The hydro-geomorphological setting of the Old Kingdom town of al-Ashmūnayn in the Egyptian Nile Valley

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Abstract
The ancient Egyptian city of al-Ashmūnayn (Minyā Governorate, Egypt) has been an important regional centre since at least the Old Kingdom (c. 2686–2160 BC). It is assumed to have been founded on the banks of the Nile, although no scientific evidence was hitherto available to support this claim. In this multidisciplinary study, the results of a geoarchaeological survey were combined with the study of pottery fragments. Boreholes placed at al-Ashmūnayn produced thick layers of late Old Kingdom pottery in association with the local occurrence of river channel deposits, allowing us to conclude that it is very likely that al-Ashmūnayn originated on the banks of the Nile River. The regional borehole survey demonstrates that major geomorphological reconfigurations of the fluvial landscape occurred throughout the late Holocene, notably by the process of river avulsion. An interconnectedness of changes in the natural Nile Valley landscape and cultural dynamics of the ancient Egyptian riverine society seems possible, based on the coincidence of river reconfigurations with shifts in the preferential locations for high-status burials in the region.

KEYWORDS
Dayr al-Barshā, Egyptology, fluvial geomorphology, Holocene, pottery, river avulsion

1 | INTRODUCTION

The present al-Ashmūnayn is an agglomeration of villages in Middle Egypt (Figure 1a), located at the site of what was a major town in ancient times. The visible archaeological remains of the town mostly date back to the New Kingdom (NK: c. 1550–1069 BC) (Figure 2: II), the Late Period (LP: 664–332 BC) (Figure 2: V), the Graeco-Roman period (GRP: 332 BC to 395 AD) and the Late Roman period (LRP: 395–641 AD; dates cf. Shaw, 2000, unless stated otherwise) (Figure 2: III). During these periods, the town was an important administrative and religious centre (Kessler, 1977). The pre-NK history of the settlement is, however, poorly known (see Section 2.1). The oldest monument visible today is what remains of a temple gate (Figure 2: IV) from the reign of the pharaoh Amenemhat II (c. 1911–1877 BC) during the Middle Kingdom (MK: c. 2055–1650 BC), which was uncovered during excavations carried out between 1929 and 1939 (Roeder, 1959). Remains of an earlier temple were tentatively dated to the late Old Kingdom (OK: c. 2686–2160 BC), but were poorly documented due to water-logged conditions (Steckeweh, 1937). More recent excavations, carried out by the British Museum, located a late OK to First Intermediate Period (FIP: c. 2160–2055 BC) cemetery to the north of Seti II’s Amun temple...
This assumption has become widely accepted, but was not factually based on concrete evidence. It seems, nonetheless, likely that the geomorphology of the Nile Valley landscape and particularly the location of river channels may have played an important role in creating suitable places for settlement, and this would have influenced the connectivity between sites in the wider region. Such interconnectedness of human and natural landscapes has been suggested for the Nile Delta (e.g., Ginai et al., 2019; Pennington et al., 2021) and other regions in the Nile Valley, for example in the Memphite region (Bunbury et al., 2017; Lehner, 2014; Tallet & Marouard, 2014), Thebes (Toonen et al., 2018) and in the Sudan (N. Spencer et al., 2012).

The current study presents the results of a regional geoarchaeological survey, based on 33 newly drilled boreholes, complemented with the analysis of pottery fragments from nine dedicated cores at al-Asmûnayn. The aims of this study were (i) to determine the presence and extent of OK settlement deposits at al-Asmûnayn, (ii) to reconstruct the local environmental context of the earliest cultural deposits, (iii) to reconstruct changes in the regional fluvial landscape during the town’s existence while developing an understanding of underlying morphodynamics that caused these changes and (iv) to compare changes in the regional cultural network of sites with changes in the regional fluvial network to establish potential correlations between both.

