 2002; Barber 2006).

Documenting the evolution of technical traditions and the dissemination of techniques, or conversely, the refusal to borrow technical innovations then becomes a good way of understanding population dynamics and the mechanisms behind cultural mixing, assimilation, acculturation and conservatism. The presence of two different social groups in the Gobaad basin, the Afar and the Somali, makes it a particularly interesting area for defining communities of practice according to construction methods and learning processes (Wenger 1998: 3). It thus allows us to document inter-group diversity, to question how intra-group standardizations or inter-group differences are maintained, and to analyze whether the correlation between social perimeters and learning networks is effective in identifying phenomena of technical borrowing which themselves reflect diffusion mechanisms (*infra*). To understand these mechanisms and the meaning behind any diversity and changes over the long term, modern-day models are only of value if the research involves multiple ethnographic fields. As such, the study carried out in Djibouti is part of a broader program currently being developed. Finally, this type of research also allows us to develop a database on the methods used for the treatment of raw materials and the building techniques involved. This database will help improve protocols for analyzing Neolithic architectural remains. We have therefore compiled details on the technical gestures involved, the traces left by them, the production processes, and the explanations that accompany them.

In total, forty-nine surveys were carried out (eight within the Issa community and forty-one within the Afar community) over four weeks of fieldwork between 2022 and 2023 (Fig. 1). Initially, our research focused on the locality of As Eylā, where earth houses had been identified during surveys in 2021. Research was then carried out in a 25 km area around the locality with the aim of establishing whether there were differences in construction practices in the nearby wadis and, if so, to understand whether these differences were the result of technical, cultural or environmental constraints, particularly near the basalt hills to the north of the Wadi Dagadle. It should be noted that earth constructions in more remote areas have already largely disappeared. Our research therefore focused on three main areas: 1) Wadi Gobaad, the locality of As Eylā, and the surrounding villages of Bonta, Gaseledaba, Sagalou and Tamirou; 2) Wadi Dagadle and the villages of Ferodaba and Koûta Bouyya; and 3) the village of Kontali, 9 km from the town of Dikhil.

The survey took the form of a questionnaire divided into four sections, aimed at meeting four objectives: 1) documenting the techniques used, by recording information on the construction materials, building methods, and shape of the buildings; 2) referencing different practices, recent changes, and the socio-cultural context in which they took place; 3) identifying the networks involved in the dissemination of practices within the same group and/or within different coexisting groups; 4) defining the learning processes involved around earth construction. This questionnaire was accompanied by other means of data acquisition such as audio recordings of the surveys to facilitate their transcription and photographic coverage to create visual archives, serving as scientific proof of the technical acts involved (Griaule 1957; Mauuarin 2022).

#### 4. Description of techniques

To meet these methodological requirements, it is essential to document the technical, social and economic factors influencing earth construction practices in the Gobaad basin among the Afar and Somali populations.

##### 4.1. Use of natural resources

Earth construction depends on several fundamental resources: the earth itself, which is often obtained near the construction site; the wood (for the framework or for the walls if they are made of wattle-and-daub); and the water, which often needs to be brought from the wadi by car or on camels, as well as the temper that are added during the preparation of the earth to make it suitable for construction. One of the main admixtures used is tamarisk (*Tamarix nilotica*, known as *saganto* in the Afar vernacular) (Fig. 2A/B). The fibrous properties of the leaf make it an ideal complement to prevent the mud from cracking during drying. However, the increased aridification of the Gobaad basin in recent decades is causing the disappearance of this species from the region (Moussa Ibrahim et al. 2010). It has gradually been replaced by an invasive species, *prosois juliflora*, which was artificially introduced in the 1980s to limit desertification in the Gobaad basin (Choge & Pasiiecznik 2014: 12), however this has contributed to the depletion of water resources and local flora. The shortage of tamarisk has had a direct impact on architectural practices since it has forced builders to adapt to their environment and use other plant resources (*prosois*, straw, or acacia), or mineral tempers, animal droppings, or ash.

##### 4.2. Materials and building techniques

Two earth construction techniques have been identified in the region: molded mud bricks and wattle-and-daub. Molded mud bricks are a prefabricated material, made prior to the construction of the building, while daub is prepared during the construction process and is used as an infill on wooden frames. According to the traditional knowledge of



**Fig. 2.** Sequence of the *chaîne opératoire* for the molded mud bricks. The temper commonly used is *tamarix nilotica* (A-B), added to earth and water and mixed with a pick axe (C). The mason wets the internal walls of a bottomless mold (D) before throwing a ball of mud packed down with a fist, the excess earth scraped away by hand (E) before removed from the mold (F). The mud bricks are left to dry in the sun (G), one side at a time (H) during 5 days – Copyrights: Q. Aubourg, E. Baudouin.

experienced builders, the color of the earth is an essential qualifier. They thus differentiate between “good”, red or brown earth (*asaqalla* in Afar), which is used for building, and “bad”, white-colored earth, which is unsuitable for construction (Baudouin accepted). In total, 30 samples were collected in the field to carry out additional studies (micromorphology, geomorphology, physico-chemical analyses) on the sediments and earthen materials to characterize the nature of raw material used in earthen construction.

#### 4.2.1. Molded mud bricks

The earth for making the bricks is generally sourced near the home, often less than 200 m from the construction site. The apprentices dig it up with a pick axe in the extraction pit before mixing it by hand and gradually adding a temper and water (Fig. 2C). Only the mason has the authority and skills to assess when it is ready. It is then left to rest under a canvas for two days. Following this, the earth is mixed again before making the bricks. The masons use the so-called “à coup d'eau” technique [water splashing] (Doat et al. 1979: 113–116), which consists of wetting the internal walls of a bottomless mold (Fig. 2D) before throwing a ball of mud into it, which is then packed down with a fist. Any excess earth is scraped away by hand (Fig. 2E) before it is removed from the mold (Fig. 2F). The bricks are then left to dry in the sun, one side at a time, for approximately 5 days (Fig. 2G–H). To make 100 bricks, 25 L of water and two 50 L bags of tamarisk leaves are needed. The masons estimate that making bricks for a 4x4m dwelling can take up to 6 days, at a production rate of 100 bricks per day. This technique is used exclusively by the Afar (79 % of buildings).

With brick construction, the use of foundations and/or a substructure helps to protect the base of the walls and prevent capillary rising damp (Margueron 1985: 4). This practice is not systematic however, and mainly depends on the owner's financial means. Where such structures are observed, they are used equally by both social groups. The same technical methods are used by Afar for digging foundation trenches and building a substructure using stones and cement. In terms of the construction of the brick walls, builders follow two simple principles: the joints do not overlap from one course to the next (Aurenche 1981: 118), but they do vary the assembly methods on the horizontal plane (brickwork).

Two methods can be distinguished in the arrangement of the bricks. The most frequent is the arrangement in stretcher bonds (Fig. 3A), which involves juxtaposing the bricks so as to leave leaving the longest side visible along the axis of the wall. The second method involves the alternating arrangement of stretchers and headers, either on the same course or over different courses, so the long side of the bricks is either parallel or perpendicular to the axis of the wall (Fig. 3B). This second method, which is more expensive in terms of construction materials, is recommended to owners by professional masons but is rarely used for financial reasons. The only observed cases of constructions built using this method are relatively old buildings, dating to before 2001, found in the city center of As Eyla, Kouïta Bouÿya, and Gaseledaba, belonging to professional masons or wealthy Afar traders.

