# Long distance amazonite trading and growing social complexity in the Neolithic of the Sudanese Nile Valley

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<td>Zerboni, Andrea; Università degli Studi di Milano, Dipartimento di Scienze della Terra &quot;A. Desio&quot; Salvatori, Sandro; Centro Studi Sudanesi e Sub-Sahariani, Centro Studi Sudanesi e Sub-Sahariani Vignola, Pietro; C.N.R., Istituto per la Dinamica dei Processi Ambientali Mohammed, Abdelrahman; National Corporation for Antiquities and Museums, National Corporation for Antiquities and Museums Usai, Donatella; Centro Studi Sudanesi e Sub-Sahariani, Centro Studi Sudanesi e Sub-Sahariani; Sapienza Università di Roma, Dipartimento di Scienze dell’Antichità</td>
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Long distance amazonite trading and growing social complexity in the Neolithic of the Sudanese Nile Valley

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1. Introduction

Elements pointing to new forms of social complexity enter the Sudanese Nile Valley with the introduction of domesticates and thus the progressive adoption of a food producing economy (Salvatori et al. 2016). The first tangible evidence of this phenomenon dates to the early 6th millennium BC (Honegger 2004, 2005) and is reflected, mainly in funerary contexts, by a new variegated set of material items for body ornamentation (beads, pendants, bracelets, lip-plugs) together with other grave goods (pottery, stone objects), apparently used to highlight rank or status. Included among these are sought-after objects and raw materials imported through long-distance trade and exchange. This new material assemblage points to a strongly ideologically oriented funerary programme, which aims at reproducing and renegotiating the place of the related family into the wider social structure (identity process). Few Neolithic settlements have been excavated or tested in Sudan, and all are badly preserved due to post-depositional disturbances (Arkell 1953; Caneva 1988; Fernández et al. 1989, 2003a; El-Anwar 1981; Chłodnicki 2011); hence, archaeologists working on Neolithic Sudan can only rely on the funerary contexts to investigate the multi-faceted processes of emerging complexity. Thus, examining the origins of production of material artefacts such as stone axes, mace-heads, stone palettes, and ornaments is restricted to a handful of excavated and published cemeteries (Salvatori and Usai 2008a; Reinold 2007; Chłodnicki et al. 2011; Caneva 1988; Salvatori et al. 2016) and any attempt to reconstruct whole production processes is limited. A further hindrance is due to the somewhat limited knowledge of the distribution of raw materials sources from the sizable areas east and west of the Nile in Sudan. In addition, this topic has not adequately been studied, with a scientific approach.

Amazonite, both as finished objects (beads and pendants) and lumps of raw material is among the many intriguing materials that frequently appear in the North African and Levantine Neolithic settlements (see: Bar-Yosef Mayer and Porat 2008, and references therein). Typically, amazonite is a semi-precious green to blue-green variety of microcline with white veins, largely used to carve beads and pendants in Neolithic Sudan (Tabs 2 and 3). First discovered in the central Sudan Neolithic settlement of Shaheinab (Arkell 1953), amazonite was thought to be a marker of an exchange network with the Tibesti massif of the central Sahara, long regarded as the sole possible source origin of amazonite in North Africa (Monod 1974; de Michele and Piacenza 1999; Zerboni et al. 2017). However, recent archaeometric investigations on green-coloured stone ornaments from North Africa have questioned this assumption and highlighted a more intricate picture, including a variety of different source areas (Zerboni et al. 2017). Consequently, it was
decided to investigate the geological source of a recently excavated set of amazonite stone beads from the Nubian Middle Neolithic cemetery of R12, together with control samples of raw material obtained from sources areas in the Sahara, Sub-Saharan Africa, Nile Valley, Ethiopia, and Jordan. The main aim was to elucidate the origin of raw material employed in ornament production, to infer the trajectories of trading of this exotic and possibly prestige good in Neolithic times, and, finally discuss the archaeological and anthropological implications.

2. Archaeological background

R12 is a Nubian Middle Neolithic cemetery located in the Seleim Basin in the Northern Dongola Reach, in Northern Sudan (Fig. 1). It was in use from the close of the 6th to the end of the 5th millennium BC and has been divided in two distinctive periods, covering approximately the first and second half of the millennium respectively (Salvatori and Usai 2008a). The cemetery is just one among the many that dot the archaeological landscape in Upper Nubia (Reinold 2004; Welsby 2001), and produced 166 burials (Fig. 2), whose grave goods allowed a first assessment of the Neolithic of this region and of the Nile Valley (Salvatori and Usai 2008a). The funerary material associated with many of the burials suggests a rich world of social activities that we are unable to reconstruct fully, given the few excavated settlements in the region (Usai 2014). Even if affected by natural post-depositional episodes of groundwater wicking and/or wind erosion, normally objects made of delicate materials, like bone or ivory, as well as tools and other objects made of valued stones are well preserved in the graves. Body ornaments are very common and varied in shape and colour (Salvatori and Usai 2008b). Beads of green (amazonite; Fig. 3), red (carnelian or burnt agate), and whitish (zeolite and quartz) coloured stones as well as of ostrich eggshell, marine shells, and packed ochre powder were found alone or, more frequently, in strings with harmonious assemblages (Fig. 4); these beads are diverse in shape (Salvatori and Usai 2008b; Usai 2016).

3. Analytical results on amazonite rock samples and beads

To verify whether body ornaments represented prestigious goods in Nubian Neolithic society, it was felt necessary to consider the problem of exotic materials provenance as a possible measure of the role these objects could have played in social prestige and/or rank in the Neolithic communities. An assumption is made here that scarcity, non-local availability and difficulty in accessing a specific source constitutes one such parameter (Usai 2016 and references therein).
To assess this, nine amazonite beads recovered from the R12 cemetery and 18 samples of raw material from different African amazonite outcrops were submitted to microprobe analyses according to the protocol proposed by Zerboni & Vignola (2013) and Zerboni et al. (2017). The set of samples and the analytical protocol are described in Supplementary Material. Analytical results are summarized in Table 1 and full results are in Supplementary Materials.

Our analytical approach used microprobe analysis to determine the orthoclase-albite-anorthite percentage of amazonite crystals and the concentration of elements. The chemical composition of all the samples analysed matches that of a perthitic orthoclase-microcline in the ternary plot used for the nomenclature of ordered feldspars (Deer et al. 1992; Wise 1999; Simmons et al. 2003; Černý and Ercit 2005); the absence of Ca confirms the attribution to amazonite (Fuhrman and Lindsley 1988). As discussed by Martin et al. (2008), the geochemical trace element signature of single minerals of potassic microcline from a pegmatitic dike closely reflects the composition of the whole granitic source. The chemical composition obtained for each sample is generally representative of the mean geochemical character of the magmatic rocks of its source area, thus our analyses are suitable to trace the provenance of raw material.