2 | CULTURAL AND ENVIRONMENTAL SETTING

2.1 | Old Kingdom Khemenu

The Arabic name for al-Asmûnayn is the grammatical dual of the earlier Coptic name Shmûn: ‘the two Shmûns’ (Gardiner, 1947). This may reflect the existence of two settlements in pharaonic times: Khemenu and Wenu. The exact meaning of Shmûn is still debated, but its etymological connection to ancient Egyptian Khemenu was demonstrated by Gardiner (1947). In Egyptian mythical narratives, Khemenu was considered to be the place where a group of eight primordial gods created the world. Wenu, ‘the Town of the Hare’ (Zibelius, 1978, pp. 64–67), refers to the nome (province) of the Hare, of which it was the capital (Figure 1a: 1). The name of Khemenu is earliest attested in the pyramid temple of pharaoh Sahure of the early Fifth Dynasty (c. 2487–2475 BC) (Zibelius, 1978, p. 189; Zivie-Coche, 2009). The name Wenu is even older, being attested for the first time in the Early Dynastic Period (EDP: c. 3100–2686 BC) (Zibelius, 1978, pp. 64–66).

Although several large monolithic baboon statues representing Thoth, the main deity of Khemenu, were excavated from al-Asmûnayn (Figure 2i), most information on Khemenu derives from burial sites in the region, which suggests that a major urban centre existed at least from the late Fifth and Sixth Dynasties onwards (c. 2400–2180 BC). The highest officials of the Hare nome of that time had their tombs built at al-Shaykh Sa’îd (Davies, 1901), in the limestone cliffs that border the alluvial plain (Figure 1a: 4). Some of the inscriptions found in these tombs explicitly refer to Khemenu. No tombs are known for the nomarchs of the FIP, but in the alabaster quarries of Hatnub in the Eastern Desert (Figure 1a: 5),
several of the early inscriptions render nomarch names (Anthes, 1928, pp. 18–24). Names like Djehutinakht include the element 'Djehuti', which is the name of the god Thoth, and thus suggests that the nomarchs originated from Khemenu.

At Dayr al-Baršā, c. 5 km north of al-Shaykh Sa'id and c. 10 km east of Khemenu/al-Ashmūnayn (Figure 1b: 6), there are several late OK inscribed tombs of officials that refer to a deity designated as 'he who is in Khemenu', which may again refer to Thoth (De Meyer, 2008, pp. 48–60).

These texts refer to the tomb owners as a 'revered one near the One who is in Khemenu', suggesting that both al-Shaykh Sa'id and Dayr al-Baršā were part of Khemenu's sphere of influence, and probably acted as satellites for burial activities. Other cemeteries in the region that may have been connected to Khemenu are a late OK cemetery on the southern outskirts of the modern village of Dayr al-Baršā (Willems, 2013) and extensive early OK low-status cemeteries in the foothills of the Eastern Desert between Dayr al-Baršā and Dayr Abū Ḥinnis (Vanthuyne, 2017).
Moreover, an early Fourth Dynasty industrial site and quarry settlements recently discovered near al-Shaykh Sa'id may also have been linked to Khemenu (Willems et al., 2009).

2.2 | The fluvial environment

The regional landscape may have played a pivotal role in Khemenu’s and later al-Ashmūnāyn’s importance as a major town and administrative centre throughout ancient Egyptian history. First, its location in one of the widest parts of the Nile Valley, measuring just over 15 km across, offered an extensive agricultural hinterland. A second factor of importance may have been its supposed proximity to the river, allowing trade and facilitating transport between the town and its satellite locations, and beyond. Although the present Nile is positioned at the eastern fringe of its valley (Figure 1b), and is assumed to have been active in that zone throughout at least the last few millennia (Verstraeten et al., 2017), it has been suggested that the Nile flowed through the central part of the valley during the OK (Butzer, 1976). His suggestion was based on the assumption that floodplain settlements could only emerge on high landscape features, such as levees, that were beyond the reach of regular Nile floods. Accordingly, the location of Khemenu was inferred to imply the position of the Nile in the centre of the valley. The main channel of the Nile would have migrated steadily in an eastward direction since the OK. Butzer’s eastward channel migration premise has become a widely used model for the long-term change of the fluvial landscape in Egypt; Bunbury and Malouta (2012) applied this model also to the al-Ashmūnāyn region (Figure 3). Yet, the model has not been supported by targeted geomorphologic reconstruction of the past landscape neither in our area of interest, nor in the Sohag region for which it was initially formulated (Figure 1a).