#### 4.2.2. Wattle-and-daub

In the case of wattle-and-daub, the earth does not have a structural function (Aurenche et al. 2011: 28), as it is applied directly to a supporting wooden structure. During our field study, it was not possible to observe the construction of wattle-and-daub walls, however the 17 testimonies collected on this technique (Fig. 3C) corroborate observations made elsewhere, without any variations being remarked in the *chaîne opératoire* (Pelmoine & Mayor 2020: 12). The species used are mainly tamarisk, acacia and prosopis. Since the daub is not self-supporting, it is applied in a relatively wet state (Aurenche 1977: 57). The wooden frame thus forms the structure of the building. A foundation trench a few dozen centimeters deep is dug at the location of the wall. A framework of posts and stakes is put in place before the trench is filled with stones and compact mud (Fig. 4A–B). For the positioning of the

wattle, standard procedures can be observed, with larger pieces of wood (10–15 cm in diameter) placed vertically at the corners of the building and on the short and long sides of the building (Fig. 4C), unevenly spaced apart, depending on the construction (between 40 cm and 1.5 m). Stakes of a smaller diameter (3–8 cm) are placed vertically between these posts (Fig. 4E). Horizontal poles (Fig. 4D), unevenly spaced, 20–80 cm apart, are then attached to the posts and stakes with cords made of plant materials (bendy tamarisk branches) or, more often, with leftover fabric rope and plastic ties (Fig. 5B). The wet daub is then plastered onto the wooden frame and smoothed with the flat of the hand or a tool (Fig. 5A–C–D). This technique is documented in more than 21 % of cases among the Afar, while among the Issa, earth constructions are entirely built with wattle-and-daub.

#### 4.2.3. Roof structures

Three types of roofs can be distinguished in the Gobaad basin: conical roofs with concentric frames, gable roofs, and flat roofs (Fig. 6). The concentric frames are made of an assembly of tamarisk or acacia wood and palm leaves and are only used for circular buildings (Fig. 6C). With this style of roof, pieces of wood about 6–10 cm in diameter, are arranged radially and grouped together at the top of the roof, which is generally supported by a central post (Fig. 7A). They are then connected to each other by a succession of concentric rings made of flexible branches and held in place with plant or plastic ties (Fig. 7B). The distance between the concentric rings becomes greater the further they are from the top of the roof. Dried palm leaves fill the gaps and are also placed above the frame and held in place by ties. This form of roof seems more favored by the Issa (50 %) than the Afar (18 %).

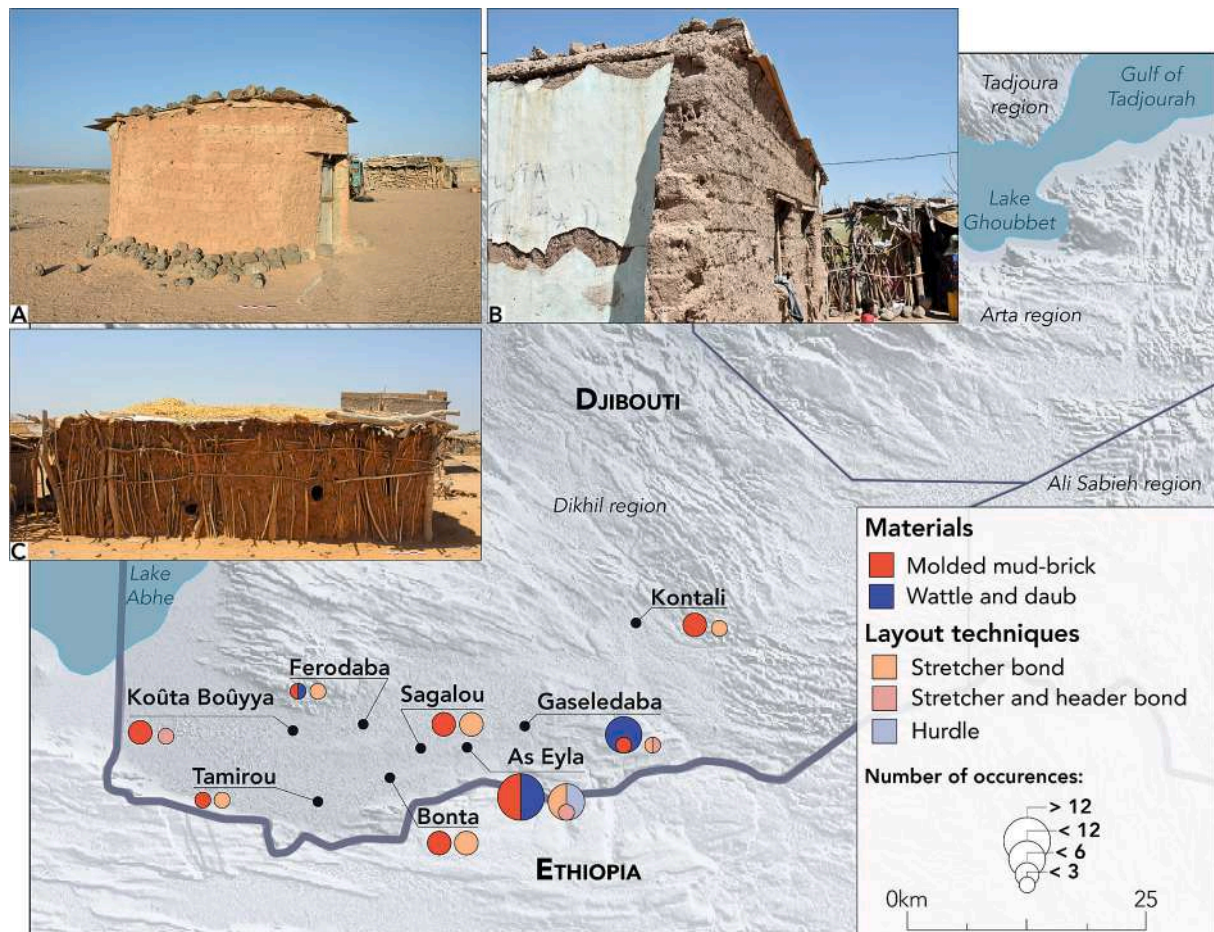
All the quadrangular buildings have gable roofs (Fig. 6B). The slope of these roofs is gentle—less than 45°—which can make them appear flat from the outside. The ridge pole is often made of a metal tube approximately 10–15 cm in diameter (Fig. 7C–E), spanning the entire length of the building, while the purlins are made of wooden logs of the same length, approximately 6–10 cm in diameter. Finally, the rafters are composed of wooden logs approximately 4–8 cm in diameter, which are then installed on the purlins and firmly attached to them by plant ties (woven palm?) or pieces of fabric. Depending on the size of the building, one or more posts support the ridge pole. In some cases, the roof is also reinforced by posts placed at the corners or even on the lengths of the building, but always on the outside (Fig. 7D). This type of roof is documented among both the Issa (33 %) and the Afar (29 %).

While flat roofs are the preferred shape for quadrangular buildings, they are also found on some circular buildings in mud brick. The flat roofs are actually slightly inclined to facilitate the drainage of rainwater (Fig. 6A). They rest on a wooden frame made up of a series of square beams about 8–15 cm wide and joists spaced about 80 cm apart. This style of roof is exclusively documented among the Afar.

With all three types of roof, the framework is covered with tarpaulins and sheets of corrugated iron (Fig. 6A), which require less maintenance than the palm leaves traditionally used (Fig. 6C). Observation of the roofs shows that they most often involve an assembly of mixed materials including plastic tarpaulins, textiles, concrete blocks, and even tires (Fig. 7E–F), in other words, any reusable material likely to weigh down the sheets of corrugated iron or wood and waterproof the roof. These results show that while the Issa do not use flat roofs, there is no particular preference for the conical or gable roof among the Issa and the Afar.

#### 4.3. Household organization

Each household is organized into several interdependent structures with different functions. The earth constructions are generally for



**Fig. 3.** Distribution of materials and layout techniques – CAD: E. Baudouin. Circular building in molded mud bricks arranged in stretcher bond (A); Rectangular building in molded mud bricks arranged in stretcher and header bond (B); Rectangular building in wattle-and-daub (C) – Copyrights: Q. Aubourg, E. Baudouin.

domestic use,<sup>2</sup> mainly for sleeping, but they can also involve other activities, such as storage or cooking. They are accompanied by other constructions, generally used for receiving guests, resting, storage, and cooking. These structures can take different forms and may be exclusively built from reclaimed wood known as *dabo* in the Afar language (Fig. 8A-B). In parallel, the *daboyta*, the traditional Afar habitat, may also be used as a storage or cooking area. The *daboyta* is a type of nomadic construction made of flexible wooden frames covered with mats that have been hand-woven by the women (Morin 1980). They can be found alongside circular wooden enclosures dedicated to pastoral activities and buildings made of reclaimed materials.