Analytical data are represented in Fig. 5 as K/Rb vs Rb diagram. Rb and K are the elements that best differentiate the chemical composition of the pegmatite outcrops and, thus, describe the provenance of the amazonite crystals (Zerboni et al. 2017). The K/Rb vs Rb diagram shows a great variability of the distribution of chemical composition of each pegmatite outcrop and ornament considered. Dots’ distribution is along a wide range of chemical values, with Rb content between 1000 to 10,000 ppm and the ratio between K and Rb is between 10 and 140. This therefore implies different plutons of raw material provenances, but several clusters can be identified.

4. Discussion

4.1. Amazonite provenance and beads production

Amazonite is a semi-precious green to blue-green variety of microcline with white veins, and a common rock-forming mineral in the niobium-yttrium-fluorine geochemical type of granitic pegmatites that has reacted with deposits of massive sulphides containing Pb (Černý and Ercit 2005; Wise 1999; Martin et al. 2008). The occurrence of amazonite-bearing pegmatites in North Africa is illustrated in Supplementary Material, and the significance of our data is discussed in the following section.
The K/Rb vs Rb diagram (Fig. 5) discriminates the geochemical signature of each sample and helps discern the pegmatite of provenience, several clusters are evident. A first cluster includes the samples from the outcrop at Eghei Zuma, in the Tibesti region, and the ornaments from ethnographic collections from Sudan and Mali, thus confirming a recent exploitation of the quarry in southern Libya, which was suggested by some authors (de Michele & Piacenza 1999), and confirmed by Zerboni and Vignola (2013) and Zerboni et al. (2017). A second cluster, much more important for this study, is evident, and suggests a similar chemical composition for all the items collected at R12. This implies that the origin of raw material employed to produce the beads from R12 came from the same pegmatitic field.

If we consider the Neolithic archaeological sites along the Nile Valley, we note that many graves include allochthonous or exotic prestige goods, for instance those made of sea-shells (see Tables 2 and 3). The provenance of shells from the Red Sea coast is almost certain and self-evident, but it is, at present, impossible to trace the trade routes or exchange mechanisms, which allowed these specimens to reach the Sudanese Nile Valley during the Neolithic. On the contrary, the provenance of geological raw material can only be determined through geochemical analyses. For this reason, we compared R12 amazonite beads with samples of amazonite raw material originating from many other possible procurement areas within North Africa (Fig. 6). Traditionally, the Tibesti has been indicated as the area of amazonite procurement (Monod 1974; Arkell 1953; de Michele and Piacenza 1999). However, this possibility must be dismissed, at least for the R12 amazonite specimens. In fact, quite unexpectedly, chemical analysis shows that amazonite beads from R12 have a composition matching the one of the amazonite from Kenticha (southern Ethiopia), therefore suggesting that the Ethiopian Highlands is more likely the raw material source.

Trade links between Ethiopia and Sudan during the Neolithic have not previously been documented, partly because the archaeological data available for contemporary prehistoric groups in Ethiopia are scarce (Brandt 1986; Finneran 2007; Hildebrand et al. 2010). Furthermore, eastern Sudan, one of the possible bridges between the two areas, via the Gash and Atbara rivers, has also been unevenly explored (Shiner 1971; Fattovich et al. 1984; Marks and Fattovich 1989) with recent research in the region concentrated mainly on the later 3rd and 2nd millennia BC (Manzo 2017). Nevertheless, one or more routes from Upper Nubia and Central Sudan to the Red Sea coast were active from the beginning of the 6th millennium BC and during the 5th and 4th millennia BC. This is proved by the presence at el Barga, R12, and other Neolithic sites along the Nile of marine shells.
from the Red Sea used as beads (Tables 2 and 3). The transfer of raw material (amazonite and of other exotic materials) to the sites along the Sudanese Nile may have taken a different route but “whether prehistoric artefacts moved from source to destination by exchange from person to person or whether, on the other hand, individuals went directly to the source” (Hodder 1995: 108) cannot, currently, be proven.

Finally, it would also be important to establish whether Neolithic people exchanged amazonite raw material or finished beads, or, possibly, both. The presence of unfinished amazonite beads in a Sudanese Neolithic context (Arkell 1953) and other pieces of evidence such as amazonite lumps (Table 2 and 3) would point to a local production of beads in association with that of carnelian, zeolite, and ostrich-eggshell ornaments (Usai 2016), but this assumption could not be definitively confirmed by data.

4.2. Anthropological implications

While bead production is attested since the Palaeolithic (White 1989; Bednarik 2005; Derevianko et al. 2005; d’Errico et al. 2005; Vanhaeren and d’Errico 2005; Bouzouggar et al. 2007; Richter et al. 2011), brightly coloured specimens are more common in Neolithic assemblages. Recent work (Bar-Yosef Mayer and Porat 2008) suggests colour may have been used as a meta-language, and it is argued that the prevalence of green stone beads in the Neolithic of the Near East is directly related to the onset of agriculture (Bar-Yosef Mayer and Porat 2008); though, the Neolithic societies of the Nile Valley in Sudan, have been mostly described as overwhelmingly pastoral (e.g., Caneva 1988, 1993; Marshall and Hildebrand 2002; Gatto 2011) or as a primary pastoral community (Wengrow et al. 2014). Recently, however, the identification of domestic cereals and cultivation of millet in Upper Nubia and Central Sudan since the second half of the 6th millennium BC or earlier (Madella et al. 2014; Out et al. 2016), has led to some dissension from this viewpoint. Nonetheless, a search for more valued and diverse materials was possibly prompted by changes in the socio-economic structures and new forms of symbolism characteristic of the Sudanese Neolithic; among the others, to place bucrania and vegetal pillows in the graves (Salvatori and Usai 2008a; Salvatori et al. 2016).

However, while symbols remain a highly speculative field of debate in archaeology (Hodder 2010), it seems more practical to attempt to establish the relationship between exotic materials and the emergence of complexity (e.g., Rosen et al. 2005; Dillian and White 2010; Rosenberg et al. 2010). Here, knowledge of the distribution of raw material sources is essential. Many of the objects found at R12 are made of materials exotic to the local bedrock (serpentinite,
syenite, amphibolite, gabbro-diorite, diorite, gneiss) (Maritan and Santello pers. comm.). According to the Geological Map of Sudan (2004), formations of these rocks are present in the Nubian Desert and in other regions of Sudan; but a detailed source-mapping in Sudan is lacking, as otherwise done for Egypt (Nicholson and Shaw 2000), and this seems to be a conditio sine qua non for the reconstruction of the dynamics inherent to any transport networks and production.