3 | METHODOLOGY

A multidisciplinary approach was used to reconstruct the past fluvial landscape and to date natural and cultural deposits. This reconstruction was based on the general characteristics and architecture of deposits indicative for specific formative processes, agents of transport and the resulting landforms (cf. Bridge, 2003; Miall, 1985). As the shipping of sample material for radiometric dating is restricted in Egypt, our main source of dating information was the analysis of pottery fragments following a similar methodology as that used at many other sites in Egypt (see Section 3.2 and Supporting Information SA).

3.1 | Survey of subsurface deposits

Boreholes were drilled at 33 locations in three main zones: (i) nine boreholes distributed within the archaeological zone of al-Ashmūnāyn, and two additional boreholes that flank the tell (town mound) on each side.
side, (ii) 13 boreholes in a southwest–northeast-oriented transect passing the modern town of ‘Izbat Tabūt (Figure 2a) and (iii) another nine boreholes in a west–east-oriented transect in the floodplain area between the towns of Qulubba and Mallawi (Figure 2a). At al-Ashmūnayn, two boreholes (#1 and #2) were placed near the MK gate in the deepest part of Roeder’s excavation trench (Figure 2c), from which deposits of the last c. 4000 years had already been removed. Five boreholes (#3–7) were drilled between the NK Amun temple of Seti II (c. 1200–1194 BC) and the LP Thoth temple of Nectanebo I (c. 380–362 BC) to the north, to cover the area around the FIP cemetery (Figure 2d). The remaining boreholes (not rendered in Figure 2—all borehole locations provided in Supporting Information SB) were positioned east of the paved road leading to the visitor centre of al-Ashmūnayn.

The two borehole transects to the south of al-Ashmūnayn were aimed at investigating the potential fluvial context of the settlement, which is difficult to do systematically at the archaeological site due to modern occupation and the thick overlying anthropogenic layers containing numerous stone blocks. The general west–east alignment of the transects is perpendicular to the general south–north slope of the Nile Valley, and allows one to produce cross-sections of the landscape that are used to identify past landforms. The general spacing of c. 200 m between individual boreholes ensures that no major geomorphologic elements in the subsurface, such as channel belts, were missed.

Boreholes were drilled using an Eijkelkamp percussion drilling set and a manual Edelman auger. At the site of al-Ashmūnayn, only the percussion core sampler was deployed to penetrate pottery-packed occupation layers. For both soil-sampling kits, the maximum coring depth was c. 10 m below the surface. The main sedimentary characteristics were described in the field following the USDA (2017) soil classification system (borehole logs provided in Supporting Information SB). The location of boreholes was recorded using a handheld Garmin GPS. A dumpy level and topographer’s rod were used to determine local relative elevations, which were subsequently linked to a local Survey of Egypt point at al-Ashmūnayn for Datum reference.

3.2 Study of pottery fragments

Pottery fragments were collected and bagged in the field per c. 10–20 cm interval. After rinsing and drying, fragments larger than 5 mm were selected for further study. The bulk of these pottery finds consisted of body fragments, but also included a scatter of diagnostic specimens, such as rims, bases and handles (Figures 6–8). These were described and drawn if sufficiently large and well enough preserved. This type of study unlocks chronological information by scrutiny of fabrics, surface treatment, manufacturing technology and shape—all of which changed over time (Bourriau, 2006). The classification system is presented in Supporting Information SA.