The households are either open, the buildings being organized together without any physical limits, or enclosed by a hedge of shrubs and thorny plants. There is a clear morphological difference between the organization of the Afar inhabited space, which is mainly open (95 %), and the Issa inhabited space (Fig. 8C), which is exclusively closed. In terms of the flooring in the domestic buildings, the Afar prefer beaten earth (87 %) while among the Issa we can observe the use of sand (50 %), gravel (25 %) or a mixture of earth and gravel (25 %). For the outside walls, red earth is favored by both groups (46 %). In other cases, gray earth (5 %) and cement (3 %) are used exclusively by the Afar. Plaster made of a mixture of earth and cement is used by both the Afar (3 %) and the Issa (8 %). For the interior plaster, red earth is favored by the Afar (25 %) and frequently used by the Issa (23 %) while cement is

used in 10 % of cases by the Afar compared to 25 % by the Issa. Gray earth is only used by the Afar (8 %) to coat the interior walls of buildings. Finally, the most widespread architectural type is the single-cell rectangular habitat, which predominates over multi-cell quadrangular habitats and circular houses, which are always single-cell (Fig. 6). The single-cell quadrangular form is the most common structure among the Afar (69 %). In this social group it is found alongside multicellular quadrangular forms comprising a maximum of two housing cells (7 %) and circular forms (24 %). Conversely, among the Issa, circular forms are more common (62 %) than single-cell quadrangular forms (38 %).

#### 4.4. The lifespan of earth constructions

Contrary to common assumptions, wattle-and-daub houses have an average lifespan nearly equal to that of brick houses, lasting 18 years compared to 21 years. In half of the cases, brick buildings are used for 12–27 years compared to 12–28 years for those made of wattle-and-daub (Fig. 9). This data confirms the relative longevity of earth constructions, especially if the plastering is regularly maintained. A comparison of data regarding the lifespan of buildings and the presence or absence of foundations and/or a substructure shows that in half the cases, a building will last for 7–29 years if it has foundations, 12–28 years if it only has a substructure, and 16–30 years if it has both. In the absence of either, the lifespan of the buildings drops to 11–24 years (Fig. 10).

<sup>2</sup> In few cases, earthen architecture is chosen to build community buildings as mosques.



**Fig. 4.** Wattle-and-daub technique. Foundation and basement with stones and compact mud (A-B). Large pieces of wood are placed vertically at the corners and long sides of the building (B-C). Horizontal poles, unevenly spaced, are then attached to the posts and stakes with cords made of plant materials (D). Stakes of a smaller diameter are placed vertically between these posts (E) – Copyrights: Q. Aubourg, E. Baudouin.



Fig. 5. Wattle-and-daub technique. Poles and branches are attached with cords or fabric rope (A-B). The wet daub is plastered onto the wooden frame and smoothed with the flat of the hand or a tool (C-D) – Copyrights: E. Baudouin.

#### 4.5. Stakeholders in the construction sector

Mainly for financial reasons, the sourcing and delivery of the raw materials is usually carried out by the owner, family, friends, or with help from the community (*lula* in Afar). Building professionals play very little role in this initial stage. This pattern is reversed, however, when it comes to preparing the mud and carrying out the building work. Building professionals (masons and laborers), who are exclusively male, intervene in nearly 64 % of cases, and the help of the owner, family or community becomes secondary.

According to our surveys, professional masons seem to be particularly involved in the construction techniques considered complex—according to both the owners and builders—in particular, preparing and building mud brick walls and roofs. In the case of mud brick buildings, the selection of the earth, mastery of the mixing process and experience in building techniques play a determining role in the final result. However, the selection of the earth and the molding of the bricks can also be carried out by qualified workers or by attentive laymen. There appears to be a sharing of knowledge between professionals and amateurs through observation and practice at construction sites. However, experienced masons are more in demand in the construction teams for brick buildings (61 %) than in the case of wattle-and-daub (25 %).

#### 4.6. Building professionals: Organization of work and transmission of knowledge

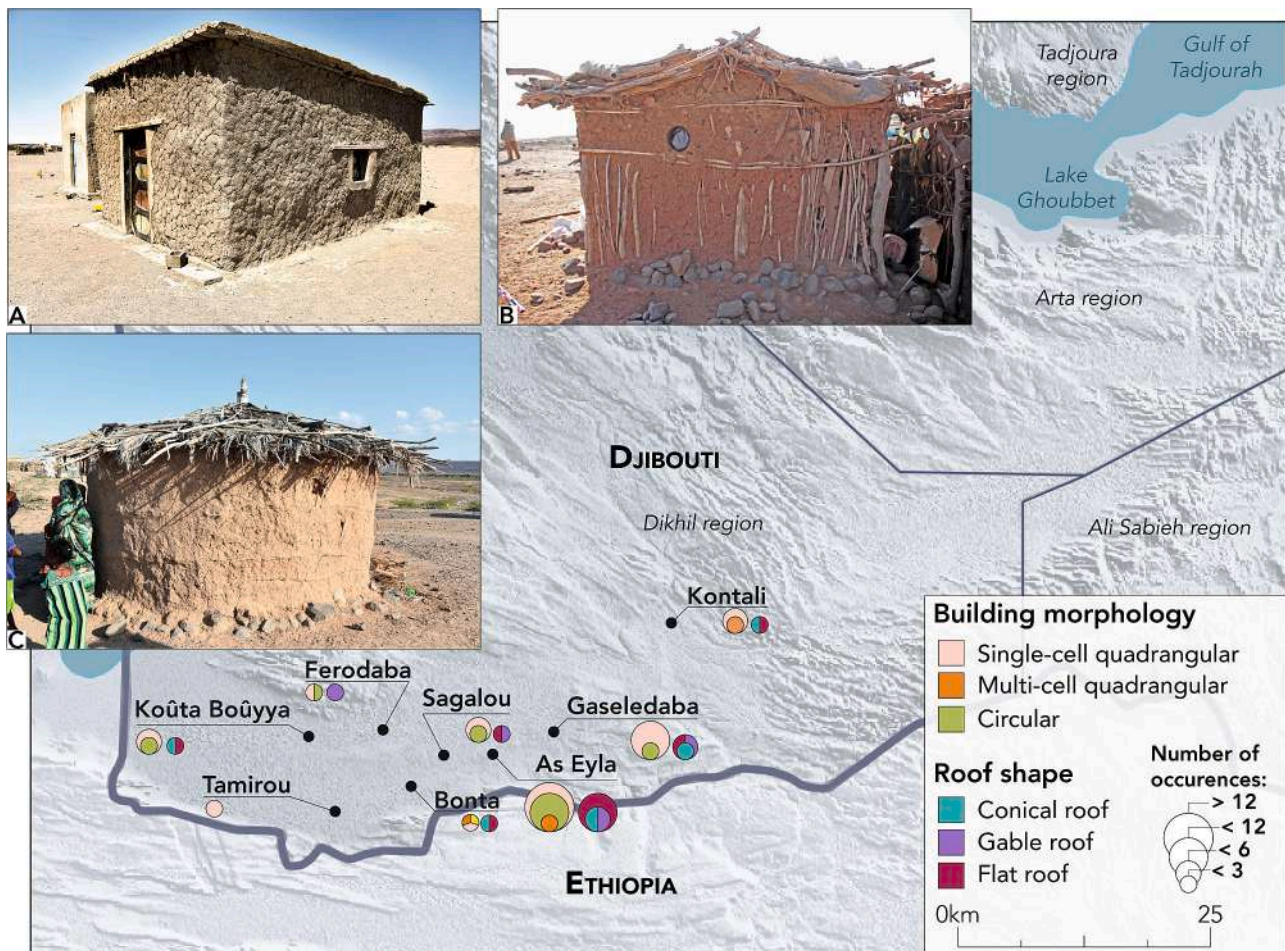
All the builders interviewed were from the Afar community. They all agreed that mud houses are generally built by professional masons at the request of the owners. They also confirmed the disappearance of earth

constructions in favor of concrete blocks: those who continue to this day as masons now only build with concrete blocks. The last time one of the builders was employed for an earth construction was in 2019. This observation is striking and shows to what extent knowledge linked to earth construction is in danger of disappearing in the region. With the exception of two builders, they all mentioned the fact that the masons and apprentices work together in cooperatives or associations, grouping together 1 to 6 masons for 8 to 15 apprentices. They tend to meet regularly, up to once a month, but most often when they are called for work.