Of these rocks and minerals, the distribution of amazonite in sites across the Neolithic Sudan is variable, for example, it is quite commonplace across northern Sudan, but much more rare in central Sudan. Furthermore, in the north, its frequency varies, as it is not found in all cemeteries and, in cemeteries where it is present, it is not present in all graves. Its presence at Neolithic sites in Sudan (Tabs 2 and 3; Salvatori and Usai 2008b; Usai 2016) suggests that it conveys a specific meaning and symbolic value. The evidence of local production of beads (Usai 2016) suggests the existence of specialized or semi-specialized artisans, likely indicating a subsequent trend to a more structured Neolithic social organisation. Such a process of incipient specialization can also be observed in pottery production of the second half of the 5th millennium BC (Dal Sasso et al. 2014; Salvatori and Usai 2016). In this context, the access to raw materials not locally available reflects a widespread network of inter-communities and/or interregional relationships. The type and number of exotic objects and raw materials can be a meaningful index of external relationships, an extension of their geographic dimension and, possibly, of the continuous reworking of symbolic meaning of a wide range of materials in the process of social ranking, identity and ideological complexity of the Neolithic communities of Upper Nubia and central Sudan. This is also evidenced in many other Neolithic communities in the Near East and Europe (e.g., Cohen 1985; Perlès 2001; Bar-Yosef Mayer et al. 2004; Fogelin 2007; Watkins 2008).

Amazonite and obsidian beads, and Red Sea shells are present in the early 6th millennium BC Early Neolithic graves from el-Barga, in the Kerma area (Honegger 2004, 2005). At R12 Middle Neolithic cemetery amazonite beads, pendants, and lumps (Fig. 2), together with other exotic prestige items like malachite splinters and seashells from the Red Sea coast, are differently distributed in the graves and similar items are found in each of the published excavated cemeteries of the 5th and 4th millennium BC (Tabs 2 and 3). Variability in the quantitative and qualitative presence of exotic materials is significant across the different sites (Tabs 2 and 3), and more attention to quantitative analyses would be needed, especially when dealing with problems concerning the infra- and inter-community construction of identity and shared ideology.
Data on amazonite beads together with those reviewed in Tables 2 and 3, suggest that during the 5th millennium BC, each community confers a specific symbolic meaning to different exotic materials used as body ornaments. The different use of malachite powder and the great variability of its occurrence in graves (Salvatori and Usai 2008b), as well as the variability in the use of amazonite beads supports the hypothesis that each community had its own ideological construction and identity markers. Furthermore, from the mid-5th millennium BC, both in Upper Nubia and in central Sudan, other material productions like pottery (Salvatori 2008; Salvatori and Usai 2016) reflect strong regional identities, as denoted by the Multaga phase (Salvatori and Usai 2008a) in Upper Nubia and the Shaheinab phase in the central Sudan (Salvatori et al. 2016). At a more local level, communities, in spite of the unquestionable process of socio-cultural consolidation of the second half of the 5th millennium BC, retain clear differences in the use of material items in their funerary programs. Even if the use of exotic materials is a clear index of the holder’s prestige, it is still difficult to infer the different exotic materials supply routes and the level of engagement of the local communities. Amazonite beads are relatively common in necklaces worn by R12 individuals, but they are rare, nearly absent among ornaments worn by Ghaba and Kadero individuals (Chłodnicki et al. 2011; Usai 2016). Ghaba and R12 communities are roughly contemporaneous, but they show important differences in the form of social behaviour, as inferred from funerary contexts (Salvatori and Usai 2016), and different levels of complexity. At R12, beads typology and raw materials used to produce them are much more varied; technological attributes and stages of production are more elaborate suggesting that individuals were involved in a form of specialised activity (Salvatori and Usai 2008b; Usai 2016).

5. Conclusion: an emerging Neolithic trading network

The distance of amazonite raw material travelling between its source in Ethiopia and graves sites in the Northern Dongola Reach is considerable (more than 1700 km). However, long-distance trade and exchange are attested in other parts of the world even if, exchange mechanisms sometimes remain unknown (Renfrew 1977; Dillian et al. 2010; Düring 2014; Freund and Batist 2014; Gibaja et al. 2014). This scale long-distance exchange (300 to 700 km) is, furthermore, proved by the Red Sea seashells found in the Nile valley Neolithic sites.

The possible route through which amazonite reached the Sudanese Nile Valley is not known, but the evidence from the R12 graves suggests that some communities clearly regarded amazonite as having special meaning and may have had connections of some sort with the
material source or sources. The data on amazonite beads from R12 suggest (Fig. 6), at present, a Neolithic exchange network encompassing the Red Sea shores and a south-east/north-west path, possibly along the Atbara and Gash rivers to the Ethiopian Highlands. Further analysis on amazonite samples from other Neolithic sites and sources (quarries) along the Nile Valley would certainly widen our understanding of the system of exchange from north to central Sudan, and to exotic material sources. It would highlight whether different sources were exploited by the individual communities. This would also aid understanding of infra- and inter-community interaction, and the role played by exotic materials in the shaping of a shared or diverging identity and ideology. Certainly, as Dillian and White (2010: 7) note “Within the context of material exchange, social ties were reinforced and created, information was shared, and positions of status were established and maintained.”

Acknowledgments

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References


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Table 1. Averaged WDS electron-microprobe analyses of selected elements of amazonite samples (full results in Supplementary Materials).

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Table 2. Exotic materials recorded in Nubian Early Neolithic (El Barga), Nubian Middle Neolithic (J. Ramlah, Kadruka and R12), and Central Sudan Early Neolithic sites (Ghaba and Kadero).

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<tr>
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<td>Honegger 2004</td>
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<td>Reinold 2000, 2005</td>
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<td>R12 North Sudan</td>
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<td>23</td>
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<td>Umm Melyekta North Sudan</td>
<td>ND</td>
<td>Fuller 2004</td>
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<td>Multaga North Sudan</td>
<td>ND</td>
<td>Peressinotto et al. 2004</td>
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<tr>
<td>Ghaba Central Sudan</td>
<td>&gt;276 + 64 graves</td>
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<td>Kadero Central Sudan</td>
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<td>Krzyżaniak 2011</td>
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Table 3. Exotic materials recorded in Late Neolithic sites in central and eastern Sudan.