Pottery dates were based on the information from individual diagnostic fragments combined with the characteristics of the assemblage of finds at the same level and relative age indications derived from the vertical succession throughout the borehole. In the absence of an independent absolute radiometric dating control and other (inscribed) finds tying samples to the dynastic history of Egypt, the dating was largely based on comparative analyses of the materials with well-dated sequences of pottery and singular finds from other sites. Table SA1 presents a detailed overview of all the used analogues—OK pottery was mainly compared with pottery chronologies from the Memphite region just south of modern Cairo (Kytanová, 2009; Rzeuska, 2006).

Pottery derived from boreholes (#4–6) that demonstrated clear mixing upon initial inspection was not considered in detail in this study. Mixing, most likely caused by the digging of foundations and the excavation of archaeological material, was usually easily identified inter alia by the presence of distinct brown LRP Amphorae (Type 7) fragments, whose fragments dominate the present surface deposits at al-Ashmūnayn. The identification codes for diagnostics were compiled from the borehole identification number, followed after a slash by its depth interval (in metres) and then an additional character if multiple specimens were derived from the same interval, for example, specimen F from a depth of 4.4–4.6 m in borehole #3 is identified by the following code: #3/4.4–4.6F.

4 RESULTS

4.1 Sedimentary units and regional geomorphologic interpretation

The two lithological profiles to the south of al-Ashmūnayn show a rather similar lateral and vertical succession of deposits (Figure 4). Six main sedimentary units were recognized and interpreted as the basic geomorphological elements of the past riverine landscape: a coarse-grained regional substrate (Unit A), sandy accretional channel deposits (Unit B), heterogeneous channel-fill deposits (Unit C), levees (Unit D), fine-grained floodplain deposits (Unit E) and minor channel and/or crevasse-splay deposits (Unit F).

Unit A represents the local substrate with its top located at a depth of 8–10 m below the present surface (c. 32–34 m asl: above the mean sea level). The medium to coarse sands (300–500 μm) were poorly sorted. Borehole collapse prevented deeper penetration; however, Attia (1954) suggests a thickness of this regional substrate, which consists of coarse sands and gravels, of at least 35 m. Similar deposits exist throughout the Egyptian Nile Valley, and are thought to have formed in a distinctly different fluvial environment that existed in the Early Holocene (Butzer, 1998; Said, 1993). The transition with the overlying sedimentary units was characterized by the frequent occurrence of calcium carbonate nodules (rhizoliths), and iron and manganese flecks. Such pedogenic features suggest that the top of the regional substrate has been an exposed surface level for a prolonged period (cf. Klappa, 1980); similar features have been observed in the Luxor region (Toonen et al., 2019) and in the Nile Delta (e.g., Chen & Stanley, 1993).

Unit B consists of a c. 800–1000 m wide zone of (loamy) sands that rises to max. 3 m above the regional substrate. These quartz-rich
sands fine upward, from 500 μm at their base to c. 100 μm in their top levels. Compared to the substrate, these sands are much more heterogeneous, with 1 cm-scale loam and clay laminations. Mm-scale layering within the sands was interpreted as cross-beded features that formed within the active river channel, as internal structures found in bars or dunes (Miall, 1985). The width of this sand body reflects the maximum possible width of the active river channel. Presumably, the active channel would only have occupied part of the sand body, with lateral movement leaving the sandy deposits at its flanks. Given the low-sinuosity and cohesive clayey banks of the Nile, the amount of lateral migration would probably have been limited, suggesting the presence of a large (primary) channel of the Nile close to al-Ashmūnayn. A weak palaeosol was encountered in the top of Unit B at the transition with overlying fine-grained sediments. At this level, c. 6 m below the present surface, many charcoal flecks and degraded pottery fragments were found. This suggests that the relatively high grounds of the channel belt and its levees were a preferred location for human activity.