In three-quarters of cases, the existence of a real specialization is mentioned, implying that masons and apprentices are recruited for specific skills: the chief mason supervises the work and builds the walls, while the apprentices make the bricks, but may also have a specialty (preparing the daub, plastering, building the wooden framework, etc.). None of them mentioned the existence of a hierarchy within the cooperatives however (other than the special place given to elders, who are considered wise) nor the existence of a particular status granted to the mason and his apprentices.

In terms of pay, they are either paid by the day or work under a contract negotiated in advance with the owner. For a house, the price amounts to around 100,000 Djiboutian francs (US\$610)<sup>3</sup> paid directly to the mason. Depending on the situation, the daily rate for a mason is estimated between 1,500 and 4,000 Djiboutian francs (US\$9.2–24.5/day), but can be as low as 1,000 Djiboutian francs (US\$6/day) (rate

<sup>3</sup> The currency conversion from Djiboutian franc to US dollar is related to the end of April 2024 exchange rate (US\$1 = 177,76 Djiboutian francs).



**Fig. 6.** Distribution of the shape of buildings and roof shape – CAD: E. Baudouin. A single-cell quadrangular building with a flat roof (A); A single-cell quadrangular building with a gable roof (B); A circular building with a conical roof (C) – Copyrights: Q. Aubourg, E. Baudouin.

negotiated by the owner) and as high as 5,000 Djiboutian francs (US \$30/day) in the case of work far from home. For workers, the daily wage ranges between 1,500 and 2,000 Djiboutian francs (US\$9.2–12/day).

Their mobility varies greatly, with some builders only working in As Eylâ, Gaseldaba or Sagalou or within a radius of less than 5 km (between Gaseldaba and As Eylâ, for example, where the communities seem to have close ties), while others may go as far as Dikhil (30 km) or Tadjoura (120 km) for a higher daily wage (Fig. 11).

The trade is often learnt within the family (6 cases out of 8) and is often a paternal heritage. The first stages of the apprenticeship concern preparing the mud and using brick molds, before moving on to masonry work and building the walls. On average, apprenticeships begin at around age 12, with a training period of approximately 6 years to become a confirmed mason.

## 5. Standardization and diversity of techniques among the Afar and Issa

Based on these results, we sought to compare architectural practices among the Afar and Somali groups, taking into account the environmental, social, economic and historical criteria. The objective was to characterize the diversity of architectural practices, whether high or low, based on empirical observations. At the end of this article, three scenarios are proposed.

### 5.1. Diversity in architectural practices among the Afar

The first scenario concerns the significant diversity in architectural

practices across the Gobaad basin within the Afar community (Fig. 12). There are a multitude of combinations, including quadrangular brick buildings with gable roofs (15 %), quadrangular wattle-and-daub buildings with gable roofs (12 %), circular brick buildings with conical roofs (9 %), circular wattle-and-daub buildings with conical roofs (6 %), and circular brick buildings with flat roofs (6 %). This diversity is relative if we take into account a general trend towards quadrangular brick houses with flat roofs (52 %). It cannot be attributed to the conditions of the natural environment, which are similar throughout the Gobaad basin. In other words, if the environment does not play a determining role in the choice of technical practices, the diversity can be explained, according to Besenval (1984: 168), by the significant impact of socio-cultural factors.

It is therefore necessary to explain this architectural diversity among the Afar by tracing the history of techniques and the actors involved in their transmission, with the aim of documenting the processes of borrowing, non-borrowing and adaptation. Multiple, largely concomitant factors actually come into play in the case of the Horn of Africa, which can partly explain the diversification in housing types. Among these is the gradual sedentarization of nomadic breeders in urban areas, a phenomenon that accelerated in the 1970s (Chire 2000), where breeding was no longer possible as it was in the vast grazing areas of the old way of life. These areas were distributed among families and tribal fractions according to strict rules which were very respected in the Afar world (which was not the case in the Somali world). The great difficulty and need of families who are now increasingly settled is to find new resources, mainly in the informal economy, in the absence of that provided by owning livestock. The resulting food insecurity, which is



**Fig. 7.** Roof shape and framework. The concentric frames of the conical roof are arranged radially and grouped together at the top of the roof (A) attached with plant or plastic ties (B). For the gable roofs, the ridge pole is made of a metal tube while the purlins are made of wooden logs and attached by plant ties or pieces of fabric (C). The slope of these roofs is gentle and reinforced by posts placed at the corners and on the lengths of the building on the outside (D). The framework is covered with mixed materials including plastic tarpaulins, textiles, concrete blocks, and even tires (E-F) – Copyrights: Q. Aubourg, E. Baudouin.

compensated as best as possible by the Djiboutian government and Western food distribution programs, has had, among others, the consequence of changing living spaces. We can thus observe the appearance and multiplication of quadrangular shape buildings for storing food in domestic compounds, while in the traditional nomadic domestic space, round structures, which were the norm, are tending to disappear, regardless of their function (Le Bozec 2004).

Since the 1960s, the democratization of quadrangular habitat has coincided with the introduction of molded mud bricks by Westerners. While our research in Djibouti does not go back beyond this date, other sources indicate that the introduction of ‘Western’ molded mud bricks occurred in certain regions of the Sahel in the 1930s (Lauber 1998). The

1960s and 1970s align with the opening of the brickworks “La Tranchée” in As Eylā. Few details are available about this factory, other than that it remained active until the early 1990s. The shift in construction methods during this period was accompanied by the emergence of the first skilled masons in Djibouti. They were generally former nomadic herders from Afar community transitioning to a new trade in urban areas. They were trained by Yemeni masons commissioned by the French state. Upon completing their training, they received a state diploma issued by the French government. This official recognition led to the institutionalization of masonry work, and thus to the development of cooperatives of masons and workers that endured after Djibouti’s independence in 1977 within the Afar community.



**Fig. 8.** Traditional light Afar habitat and household organization in Issa. *Daboyta* covered with basketwork and internal wooden structure (A-B). The Issa inhabited space is enclosed by a hedge of shrubs and thorny plants (C) – Copyrights: Q. Aubourg, E. Baudouin.