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<tr>
<td></td>
<td></td>
<td>Conus sp.</td>
<td>Glycymeris pectunculus</td>
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<tr>
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<td>Central Sudan</td>
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<td>Central Sudan</td>
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<td>UA53 Kassala</td>
<td>East Sudan</td>
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<td>Amazonite lumps</td>
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References:
- Reinold 2007
- Reinold 1982
- Arkell 1953
- Carannante 2012
- Arkell 1953
- Reinold 2007
- Reinold 1982
- Caneva 1988
- Fernandez et al. 2003b
Long distance amazonite trading and growing social complexity in the Neolithic of the Sudanese Nile Valley

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1. Introduction

Elements pointing to new forms of social complexity enter the Sudanese Nile Valley with the introduction of domesticates and thus the progressive adoption of a food producing economy (Salvatori et al. 2016). The first tangible evidence of this phenomenon dates to the early 6th millennium BC (Honegger 2004, 2005) and is reflected, mainly in funerary contexts, by a new variegated set of material items for body ornamentation (beads, pendants, bracelets, lip-plugs) together with other grave goods (pottery, stone objects), apparently used to highlight rank or status. Included among these are sought-after objects and raw materials imported through long-distance trade and exchange. This new material assemblage points to a strongly ideologically oriented funerary programme, which aims at reproducing and renegotiating the place of the related family into the wider social structure (identity process). Few Neolithic settlements have been excavated or tested in Sudan, and all are badly preserved due to post-depositional disturbances (Arkell 1953; Caneva 1988; Fernández et al. 1989, 2003a; El-Anwar 1981; Chłodnicki 2011); hence, archaeologists working on Neolithic Sudan can only rely on the funerary contexts to investigate the multi-faceted processes of emerging complexity. Thus, examining the origins of production of material artefacts such as stone axes, mace-heads, stone palettes, and ornaments is restricted to a handful of excavated and published cemeteries (Salvatori and Usai 2008a; Reinold 2007; Chłodnicki et al. 2011; Caneva 1988; Salvatori et al. 2016) and any attempt to reconstruct whole production processes is limited. A further hindrance is due to the somewhat limited knowledge of the distribution of raw materials sources from the sizable areas east and west of the Nile in Sudan. In addition, this topic has not adequately been studied, with a scientific approach.

Amazonite, both as finished objects (beads and pendants) and lumps of raw material is among the many intriguing materials that frequently appear in the North African and Levantine Neolithic settlements (see: Bar-Yosef Mayer and Porat 2008, and references therein). Typically, amazonite is a semi-precious green to blue-green variety of microcline with white veins, largely used to carve beads and pendants in Neolithic Sudan (Tabs 2 and 3). First discovered in the central Sudan Neolithic settlement of Shaheinab (Arkell 1953), amazonite was thought to be a marker of an exchange network with the Tibesti massif of the central Sahara, long regarded as the sole possible source origin of amazonite in North Africa (Monod 1974; de Michele and Piacenza 1999; Zerboni et al. 2017). However, recent archaeometric investigations on green-coloured stone ornaments from North Africa have questioned this assumption and highlighted a more intricate picture, including a variety of different source areas (Zerboni et al. 2017). Consequently, it was...
decided to investigate the geological source of a recently excavated set of amazonite stone beads from the Nubian Middle Neolithic cemetery of R12, together with control samples of raw material obtained from sources areas in the Sahara, Sub-Saharan Africa, Nile Valley, Ethiopia, and Jordan. The main aim was to elucidate the origin of raw material employed in ornament production, to infer the trajectories of trading of this exotic and possibly prestige good in Neolithic times, and, finally, discuss the archaeological and anthropological implications.

2. Archaeological background

R12 is a Nubian Middle Neolithic cemetery located in the Seleim Basin in the Northern Dongola Reach, in Northern Sudan (Fig. 1). It was in use from the close of the 6th to the end of the 5th millennium BC and has been divided in two distinctive periods, covering approximately the first and second half of the millennium respectively (Salvatori and Usai 2008a). The cemetery is just one among the many that dot the archaeological landscape in Upper Nubia (Reinold 2004; Welsby 2001), and produced 166 burials (Fig. 2), whose grave goods allowed a first assessment of the Neolithic of this region and of the Nile Valley (Salvatori and Usai 2008a). The funerary material associated with many of the burials suggests a rich world of social activities that we are unable to reconstruct fully, given the few excavated settlements in the region (Usai 2014). Even if affected by natural post-depositional episodes of groundwater wicking and/or wind erosion, normally objects made of delicate materials, like bone or ivory, as well as tools and other objects made of valued stones are well preserved in the graves. Body ornaments are very common and varied in shape and colour (Salvatori and Usai 2008b). Beads of green (amazonite; Fig. 3), red (carnelian or burnt agate), and whitish (zeolite and quartz) coloured stones as well as of ostrich eggshell, marine shells, and packed ochre powder were found alone or, more frequently, in strings with harmonious assemblages (Fig. 4); these beads are diverse in shape (Salvatori and Usai 2008b; Usai 2016).

3. Analytical results on amazonite rock samples and beads

To verify whether body ornaments represented prestigious goods in Nubian Neolithic society, it was felt necessary to consider the problem of exotic materials provenance as a possible measure of the role these objects could have played in social prestige and/or rank in the Neolithic communities. An assumption is made here that scarcity, non-local availability and difficulty in accessing a specific source constitutes one such parameter (Usai 2016 and references therein).
To assess this, nine amazonite beads recovered from the R12 cemetery and 18 samples of raw material from different African amazonite outcrops were submitted to microprobe analyses according to the protocol proposed by Zerboni & Vignola (2013) and Zerboni et al. (2017). The set of samples and the analytical protocol are described in Supplementary Material. Analytical results are summarized in Table 1 and full results are in Supplementary Materials.

Our analytical approach used microprobe analysis to determine the orthoclase-albite-anorthite percentage of amazonite crystals and the concentration of elements. The chemical composition of all the samples analysed matches that of a perthitic orthoclase-microcline in the ternary plot used for the nomenclature of ordered feldspars (Deer et al. 1992; Wise 1999; Simmons et al. 2003; Černý and Ercit 2005); the absence of Ca confirms the attribution to amazonite (Fuhrman and Lindsley 1988). As discussed by Martin et al. (2008), the geochemical trace element signature of single minerals of potassic microcline from a pegmatitic dike closely reflects the composition of the whole granitic source. The chemical composition obtained for each sample is generally representative of the mean geochemical character of the magmatic rocks of its source area, thus our analyses are suitable to trace the provenance of raw material.