Unit C represents local anomalies in the sandy deposits of Unit B (Figure 4). Instead of sands, up to 3 m thick sequences of strongly laminated loams were found, at 6–9 m depth. A slight downward coarsening occurred towards the bottom, where such sequences graded into the sands of Unit B. The mm-scale laminations can be linked with individual flood events, as recorded in the sedimentary fill of residual channels (Toonen et al., 2012).

Unit D is composed of loamy sediments, ranging from loamy sands to silty clay loams (30–80 μm), that often featured mm-scale laminations. This unit flanked Unit B in 200–300 m wide zones, where it directly overlies the regional substrate and reached up to similar levels as Unit B. It fined and thinned at increasing distance from the channel sands. Based on its configuration, the texture of deposits and the lateral fining, this unit was interpreted as the levees of the aforementioned river channel.

Unit E is dominated by homogeneous brown-grey-coloured silty clays that often lacked clear sedimentary structures. Their mean grain size ranged between c. 10 and 30 μm. Unit E was found in all boreholes, but its thickness varied widely; where Units B and F were absent, the silty clays reached from the substrate to the present surface. These alluvial fines were interpreted as common floodplain fines that were deposited as overbank material during Nile floods.

Unit F is a group of (silt-)loam to fine-sand deposits found in the upper metres of the floodplain. Their thickness was usually c. 1–1.5 m, and the dominant texture was loam. At a few places, the thickness of this unit increased to c. 3 m (Figure 4), where sediments also coarsened to fine (loamy) sands (100 μm). The location of these roughly matches those of irregularly shaped waterways indicated on historical maps of the region (Jacotin, 1821; Willems et al., 2017) (Figure 3). Based on our observations, it seems plausible that parts of the modern drainage system have emerged from a pre-existing network of minor channels, whose configuration, together with the presence of relatively thin sheets of loamy material, resembles that of crevasse-splay complexes (Smith et al., 1989; Toonen et al., 2015).
4.2 | Deposits at al-Alshmūnayn

At al-Alshmūnayn, the deepest core in Roeder’s excavation trench (Figure 2c: #1), reached 9 m below the local surface (at 41 m + msl; Figure 5). The lowest 2 m of deposits consisted of fine to medium sands (up to c. 300 μm) with mm-scale layering and intercalated clay loams. Charcoal and pottery fragments were found in the top half of these sands. Above the sands, a c. 3 m thick sequence of laminated clay loams was found (34–37 m + msl), again with pottery and an abundance of charcoal fragments. The upper 4 m of sediment consisted of sandy deposits with many pottery fragments and occasionally some charcoal fragments. The loose structure and high water content of these sands resulted in a rather poor sample recovery in the bottom metre of this unit.

Borehole #2 had a lower depth. The lowermost deposits around 6 m depth (35 m + msl) were clay loams with many charcoal fragments. These correlate to the deposits at similar depth in the nearby borehole #1 (Figure 5). Above this level, relatively fine-grained sandy deposits were encountered all the way up to the surface. The lower part of these sands contained many charcoal and pottery fragments. Between 2.5 and 4.5 m depth (37.5–39.5 m + msl), the deposits were loamier and strongly laminated. The top of this sequence consists of unconsolidated sands, similar to borehole #1.

Borehole #3, with a surface elevation of c. 41.5 m + msl, featured comparable deposits as those found in boreholes #1 and #2. Medium sands at the bottom (33.5 m + msl) were occasionally layered and contained some charcoal fragments, but only a few pottery fragments. The number of charcoal fragments increased in the overlying c. 1 m of silty clay loams. After another metre of medium sands, again 50 cm of clay loam was found. Both contained an abundance of charcoal fragments and pottery. Above c. 37 m + msl (Figure 5), unconsolidated sandy deposits reached to the present surface. Locally, these sands were characterized by many laminations, charcoal and chunks of clay. The latter are probably rip-up clasts, the remains of clayey deposits or laminations that were eroded by river flow and its fragments rounded during transport.