Alongside this type of architecture, there is a lesser proportion of circular wattle-and-daub houses with conical roofs. All investigations indicate that these dwellings were built by refugee masons from Ethiopia in the 1980s and 1990s, who are generally thought to have belonged to the Oromo and Amhara ethnic groups present in As Eylā (Fig. 1). This kind of housing was considered by those interviewed as exogenous to the region. They described these habitats as “Ethiopian style”, designating both the circular shape of the housing, the construction technique (wattle-and-daub) and the conical shape of the roofs. In the collective memory, this type of habitat appeared in the Dikhil region in the early 1980s. While Ethiopian migrations to Djibouti have long existed (Mahamoud Ismael 2018), this element can be corroborated by historical facts, given the main migratory phase towards the Republic of Djibouti in the 1970s and the repeated wars in Ethiopia in 1977 (Ogaden) and 1991, which lead to an unprecedented rural exodus. As far as we know, this “Ethiopian style” cannot be linked to a specific social group nor to a particular geographical area, even if there is mention of connections with the region of Dire Dawa, 160 km south of the Gobaad basin (Fig. 11). But the most interesting aspect is the reappropriation of certain exogenous techniques by Afar builders. One observes an architectural hybridization of the “Ethiopian style”, resulting partly from an adaptation process by Afar builders. This is the case with wattle-and-daub used in Afar quadrangular houses, or circular houses made of mud brick. Depending on the architectural features involved, three

reasons may explain this hybridization: 1) It may involve economic concerns. This is particularly the case for quadrangular wattle-and-daub houses with a gable roof (12 %), where the choice of wattle-and-daub by Afar owners is driven by the need to reduce the cost of building their house. Typically, the owners build their own houses after a period of observation and training (i.e. by participating as laborers on construction sites) under the guidance of skilled Afar masons. On their sites, owners do not hire professional masons, whether Afar or Ethiopian, for same economic reasons. This also implies that the most likely hypothesis is that some Afar masons have also trained in these techniques due to high demand from a part of the population wishing to work independently afterward; 2) It may also reflect a desire to preserve traditional techniques. Regarding circular flat-roofed brick houses (6 %), these are linked to an intention by Afar owners to preserve a heritage connected to Ethiopian traditions through the shape of the structure, while “modernizing” it by incorporating bricks. Afar owners express a sense of nostalgia for circular earthen housing, which they have seen disappearing over the past few decades. To build their houses, they either hired Afar masons or Ethiopians masons who had been trained as laborers on construction sites in Djibouti by Afar masons; 3) The third situation reflects the preservation of strong cultural ties between Afar owners and Ethiopia through the maintenance of specific know-how, as is the case for circular brick houses with conical roofs (9 %). In an exceptional case, the construction was entirely built by and Afar mason

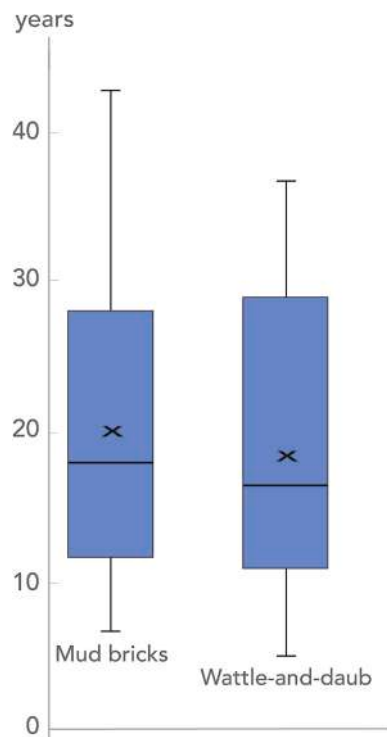


Fig. 9. Duration of use of buildings according to the materials used – CAD: E. Baudouin.

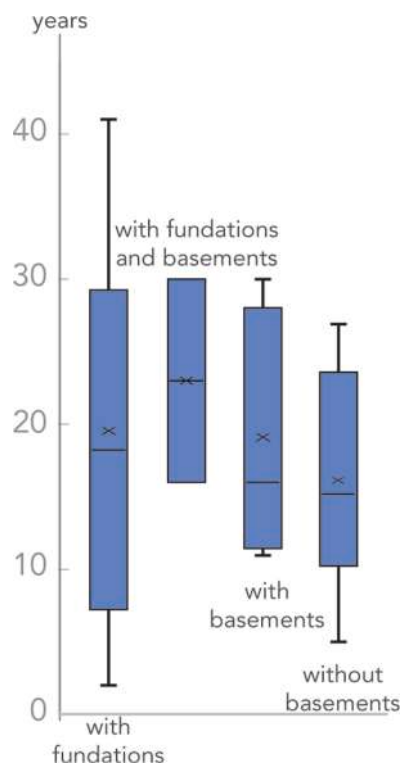


Fig. 10. Duration of use of buildings depending on whether or not foundations and/or basements are used – CAD: E. Baudouin.

who traveled to Ethiopia and learned traditional construction techniques there, including roof building. In another case, the construction resulted from a collective effort evolving an Afar mason for brick making and wall construction, and an Ethiopian craftsman for the conical roof.

This variability within the Afar community is explained more by the history of technical practices than by the function of earthen buildings, which generally remains unchanged compared to the traditional *daboyta*, where multifunctional activities within a single-cell dwelling are still the norm. However, the legacy of traditional Afar nomadic housing has been considerably affected by the lifestyle changes experienced by communities during their shift to a sedentary way of life. From these historical and socio-cultural aspects, we can then identify the specific characteristics of the Afar group. Thus, the evolution of earthen architecture in the region is complex. The quadrangular house made of molded mud bricks with a flat or gable roof, from Western origin, is built by Afar masons for the Afar community. In terms of cultural dynamics, this situation reflects a case of technical innovation that may have developed through the gradual specialization of the masonry trade. Moreover, the circular wattle-and-daub dwelling with a conical roof of “Ethiopian style”, which reflects a situation of demic movement (see below), was not directly reappropriated by Afar communities because it requires specific skills, particularly for the roof. However, Afar builders have borrowed certain technical features (see above) and the resulting technical hybridization reflects the architectural variability within this cultural group. If we take Morin’s description, Afar identity is based on “a dual definition, one which is both geographical and agnatic, of what we indifferently call a tribe or clan, i.e. the patrilineal group to which all Afar belong and relate to from birth” (Morin 2004: 16). The author also emphasizes the Afar’s great capacity for assimilation. This would explain the permeability of techniques within the region’s communities, leading to an abundance of stylistic variations across the Gobaad basin. Modern-day models have shown that we borrow more from individuals outside our social perimeter, implying a certain geographical distance from the group where the borrowing is adopted, and that an individual is more likely to borrow if they themselves are an expert in the field (Roux 2020: 26). In other words, they are more likely to borrow if they already have the capacity to explore new activities within their practice and are able to force the system by going beyond the cultural representations that have formed their “way of seeing and doing things”, thus solving problems and discovering new techniques and skills (Roux 2015; Roux & Lara 2016; Roux et al. 2017; Manzo et al. 2018; Roux & Manzo 2018; Roux et al. 2018). In this context, the assimilation and subsequent adaptation of techniques naturally lead to a wide variety of methods through liberties taken during the construction process (Dietler & Herbich 1994). As we have seen, this can be explained by economic factors, as in the case of wattle-and-daub, or by identity-related factors, when it comes to the circular shape of the dwellings and the conical roof, which are linked to the preservation of technical traditions and strong cultural ties with Ethiopia. Thus, ethnic style involves “the specific way a given community chooses to mark forms, values and rhythms” (Leroi-Gourhan 1965: 93), which does not prevent it from being considered the marker of group identity. It represents both the combined influence of the individual and the group in the architectural variations observed and the stylistic features specific to the group (Coudart 1994: 236). In line with this, studies into learning processes have revealed that the mechanisms for acquiring complex motor skills are governed by biological processes that require an individual learn not by innovating, but by reproducing from a model (Bril 2002; Bril & Goasdoué 2009; Bril et al. 2010). Once the learning process is completed, the subject will have fully consolidated the necessary motor and cognitive skills, however these skills will only have been developed according to the current model in their culture. Based on this model, they will have constructed a representation of the technical process, shared by all the actors within their culture (Roux 2016). In other words, while there are variations in the content learnt at a cultural level, the learning processes are universal if we consider that the acquisition of a skill is not innate, but adopted through a process of education and socialization that is deeply influenced by the human and material environment in which it takes place.