Analytical data are represented in Fig. 5 as K/Rb vs Rb diagram. Rb and K are the elements that best differentiate the chemical composition of the pegmatite outcrops and, thus, describe the provenance of the amazonite crystals (Zerboni et al. 2017). The K/Rb vs Rb diagram shows a great variability of the distribution of chemical composition of each pegmatite outcrop and ornament considered. Dots’ distribution is along a wide range of chemical values, with Rb content between 1000 to 10,000 ppm and the ratio between K and Rb is between 10 and 140. This therefore implies different plutons of raw material provenances, but several clusters can be identified.

4. Discussion

4.1. Amazonite provenance and beads production

Amazonite is a semi-precious green to blue-green variety of microcline with white veins, and a common rock-forming mineral in the niobium-yttrium-fluorine geochemical type of granitic pegmatites that has reacted with deposits of massive sulphides containing Pb (Černý and Ercit 2005; Wise 1999; Martin et al. 2008). The occurrence of amazonite-bearing pegmatites in North Africa is illustrated in Supplementary Material, and the significance of our data is discussed in the following section.
The K/Rb vs Rb diagram (Fig. 5) discriminates the geochemical signature of each sample and helps discern the pegmatite of provenience, several clusters are evident. A first cluster includes the samples from the outcrop at Eghei Zuma, in the Tibesti region, and the ornaments from ethnographic collections from Sudan and Mali, thus confirming a recent exploitation of the quarry in southern Libya, which was suggested by some authors (de Michele & Piacenza 1999), and confirmed by Zerboni and Vignola (2013) and Zerboni et al. (2017). A second cluster, much more important for this study, is evident, and suggests a similar chemical composition for all the items collected at R12. This implies that the origin of raw material employed to produce the beads from R12 came from the same pegmatitic field.

If we consider the Neolithic archaeological sites along the Nile Valley, we note that many graves include allochthonous or exotic prestige goods, for instance those made of sea-shells (see Tables 2 and 3). The provenance of shells from the Red Sea coast is almost certain and self-evident, but it is, at present, impossible to trace the trade routes or exchange mechanisms, which allowed these specimens to reach the Sudanese Nile Valley during the Neolithic. On the contrary, the provenance of geological raw material can only be determined through geochemical analyses. For this reason, we compared R12 amazonite beads with samples of amazonite raw material originating from many other possible procurement areas within North Africa (Fig. 6). Traditionally, the Tibesti has been indicated as the area of amazonite procurement (Monod 1974; Arkell 1953; de Michele and Piacenza 1999). However, this possibility must be dismissed, at least for the R12 amazonite specimens. In fact, quite unexpectedly, chemical analysis shows that amazonite beads from R12 have a composition matching the one of the amazonite from Kenticha (southern Ethiopia), therefore suggesting that the Ethiopian Highlands is more likely the raw material source.

Trade links between Ethiopia and Sudan during the Neolithic have not previously been documented, partly because the archaeological data available for contemporary prehistoric groups in Ethiopia are scarce (Brandt 1986; Finneran 2007; Hildebrand et al. 2010). Furthermore, eastern Sudan, one of the possible bridges between the two areas, via the Gash and Atbara rivers, has also been unevenly explored (Shiner 1971; Fattovich et al. 1984; Marks and Fattovich 1989) with recent research in the region concentrated mainly on the later 3rd and 2nd millennia BC (Manzo 2017). Nevertheless, one or more routes from Upper Nubia and Central Sudan to the Red Sea coast were active from the beginning of the 6th millennium BC and during the 5th and 4th millennia BC. This is proved by the presence at el Barga, R12, and other Neolithic sites along the Nile of marine shells.
from the Red Sea used as beads (Tables 2 and 3). The transfer of raw material (amazonite and of other exotic materials) to the sites along the Sudanese Nile may have taken a different route but “whether prehistoric artefacts moved from source to destination by exchange from person to person or whether, on the other hand, individuals went directly to the source” (Hodder 1995: 108) cannot, currently, be proven.

Finally, it would also be important to establish whether Neolithic people exchanged amazonite raw material or finished beads, or, possibly, both. The presence of unfinished amazonite beads in a Sudanese Neolithic context (Arkell 1953) and other pieces of evidence such as amazonite lumps (Table 2 and 3) would point to a local production of beads in association with that of carnelian, zeolite, and ostrich-eggshell ornaments (Usai 2016), but this assumption could not be definitively confirmed by data.

4.2. Anthropological implications

While bead production is attested since the Palaeolithic (White 1989; Bednarik 2005; Derevianko et al. 2005; d’Errico et al. 2005; Vanhaeren and d’Errico 2005; Bouzouggar et al. 2007; Richter et al. 2011), brightly coloured specimens are more common in Neolithic assemblages. Recent work (Bar-Yosef Mayer and Porat 2008) suggests colour may have been used as a meta-language, and it is argued that the prevalence of green stone beads in the Neolithic of the Near East is directly related to the onset of agriculture (Bar-Yosef Mayer and Porat 2008); though, the Neolithic societies of the Nile Valley in Sudan, have been mostly described as overwhelmingly pastoral (e.g., Caneva 1988, 1993; Marshall and Hildebrand 2002; Gatto 2011) or as a primary pastoral community (Wengrow et al. 2014). Recently, however, the identification of domestic cereals and cultivation of millet in Upper Nubia and Central Sudan since the second half of the 6th millennium BC or earlier (Madella et al. 2014; Out et al. 2016), has led to some dissension from this viewpoint. Nonetheless, a search for more valued and diverse materials was possibly prompted by changes in the socio-economic structures and new forms of symbolism characteristic of the Sudanese Neolithic; among the others, to place bucrania and vegetal pillows in the graves (Salvatori and Usai 2008a; Salvatori et al. 2016).

However, while symbols remain a highly speculative field of debate in archaeology (Hodder 2010), it seems more practical to attempt to establish the relationship between exotic materials and the emergence of complexity (e.g., Rosen et al. 2005; Dillian and White 2010; Rosenberg et al. 2010). Here, knowledge of the distribution of raw material sources is essential. Many of the objects found at R12 are made of materials exotic to the local bedrock (serpentinite,
syenite, amphibolite, gabbro-diorite, diorite, gneiss) (Maritan and Santello pers. comm.). According to the Geological Map of Sudan (2004), formations of these rocks are present in the Nubian Desert and in other regions of Sudan; but a detailed source-mapping in Sudan is lacking, as otherwise done for Egypt (Nicholson and Shaw 2000), and this seems to be a *conditio sine qua non* for the reconstruction of the dynamics inherent to any transport networks and production.