Borehole #4 was farthest north and placed in the excavation trench of the Nectanebo I’s Thoth temple at c. 4 m (40 m + msl) below the surrounding surface levels. Mixed sandy deposits started at a depth of 1.5 m, but pristine sands appeared from c. 2.5 m (37.5 m + msl; Figure 5) and continued down to the base of the borehole at 8 m depth. The sandy deposits demonstrated an overall coarsening-down trend from 300 to 800 μm with an increase in small gravels. The upper 1.5 m of deposits was heavily disturbed and contained a few pottery and limestone fragments.

Borehole #5 (c. 43 m + msl) was positioned north of the FIP cemetery (Figure 2c). Sands occurred below c. 6.5 m depth (36.5 m + msl). These coarsened down from 300 μm in the top to 500 μm in the basal parts of the borehole at 10 m depth. The strongly internally laminated top 6 m of sediments was very heterogeneous, with layers of (silty) clay loam to loamy sediments (20–50 μm) intercalating with more sandy loams and loamy sands (60–80 μm). A concentration of charcoal flecks was found between 2.8 and 3.4 m and again between 5.3 and 6.3 m depth (Figure 5); yet, pottery fragments were relatively rare.

At borehole #7 (c. 41.5 m + msl), located at c. 50 m northwest of Seti II’s Amun temple, relatively coarse sands were encountered below 7.5 m depth (33.5 m + msl). The upper 7.5 m of sediments were dominated by loams, but highly variable, with a texture ranging between silty clay loam (20 μm), sandy loams (50 μm) and occasionally c. 30 cm thick intervals of sands (200–300 μm). The entire interval above 37 m + msl was marked by an increase in the occurrence of pottery fragments, charcoal flecks and chunks of clay (Figure 5).

Other boreholes at al-Alshmūnayn did not penetrate the mixed top-soil or had mixed stratigraphies and are therefore not discussed here; their data are presented in Supporting Information SB. As they did not yield significant geogenetic or chronological information, they were excluded from further analysis and interpretation.

Borehole #10 was placed in an agricultural plot c. 150 m west of al-Alshmūnayn (Figure 2b). At least 8.8 m (42.0–33.2 m + msl) of fine-grained deposits, predominantly silty clay loams, were found. The top 6 m was characterized by the occurrence of loamy laminations and small pottery fragments. Between 6 and 7 m depth (36–35 m + msl), a loamy sand interval (100 μm) was found, devoid of any archaeological material. The stiff silty clay loams in the lowest metre featured small pottery fragments.

Borehole #11 was located c. 125 m east of al-Alshmūnayn (Figure 2b). The top 9 m (42.0–30.0 m + msl) had a texture ranging from silty clay loam to sandy loam, with some pottery fragments occurring in the upper metre and between 1.7 and 7 m depth. The basal metre (33–32 m + msl) consisted of sandy deposits that coarsened downward from 80 to 300 μm.

4.3 | Pottery finds and chronologies from al-Alshmūnayn

Four boreholes at al-Alshmūnayn produced reliable continuous chronologies: #1-3, and #7 (Figure 2c). Despite the presence of many pottery fragments, borehole #1 produced only 12 diagnostic fragments, of which eight were well enough preserved and sufficiently large to be drawn (Figure 6a). The deepest segment of the core that yielded pottery, between 6.0 and 8.0 m depth (33–35 m + msl), predominantly contained medium coarse Nile B2/C1 fabric specimens (similar to Nile C1-2 in the Vienna System; Nordström & Bourriau, 1993, pp. 173–174, pl. II.e-i). For these, it was not possible to determine the original vessel shape. In addition, a few fragments were recovered of a fine Nile clay fabric (Nile A-B1), belonging to red-slipped and polished (inside and outside) OK bowls or plates, most evident from a rim specimen (#1/6.9-7.0: Figure 6a). A more precise date could not be suggested because this type of bowl occurred throughout the OK (c. 2686–2160 BC).