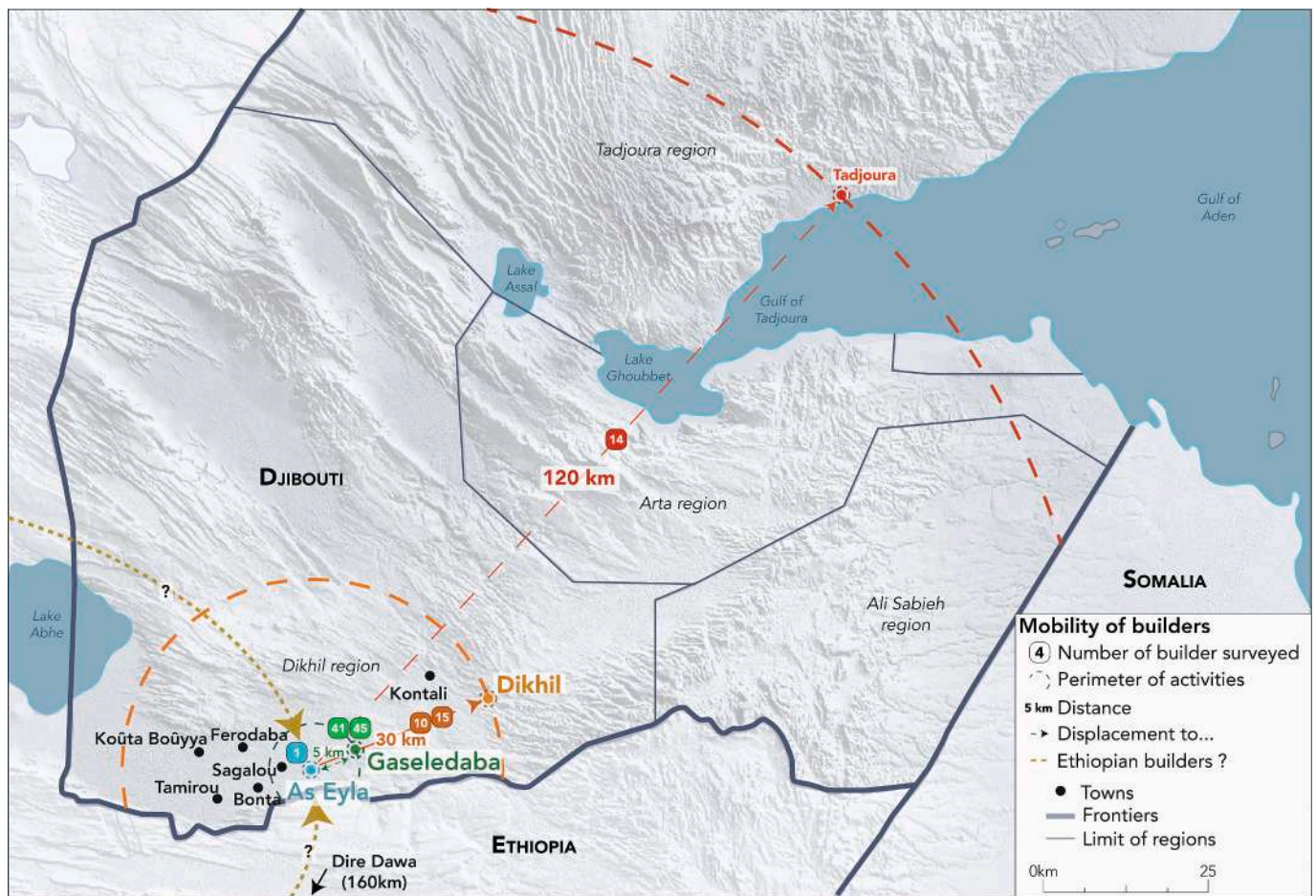


Fig. 11. Mobility of masons interviewed – CAD: E. Baudouin.

### 5.2. Persistence of an architectural tradition in the Issa community

In the second situation, with regard to the Issa community, the architectural combinations are more limited, with a preference for circular housing with conical roofs and quadrangular housing with gable roofs (Fig. 12). Furthermore, if we consider certain features in isolation, such as wattle-and-daub, which is the only technique used among the Issa, or the organization of households, whose closed form is systematic in this group, we see the presence of distinctive traits. As previously, circular wattle-and-daub housing with conical roofs in Issa communities are systematically attributed to Ethiopian builders and was not reappropriated as it is by the group. For the quadrangular habitat with gable roofs, there has been a technical reappropriation through borrowing, following a pattern that must be similar to that observed among the Afar people. In other words, these two architectural combinations result from two different social groups. However, the most unexpected result is the absence of mud brick constructions among the Issa, despite it being a characteristic of Afar architecture. The observed imbalance is due to the Issa mainly relying on Ethiopian masons or builders from their own community, which limits the introduction of new techniques like molded mud bricks and flat roofs.

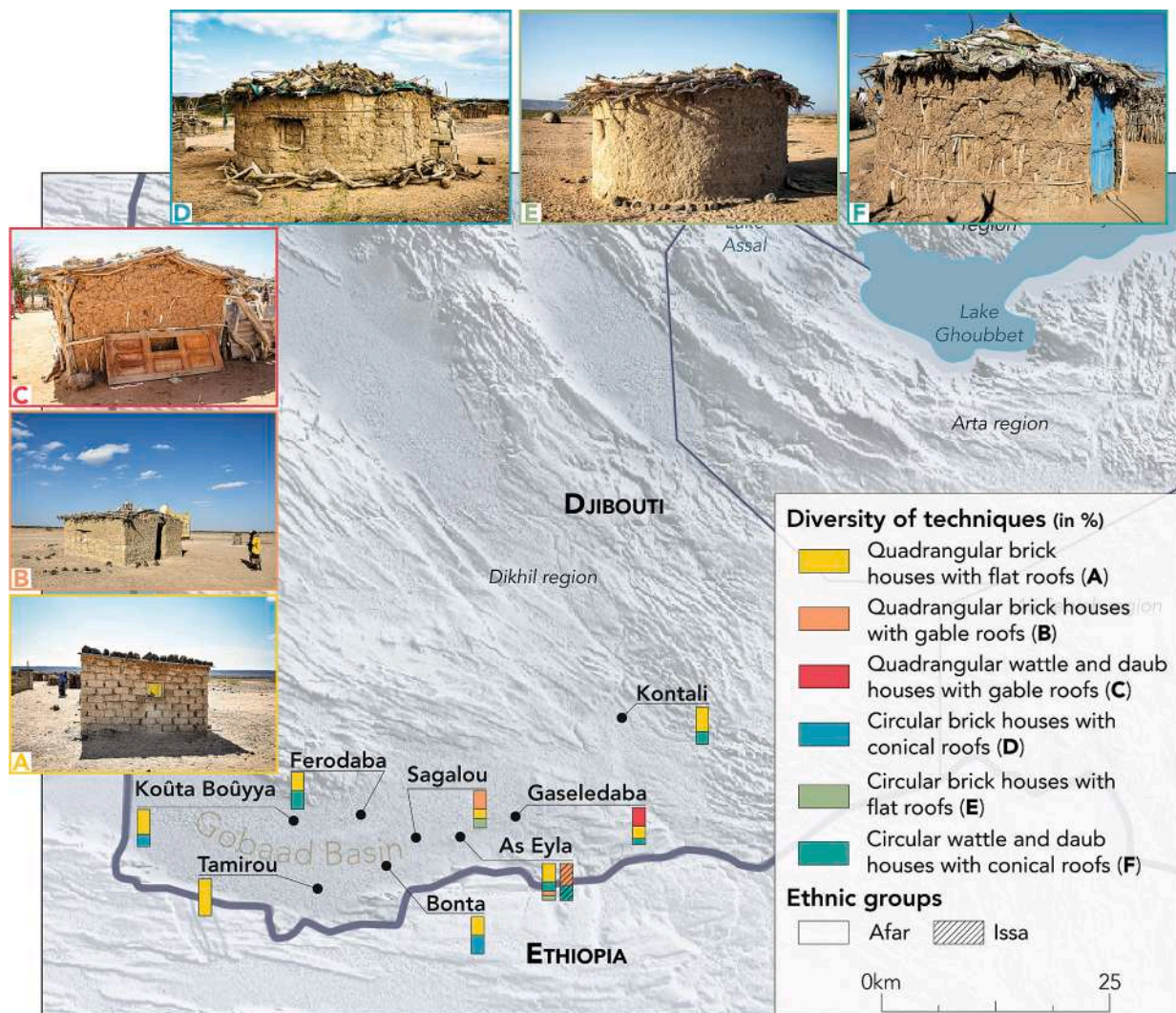
The Issa seem to deliberately rely on their own resources and traditions for building, thus emphasizing their independence from Afar architectural influences. Consequently, the technological boundaries in relation to the Afar group remain stable, leading to the preservation of distinctive norms and techniques that limit the possibilities of architectural combinations. This also highlights that the Issa have not had access to the same learning networks as the Afar, which results in the absence of professionalization in the masonry trade within this

community and explains the lack of brick-making techniques.