Of these rocks and minerals, the distribution of amazonite in sites across the Neolithic Sudan is variable, for example, it is quite commonplace across northern Sudan, but much more rare in central Sudan. Furthermore, in the north, its frequency varies, as it is not found in all cemeteries and, in cemeteries where it is present, it is not present in all graves. Its presence at Neolithic sites in Sudan (Tabs 2 and 3; Salvatori and Usai 2008b; Usai 2016) suggests that it conveys a specific meaning and symbolic value. The evidence of local production of beads (Usai 2016) suggests the existence of specialized or semi-specialized artisans, likely indicating a subsequent trend to a more structured Neolithic social organisation. Such a process of incipient specialization can also be observed in pottery production of the second half of the 5th millennium BC (Dal Sasso et al. 2014; Salvatori and Usai 2016). In this context, the access to raw materials not locally available reflects a widespread network of inter-communities and/or interregional relationships. The type and number of exotic objects and raw materials can be a meaningful index of external relationships, an extension of their geographic dimension and, possibly, of the continuous reworking of symbolic meaning of a wide range of materials in the process of social ranking, identity and ideological complexity of the Neolithic communities of Upper Nubia and central Sudan. This is also evidenced in many other Neolithic communities in the Near East and Europe (e.g., Cohen 1985; Perlès 2001; Bar-Yosef Mayer et al. 2004; Fogelin 2007; Watkins 2008).

Amazonite and obsidian beads, and Red Sea shells are present in the early 6th millennium BC Early Neolithic graves from el-Barga, in the Kerma area (Honegger 2004, 2005). At R12 Middle Neolithic cemetery amazonite beads, pendants, and lumps (Fig. 2), together with other exotic prestige items like malachite splinters and seashells from the Red Sea coast, are differently distributed in the graves and similar items are found in each of the published excavated cemeteries of the 5th and 4th millennium BC (Tabs 2 and 3). Variability in the quantitative and qualitative presence of exotic materials is significant across the different sites (Tabs 2 and 3), and more attention to quantitative analyses would be needed, especially when dealing with problems concerning the infra- and inter-community construction of identity and shared ideology.
Data on amazonite beads together with those reviewed in Tables 2 and 3, suggest that during the 5th millennium BC, each community confers a specific symbolic meaning to different exotic materials used as body ornaments. The different use of malachite powder and the great variability of its occurrence in graves (Salvatori and Usai 2008b), as well as the variability in the use of amazonite beads supports the hypothesis that each community had its own ideological construction and identity markers. Furthermore, from the mid-5th millennium BC, both in Upper Nubia and in central Sudan, other material productions like pottery (Salvatori 2008; Salvatori and Usai 2016) reflect strong regional identities, as denoted by the Multaga phase (Salvatori and Usai 2008a) in Upper Nubia and the Shaheinab phase in the central Sudan (Salvatori et al. 2016). At a more local level, communities, in spite of the unquestionable process of socio-cultural consolidation of the second half of the 5th millennium BC, retain clear differences in the use of material items in their funerary programs. Even if the use of exotic materials is a clear index of the holder’s prestige, it is still difficult to infer the different exotic materials supply routes and the level of engagement of the local communities. Amazonite beads are relatively common in necklaces worn by R12 individuals, but they are rare, nearly absent among ornaments worn by Ghaba and Kadero individuals (Chłodnicki et al. 2011; Usai 2016). Ghaba and R12 communities are roughly contemporaneous, but they show important differences in the form of social behaviour, as inferred from funerary contexts (Salvatori and Usai 2016), and different levels of complexity. At R12, beads typology and raw materials used to produce them are much more varied; technological attributes and stages of production are more elaborate suggesting that individuals were involved in a form of specialised activity (Salvatori and Usai 2008b; Usai 2016).

5. Conclusion: an emerging Neolithic trading network

The distance of amazonite raw material travelling between its source in Ethiopia and graves sites in the Northern Dongola Reach is considerable (more than 1700 km). However, long-distance trade and exchange are attested in other parts of the world, even if, exchange mechanisms sometimes remain unknown (Renfrew 1977; Dillian et al. 2010; Düring 2014; Freund and Batist 2014; Gibaja et al. 2014). This scale long-distance exchange (300 to 700 km) is, furthermore, proved by the Red Sea seashells found in the Nile valley Neolithic sites.

The possible route through which amazonite reached the Sudanese Nile Valley is not known, but the evidence from the R12 graves suggests that some communities clearly regarded amazonite as having special meaning and may have had connections of some sort with the
material source or sources. The data on amazonite beads from R12 suggest (Fig. 6), at present, a Neolithic exchange network encompassing the Red Sea shores and a south-east/north-west path, possibly along the Atbara and Gash rivers to the Ethiopian Highlands. Further analysis on amazonite samples from other Neolithic sites and sources (quarries) along the Nile Valley would certainly widen our understanding of the system of exchange from north to central Sudan, and to exotic material sources. It would highlight whether different sources were exploited by the individual communities. This would also aid understanding of infra- and inter-community interaction, and the role played by exotic materials in the shaping of a shared or diverging identity and ideology. Certainly, as Dillian and White (2010: 7) note “Within the context of material exchange, social ties were reinforced and created, information was shared, and positions of status were established and maintained.”

Acknowledgments
The excavation at R12 cemetery has been carried out by D. Usai and S. Salvatori thanks to the financial support of Italian Ministry of Foreign Affairs (DGSP, funding entrusted to D. Usai) and Ce.Ve.S.C.O. (funding entrusted to S. Salvatori); funds for geochemical analyses were provided by Università degli Studi di Milano – Linea B (entrusted to A. Zerboni). The National Corporation for Antiquities and Museums of Sudan and the Italian Embassy in Khartoum are kindly thanked for their support. J. Harrel, P. Iacumin, M.E. Peroschi, F. Cambieri, and N. Moroni are acknowledged for providing raw material samples. Many thanks to A. Risplendente for microprobe analysis, and E. Ducale and M. Marchesini for helping in samples preparation. J. Dunne is kindly acknowledged for the revision of English language. We thank two anonymous reviewers for their careful reading of our manuscript and their insightful comments and suggestions.
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List of tables

Table 1. Averaged WDS electron-microprobe analyses of selected elements of amazonite samples (full results in Supplementary Materials).