We can therefore observe a technical boundary which is representative of a social boundary. This hypothesis can be corroborated by the continued geographical isolation of part of the Issa community within a residential district of As Eylā, limited to around ten households. The reasons for these observations are likely to be found in the organization of the Issa community itself, as has been observed within other social groups (Pelmoine & Mayor 2020: 5). The endogamy characteristic of the region's nomadic herders (Piguet 1998) could explain the closed identity of the Issa in contrast with the greater social diversity observed among the Afar, who are the region's majority group. Chetima (2019: 16) has well documented this phenomenon in Cameroon. He highlighted the fact that social relationships, in particular marital relationships, play an important role in the fluidity or compartmentalization of technical exchanges between different social groups. About mechanisms, the transmission of technical characteristics can be analyzed in terms of standardization (Roux et al. 2017): technical boundaries are correlated with learning networks (Gallay 2007), rooted in specific cognitive structures and cultural traditions that influence how technical knowledge is transmitted and adopted. Polarization, i.e. the tendency of groups to develop distinct technical preferences, reinforces cultural differences and makes technological boundaries more robust against social exchanges (Flache & Macy 2011).

### 5.3. Introduction of a new type of house and dynamics of non-borrowing of exogenous technical traits

Finally, the third scenario concerns the presence of a particular kind of habitat in the Gobaad basin: circular wattle-and-daub houses with



**Fig. 12.** Diversity of techniques among the Afar and Issa – CAD: E. Baudouin. A quadrangular brick house with a flat roof (A). A Quadrangular brick house with a gable roof (B). A quadrangular wattle and daub house with a gable roof (C). A circular brick house with a conical roof (D). A circular brick house with a flat roof (E). A circular wattle and daub house with a conical roof (F) – Copyrights: Q. Aubourg, E. Baudouin.

conical roofs from Ethiopian style, which are independently present among both the Afar and Issa, but not adopted by these communities, as we have just seen. To return to the mechanisms of technical assimilation, the introduction of this new type of house appears to involve a phenomenon of demic diffusion as defined by Cavalli Sforza and Feldman (1981), that is to say, of population movement. If we think in terms of social models, it is the result of infrequent connections between groups that can be described as having “weak” ties (Collar et al. 2015: 23).

Furthermore, if the wattle-and-daub technique and the circular shape of dwellings spread independently within the two groups (see above), the conical roof illustrates a situation of non-borrowing. According to the surveys, the lack of skills among Afar and Issa builders is noted for the conical roof, making them dependent on specialized artisans who use techniques mastered only by a restricted social group. The use of traditional materials for roof construction has become rare, indicating an absence—or a loss?—of craftsmanship, and the widespread use of modern materials such as sheets of corrugated iron. This also aligns with interpretations made in other contexts, where roof construction techniques are deeply linked to cultural identity (Pelmoine & Mayor 2020: 20). According to V. Roux, such a situation of non-borrowing depends on individuals’ tendency to conform to their group’s norms, which accentuates differentiation, reinforces technical boundaries, and reduces the adoption of outside practices (Roux et al.

2017: 320).

Based on this data, the three ethnographic situations can be summarized as follows:

- 1) The arrival of circular wattle-and-daub houses with conical roof of “Ethiopian style” in the Gobaad Basin represents a phenomenon of demic movement that took root in the region no later than the 1980s. This type of dwelling, although present among both the Afar and the Issa, was not adopted by these communities due to the technical specificity involved in constructing the roof. Thus, the conical roof represents a case of non-borrowing, mainly due to the lack—or loss—of skills among local builders, which requires the intervention of skilled craftsmen.
- 2) The introduction of molded mud bricks and the rectangular plan by Westerners in the mid-20th century represents a phenomenon of architectural innovation and diffusion. The adoption of these architectural practices in the region is facilitated by the institutionalization of the masonry trade within the Afar community, leading to the widespread use of rectangular mud brick housing within this community. This situation illustrates how technical innovation responds to local needs but also transformed socio-economic dynamics by offering new professional opportunities to the Afar communities, leaving the Issa population aside, who did not benefit from this

network of practice. As a result, there is an important technical divide that aligns with a social boundary between the Afar and the Issa.

- 3) The maintenance of traditional house-building methods, such as wattle-and-daub or the circular shape of the houses, is part of a process of adoption and assimilation of techniques among both the Issa and the Afar. Among the Afar, the variability of combinations remains significant and reflects different situations that respond to two factors: economic and identity related. The financial argument about wattle-and-daub technique has certainly led Afar masons to become skillful in their architectural practice to meet the community's demands. The identity factor is reflected in the inhabitants' desire to preserve technical traditions and cultural ties with Ethiopia.

## 6. Returning to the archaeological data

The data provided by these ethnographic surveys offers us a better understanding of the socio-cultural mechanisms involved in the evolution of architectural techniques in an environment considered stable. In addition to technical data, the three scenarios proposed above allow us to consider archaeological questions regarding the diffusion of architectural techniques within the Western Asian and Caucasian Neolithic.

### 6.1. The lifespan of earth constructions in the Neolithic

It is clear that by compiling a reference base in the field of architectural techniques in a contemporary context, we are able to provide elements for interpreting the functioning of past societies. Descriptions of the *chaînes opératoires* used in preparing the materials and building the frameworks are useful as elements of technical comparison in archaeology (Baudouin 2020, 2021). Beyond the technical elements, the question of the duration of use of earth dwellings in the Neolithic is a debated subject, which has been renewed in recent decades with the contribution of Bayesian analyses. If the lifespan of dwellings in Northern Mesopotamia during the Neolithic can be estimated at 30–50 years for buildings with foundations, such as at Tell Sabi Abyad (van Plicht et al. 2011: 233) and Tell Kosak Shamali (Nishiaki & Matsutani 2001), this is reduced to 5–15 years for circular buildings in the Caucasian Neolithic, such as those found at Göy Tepe (Nishiaki et al. 2018: 7), where the walls are generally devoid of foundations or basements (Baudouin 2019: 130–133). In this context, the results provided by the surveys in Djibouti corroborate the archaeological data and confirm the variability in the duration of use of buildings according to the construction methods and materials used.

### 6.2. Explaining the diversity of architectural techniques among Halaf communities

The scenario proposed to explain the variations in architectural practices among the Afar enriches our archaeological interpretations of the social dynamics in Northern Mesopotamia. In the Middle Euphrates, the dynamism and expertise of the PPNB communities (8th–7th millennium) are manifested in this field through significant innovations (molded mud brick, pilasters, modular architecture...). However, settlements like Tell Halula (Molist 2013) and Tell Saby Abyad (Akkermans 2013) in Syria attest to the change that occurred in the middle of the 7th millennium, where the standardized architecture of the early levels gave way to a more erratic and deconstructed architecture, coinciding with the flourishing of the Halaf in Northern Mesopotamia. Within the Halaf communities (5,900–5,400BC), the diversity of building shapes (circular, rectangular, circular with rectangular annex, etc.), roof styles (conical, flat, etc.) and construction materials (mainly cob and brick) allows us to propose the slow assimilation of techniques, and even a certain inertia, in which it seems illusory to define a “center” and a “periphery” (Breniquet 2016: 208) to qualify the dissemination of techniques until the middle of the 6th millennium. The main takeaway

from the ethnographic examples collected in the field in Djibouti is that the variety of architectural practices raises questions about the identity of the builders and the social groups involved, thus revealing a complex sociological landscape. Depending on the materials, shapes and techniques, this diversity reflects different economic, cultural and social reality: techniques can be reappropriated by local communities, or, on the contrary, which remains a specialty of exogenous craftsmen as in the case with the conical roof. This particularly allowed us to explain the diversity of roof shapes in the circular architecture of this period, be it in Western Asia or in the South Caucasus, within the same environment (Baudouin et al. 2022). It is particularly important to consider socio-cultural factors, because historical and social conditions play a role in the construction of roofs. The data provided by our ethnoarchaeological study invites us to nuance these interpretations however, by showing that the cultural criterion is not always decisive in qualifying diversity. It is therefore important to consider a variety of parameters (sedentarization processes, lifestyles, etc.).

In the current state of knowledge, it is still difficult to fully understand the conditions that gave rise to the diversity of architecture in Halaf. Are we facing an adaptation process by the Halaf communities, where the modification of an architectural model did not aim to replicate the previously established codes? This raises questions about how architectural knowledge was transmitted and the nature of the social relationships between the different groups.

### 6.3. Standardized architecture and work specializations in the Ubaid

The third scenario offered by our ethnoarchaeological investigations could explain the mechanisms involved in the spread of standardized molded mud brick constructions during the expansion of the Ubaid culture from southern Mesopotamia to the north from the middle of the 6th to the end of the 5th millennium. The hypothesis of demic diffusion is consistent with the expansionist nature of the phenomenon. It is highly likely that for a specific category of buildings—the large monumental buildings observed from the end of the Ubaid (Baudouin 2021: 151–155), decorated with niches and recesses (Eridu and Tepe Gawra)—construction specialists were used. These specialists would have traveled and transmitted their knowledge and know-how within a restricted social environment, which could be described as guilds, similar to those observed in Mali (Brunet-Jailly & Scherrer 2011). This proposal is supported by the discoveries made at Tepe Gawra, where terracotta brick miniatures, at a scale of 1:10, were discovered on the floor of a monumental mud brick building (Baudouin 2022). This explanatory model must, however, be adapted in the case of Western Asia as, beyond the adoption of new architectural features, there was also an assimilation of local features, which could represent forms of architectural hybridization as much as an adaptation of techniques to environmental constraints.

This invites us to question the possibility of work specializations during this period, considering the first and the third proposed scenarios. We have shown elsewhere that the standardization of architecture at the end of the Neolithic in Western Asia must have led to the emergence of construction specialists and the architectural profession (Baudouin 2022). These elements seem to be supported by the surveys carried out in Djibouti, which show that building professionals are in greater demand for the construction of molded mud brick buildings than wattle-and-daub. In the light of the first two scenarios proposed, this leads us to hypothesize that wattle-and-daub is an elementary construction technique requiring a lower degree of technical skill, which facilitated its adoption within the Afar and Issa groups. In contrast, the production of molded mud bricks is the work of real construction specialists whose origins are found in the Middle Euphrates (Southern Turkey, Northern Syria), in the late PPNB (7,500–7,000BC), when the first standardized molded mud brick constructions appeared. This invites us to question the processes involved in learning and transmitting knowledge around a technique that is theoretically “simple”, but which

remains “complex” in terms of the interactions between groups and individuals (Perlès 2012: 587–588). To a certain extent, the case of Ethiopian masons is instructive because it shows that the conical roof, which represents a form of “standardization” of architecture, spread to the Afar and Issa communities in the Gobaad basin through Ethiopian specialized craftsmen. In this case, the technical diffusion reflects a situation of non-borrowing, which can be quite comparable to the archaeological situation mentioned for the Ubaid period.

## 7. Conclusion

Our ethnoarchaeological research regarding the technical traditions involved in earth construction in the Gobaad basin provides new data on the architectural norms and practices of the Afar and Issa communities in East Africa. It not only allows us to identify the *chaînes opératoires*, construction processes and forms of buildings in the region but also invites us to question the link between techniques and identities and the evolution of architectural techniques within the social groups involved. Chétima (2019) has demonstrated the importance of architectural practices as an expression of social identity and not simply as an ethnic marker. By exploring the link between these elements, he has demonstrated the ways in which architectural styles play a role in affirming ethnic identity. He also demonstrates that certain techniques transcend ethnic boundaries and create points of convergence between communities, confirming the existence of exchange networks and reciprocal influences between groups.

A cross-comparison of the technical, cultural, social and economic data confirms that there are well-marked architectural trends between the Afar and Issa communities. On the one hand, the architectural diversity among the Afar, in an identical environment within the Gobaad, appears to reflect a certain fluidity of social practices, which translates in the architecture into a diverse range of techniques within the region’s dominant group. In other words, the more architecturally diverse, the more sociologically diverse. In contrast, the standardized architectural traits observed among the Issa indicate social compartmentalization and a closed identity, which can be clearly observed in As Eylā. The acceleration of the sedentarization process for these communities around the 1970s did not occur in the same way within the two cultural groups. It results from an imbalance in access to knowledge in the field of construction, leading to differences in the skills acquired. Finally, the introduction in the two communities of a new exogenous type of houses to the Gobaad basin allows us to formulate two proposals. Firstly, the presence of circular wattle-and-daub habitats with conical roofs built in the “Ethiopian style” allows us to propose the hypothesis that this architectural type resulted from demic diffusion, even if its exact origin remains to be determined. Secondly, it allows us to highlight the importance of considering three fundamental variables—construction materials, building methods, and shape of the buildings—to explain changes in architecture. It shows that these elements do not evolve at the same pace and that their adoption or rejection is subject to technical and cultural choices more than environmental adaptation. These results encourage us to further explore the processes involved in the innovation and diffusion of architectural techniques and to increase the number of field surveys based on this methodology (Gallay 2011).

Given that the built environment is the expression of human behavior (Rapoport 1969), these results contribute to our research on the Neolithic architecture of Western Asia by providing socio-cultural, economic and historical interpretations. These mechanisms outlined in ethnoarchaeology allow us to propose plausible explanations for the technical frontier observed in Mesopotamia during the 6th–5th millennia. As such, the diversity in Halaf technical practices can be explained by a greater fluidity in social practices. Conversely, the adoption and subsequent spread of standardized architecture and molded mud brick constructions throughout Mesopotamia from the middle of the 6th millennium appears to be the result of a demic diffusion during the Ubaid, a phenomenon linked to the emergence of

construction specialists. According to the theoretical models of analytical sociology (Mills 2017: 388), these results allow us to qualify the nature of social links between communities considered, “strong” in the Halaf (close and continuous relationships within a dense regional network) and “weak” in the Ubaid (a network of specialists with specific knowledge). Finally, the work carried out in Djibouti offers convincing results from a purely technical point of view, which furthers our archaeological knowledge. As such, it allows us to reconstruct *chaînes opératoires* by observing the methods used by builders and to better understand the processes involved in the loss of earthen architecture.

To conclude, given the rapid and symptomatic disappearance of tangible and intangible heritage in the face of the globalization of cultures at a planetary scale (Joffroy et al. 2012), the safeguarding of this living heritage and ancestral technical knowledge is a crucial societal issue (Raveneau 2008). It is regrettable that most of the professional masons interviewed have not been building with earth for almost a decade. Earth construction has been replaced by modern materials which are often less adapted to the economic, climatic and environmental conditions but are chosen due to growing social pressure (Marcel 2022), as symbols of success and social status (Dzou-Tsanga 2016). It is therefore urgent to document and safeguard this knowledge before it completely disappears. It seems paramount to us that this heritage work finds its place among the region’s development and conservation projects, such as the Great Green Wall program, which is struggling to get off the ground in Djibouti.

## CRedit authorship contribution statement

**Emmanuel Baudouin:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Quentin Aubourg:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Formal analysis. **Xavier Gutherz:** Writing – review & editing, Writing – original draft, Validation, Resources. **Ibrahim Osman Ali:** Investigation. **Asma Youssouf Aden:** Investigation. **Mariam Abdoukader:** Investigation. **Jessie Cauliez:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Funding acquisition.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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