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<tr>
<td>Eghbi Zuma c, Libya</td>
<td>129752</td>
<td>7279</td>
<td>18</td>
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<td>Eghbi Zuma d, Libya</td>
<td>130665</td>
<td>5922</td>
<td>22</td>
</tr>
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<td>Talat Umm, Jaraf, Egypt</td>
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</tbody>
</table>

Raw material microprobe

Ancient and ethnographic comparison beads

- Mauritania: 131578 4022 33
- Mali a: 130084 7908 16
- Mali b: 130748 7320 18
- Mali c: 131661 3162 26
- Mali d: 131163 7940 17
- Mali e: 130084 9877 13

Nortelic beads (from R12 cemetery, Sudan)

- R12a: 131661 2177 60
- R12b: 131163 2041 64
- R12c: 131993 1949 68
- R12d: 131827 2326 57
- R12e: 129968 1899 68
Table 2. Exotic materials recorded in Nubian Early Neolithic (El Barga), Nubian Middle Neolithic (J. Ramlah, Kadruka and R12) and Central Sudan Early Neolithic sites (Ghaba and Kadero).

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Exotic shells</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Ramlah E-01-2</td>
<td>Egypt</td>
<td>Conus sp.</td>
<td>Kurzawska 2010</td>
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<td>Salvatori et al. 2016</td>
</tr>
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Table 3. Exotic materials recorded in Late Neolithic sites in central and eastern Sudan.

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<td>Arkell 1953</td>
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<td>Carannante 2012</td>
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<td>Rabob</td>
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<td>Fernandez et al. 2003b</td>
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Figure 1. Map of the region illustrating the position of the R12 cemetery and other Neolithic sites cited in the texts.

178x156mm (300 x 300 DPI)
Figure 2. Plan of the R12 cemetery.
Figure 3. Examples of amazonite beads (left) and a fragment of amazonite raw material (right) from the excavation at R12.

414x242mm (72 x 72 DPI)
Figure 4. Picture of a tomb at R12 and details of the same burial after excavation, illustrating a rich assemblage of precious goods including necklace with amazonite beads.
Figure 5. K/Rb versus Rb diagram of geochemical ratios of the elements considered to discriminate amazonite provenance.
Figure 6. Site location and sources with possible communication pathways established by Neolithic people living in Upper Nubia.

176x110mm (300 x 300 DPI)
Supplementary Material

1. Analysed materials

Chemical analysis on a selected set of amazonite beads (9 samples) from R12 were carried out to test the hypothesis advanced by Arkell (1953, 1964) that amazonite as a raw material originated from the Tibesti massif. The study sample set includes: two beads from Grave 83 (Middle Neolithic A: Period 1-B2; beads R12a and R12b), one from Grave 116 (Middle Neolithic A: Period 1-B2; bead R12c); a fourth bead was collected on the site surface before the excavation started (bead R12d). A further 5 beads (R12e–i) come from an eroded grave that can be dated, according to the associated pottery materials, to the Middle Neolithic B (Period 2: Multaga Phase) of the R12 cemetery. These archaeological amazonite samples were compared to a number of samples from the amazonite-bearing pegmatites that outcrop in many places across northern and eastern Africa (see for a geological discussion on their distribution: Zerboni et al. 2017), obtained from museums and private collections. Pegmatite samples here discussed are from the Tibesti massif (Eghei Zuma area) in southern Libya; Talat Umm Jaraf, Jebel Hafafit, and Jebel Migif in southeastern Egypt; Konso and Kenticha in Ethiopia and a region between Jordan and Saudi Arabia, not far from Wadi Tabuik. These amazonite outcrops are already known and in some cases (Eghei Zuma and the Egyptian sites) they display evidence for archaeological or modern quarrying. A single outcrop of pegmatite with amazonite known in Sudan is located in the Jebel Nuhud and a specimen from this locality was also analysed. Other comparison samples correspond to beads and pendants traded today across North Africa and belong to ethnographic private collections. These include a modern Tebu bead used as a pendant, nowadays traded in the old market of Omdurman, in Sudan, an ancient bead from Mauritania, and 5 beads part of a traditional necklace from Mali.

2. Description of the analytical method

According to the protocol described in Zerboni and Vignola (2013) and Zerboni et al. (2017), chemical analyses on micro-samples of 50-100 µm in diameter, sampled from the inner part of each bead and from the hand specimens from natural outcrops, were performed. Amazonite micro-flakes were enclosed in epoxy, polished, and carbon coated. Quantitative electron microprobe chemical analyses in wavelength dispersive mode (EMPA-WDS) were performed using a JEOL JXA-8200 electron microprobe on at least four points for each sample. The typical perthitic texture of amazonite (i.e., alternating lenses of microcline and albite; Fig. SM1) is fine, and for that reason
we adopted the microprobe thanks to the possibility to identify with high precision on the back-scattered electron (BSE) images the position of each point analysed. This procedure assured to collect information only on the blue microcline fraction (Zerboni et al. 2017). For these samples, due to the micro-perthitic texture of the amazonite, it is of great importance to locate the electron beam with micrometric precision, in order to avoid the micrometric-thick albite strips, which may contaminate the result of each analysis (Zerboni et al. 2017).

![Back-scattered electron (BSE) image showing the perthitic texture of one of the amazonite sample from R12. Note the occurrence of a mixture of dark and light gray areas, corresponding to albite and microcline respectively; the very light gray lamella is muscovite. The beam diameter of c. 1 µm of the microprobe permits analysis of microcline and avoids contaminations from albite crystals (within rock matrix).](image)

The system was operated with an accelerating voltage of 15 keV, a beam current of 5 nA, a beam diameter of 1 µm, a counting time of 30 sec on the peaks and 15 sec on the backgrounds for the principal elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, and K), and 30 sec on the peaks and 30 sec on the backgrounds for the minor elements (Pb, Sr, Cs, Ba, P, Rb and Cl). The natural minerals grossular for Si (Kα1, TAP), Al (Kα1, TAP) and Ca (Kα1, PET), K-feldspar for K (Kα1, PETH), forsterite for Mg (Kα1, TAP), omphacite for Na (Kα1, TAP), ilmenite for Ti (Kα1, PET), fayalite for Fe (Kα1, LIFH), rhodonite for Mn (Kα1, LIFH), cancrinite for Cl (Kα1, PET), pollucite for Cs (Lα1,
PET), celestine for Sr (Lα1, PET), baryte for Ba (Lα1, PET), galena for Pb (Mα1, PET), “apatite” for P (Kα1, PET), and synthetic compound Rb₂MnF₆ for Rb (Lα1, PET) were used as standards. The elements Ti, Cl, and P were below detection limits in all analyzed points. The raw data were corrected for matrix effects using the ΦZ method as implemented in the JEOL suite of programs; mean values between analysed points were calculated (for all analyses the 3σ value was below 1) and summarized into Table 1 of supplementary material.

The chemical composition of all the samples analysed (raw materials and ornaments) in terms of orthoclase, albite, anorthite percentage (Or, An, Ab) of blue-green areas samples plot in the area belonging to perthitic orthoclase-microcline in the ternary plot diagram used for the nomenclature of ordered ternary feldspars (Deer et al. 1992). The absence of Ca (anorthite) in the composition of the amazonite samples indicates a temperature of crystallization below 750°C at 1 kbar in the field of crystallization for the shallow level NYF pegmatites at each site and their attribution to amazonite (Fuhrman and Lindsley 1988; Wise 1999; Simmons et al. 2003; Černý and Ercit 2005). The geochemical trace elements signature of single minerals (in this case, potassic microcline) from a pegmatitic dike closely reflects the composition of the granitic source (Martin et al. 2008). For this reason, each chemical composition obtained is completely representative of the mean geochemical character of the magmatic rocks in its source area.

3. Petrogenetic development of amazonite

Amazonite is a semi-precious green to blue-green variety of microcline with white veins, and is commonly found as a rock-forming mineral in the niobium-yttrium-fluorine or NYF geochemical type of granitic pegmatites (Černý and Ercit 2005), or in pegmatites that reacted with deposits of massive sulphides containing Pb (Wise 1999; Martin et al. 2008). Pb also determines the typical colour of amazonite thanks to its incorporation into the structure of microcline at the expense of K. The replacement of K by Pb induces a structural vacancy that is filled by H₂O, which turns the whitish colour of microcline into the greenish-blue colour of amazonite (Hofmeister and Rossman 1985).
Fig. SM2. Ternary plot of the composition of K-feldspars in terms of Or-Ab-An (modified from Deer et al. 1992); Or is orthoclase, Ab is albite, An is Anorthite. Dots corresponds to the composition of analyzed samples; the whole set of samples falls in the area of microperthite or pertithic microcline.

NYF-type granitic pegmatites are generated by magmatic differentiation of calcalkaline to peralkaline granitic masses related to anorogenic or late-orogenic tectonic environments (Martin and De Vito 2005). The magmatic differentiation of these granitic masses generates swarms of pegmatitic dikes, which present a homogeneous geochemical fingerprint matching the parent granite and are highly enriched in fluorine, yttrium, and niobium. The dikes are zoned, and low-temperature green feldspar forms big masses or single crystals in the intermediate zone (Simmons et al. 2003).

On the basis of analytical data (Table 1 of the main text), the chemical composition of all the amazonite samples analyzed matches that of a perthitic orthoclase-microcline in the ternary plot of Fig. SM2, used for the nomenclature of ordered ternary feldspars (Deer et al. 1992; Wise 1999; Simmons et al. 2003; Černy and Ercit 2005). The absence of Ca confirms the attribution of the raw material to amazonite (Fuhrman and Lindsley, 1988). At the microscale of analysis, raw material outcrops belonging to our dataset presents large crystals of amazonitic microcline embedded in the pegmatitic matrix and displaying the typical perthitic pattern (Fig. SM3).
Fig. SM3. Photomicrograph of amazonitic microcline from selected outcrops in thin section (under cross polarized light) displaying the typical perthitic pattern (note also the tartar twin pattern of A). Sample provenance: A, Eghei Zuma; B, Jebel Hafafit; C, Jebel Migif; D, Konso.

4. Possible sources of amazonite raw material in northeastern Africa and adjoining regions

In Africa, amazonite-bearing pegmatites relate to a series of late- to post-orogenic calc-alkaline to peralkaline intrusive magmatic plutons that formed during the late stages of the Pan-African Neoproterozoic orogenic event c. 550 MA (Zerboni and Vignola 2013). NYF granitic pegmatites originated after magmatic differentiation of these calc-alkaline intrusive rocks and intruded into the meta-sedimentary or volcanic sequences up to continental-scale mobile belts, joining the Archean cratons. Calcalkaline granitic plutons form a series of outcrops that are roughly aligned in a NE–SW direction, and stretch from the Sinai Peninsula to Nigeria. It is within these late orogenic plutons that the NYF pegmatite swarms originated, and raw material sources of amazonite can be found (Zerboni et al. 2017).

Amazonite-bearing pegmatites have been described in Madagascar (Lacroix 1922), Malawi (Martin et al. 2008), Namibia (Bezing et al. 2008), Ethiopia (Küster et al. 2009), between Ethiopia, Djibuti, and Somaliland at Hargeysa in theMohlieh Hill region (Thoresen and Harrell 2010); Sinai Peninsula (Katzir et al. 2006), between Jordan and Saudi Arabia (Bar-Yosef Mayer and Porat 2008; Wright et al. 2008), the western coast of the Red Sea in Egypt (Harrell and Osman 2007; Küster
2009; Harrell 2012), in the Tibesti of southern Libya (Monod 1948), Adrar des Iforas in Mali (Ba et al. 1985), along the Hoggar Massif in Algeria (Ghuma and Rogers 1978; Vianello 1985; Balzi et al. 1997), in Sudan in the region of Jebel Nuhud and at Kadugli, at Buruku in Nigeria (Obaje 2009), and in the Pare Hills of Tanzania (Thoresen and Harrell 2010). Microcline-bearing pegmatites also exist within the several peralkaline complexes of North Africa including the Jebel Uweinat and Jebel Arkenu in south-eastern Libya (Flinn et al. 1991), but amazonite has never been observed at these sites.

References


### Raw material outcrops

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<th>MgO (wt%)</th>
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<td>60.79</td>
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<td>Mali a</td>
<td>Mali b</td>
<td>Mali c</td>
<td>Mali d</td>
<td>Mali e</td>
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### Ancient and ethnographic comparisons based on Newolithic beads from R12 cemetery (Ezada)

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<th>SiO2 (wt%)</th>
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### Notes

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### Minor elements

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<th>K2O (wt%)</th>
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<th>Cs ppm</th>
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### Summary

- The table provides a comparison of raw material outcrops and ethnographic artifacts from the Newolithic beads found in the R12 cemetery.
- The composition of SiO2, Al2O3, MgO, and FeO is detailed for each site.
- Minor elements such as Na2O, K2O, Pb, Cs, K/Rb, Rb, and Sr are also included in the summary.

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