Except for a single beer jar body fragment at 5.4 m, no diagnostic pottery was retrieved between 5.2 and 6.0 m depth (35–35.8 m + msl). Many fragments were found between 4.2 and 5.2 m depth (36.8–35.8 m + msl), with a suggested late OK date.
FIGURE 5  
Sedimentary logs of the al-Ashmūnayn boreholes; for their location, see Figure 2c [Color figure can be viewed at wileyonlinelibrary.com]
Most body fragments there belonged to beer jars; a single diagnostic sherd (#1/4.8-4.9A) was similar to those of phase III–IV at Saqqâra (Rzeuska, 2006, p. 382), corresponding to the reign of Pepy II (c. 2278–2184 BC) until the end of the Sixth Dynasty. This date was supported by a large Nile B1 bowl fragment with a modelled rim (#1/4.8-4.9C). Two fragments of Nile B1–B2 jars with a modelled rim but without an actual neck (#1/4.3-4.5 and #1/4.8-4.9B) may have been part of medium-sized or small jars comparable to types that occurred rather frequently during the Sixth Dynasty at Saqqâra and more exceptionally at Abū Sīr (Table SA1). Between 3.0 and 4.2 m depth, no pottery was found as a result of poor sample recovery. At 2.9–3.0 m depth, some beer jar fragments were found, but no other diagnostic material in the upper 3 m (38–41 m + msl). The present surface level at the borehole locations in Roeder’s excavation trench corresponded with the floor level of MK monuments; overlying younger deposits were excavated and removed in the past.

Borehole #2 was drilled from the same surface level as borehole #1. It produced 21 diagnostic pottery fragments, of which 18 were drawn (Figure 6b). A high density of pottery, including many large fragments, was found continuously throughout the 6 m core, with the exception of several minor intervals. These were caused by poor sediment recovery due to unconsolidated deposits and do not, therefore, represent gaps in the cultural occupation history. The lowest section (5.5–6.0 m depth; 35.0–35.5 m + msl) of the borehole was dominated by medium coarse Nile B2/C1 fabrics, similar to borehole #1, and were interpreted as body fragments from beer jars of types that occurred from the late EDP to the late OK (cf. OK examples in Rzeuska, 2006, pp. 382–383). The combination of these with fragments of fine red-slipped and polished plates and dishes (Op de Beeck, 2004; Rzeuska, 2006, pp. 198–260), as well as bread moulds (Faltings, 1998; Jacquet-Gordon, 1981, pp. 125–136) found between 5.5 and 5.7 m supports a general late OK date (Fifth or Sixth Dynasty). The diagnostics at this level are not particularly large or distinctive, but the fabrics and surface treatments support the proposed age (e.g., #2/5.6-5.7A with a parallel at Abū Sīr; Table SA1).

Similar pottery material continued to be found up to a 4.0 m depth (37 m + msl), with a general OK to late OK date. OK beer jars appeared prominently, along with red-slipped and polished open vessels and wide bread moulds (Jacquet-Gordon, 1981, fig. 2–3; Faltings, 1998, pp. 129–134). Diagnostics found between 4.0 and 4.5 m, and a single specimen at 4.8–4.9 m (Figure 6b), pointed to a more specific final OK to FIP date. These included a wide bread mould (#2/4.4-4.5B), a ‘Ma’dûm’ bowl (#2/4.2-4.4C), shallow plates or dishes with parallel finds in the western Nile Delta, at Giza, Saqqâra, Abū Sīr, Iḫnāsiya al-Madina and al-Kâb, with a groove under the

![FIGURE 6](http://www.gea.wiley.com/doi/10.1002/gea.21894) Pottery drawings of boreholes #1 and #2—see Supporting Information SC for grouping per pottery type
interior of the rim (#2/4.0-4.2 and #2/4.2-4.4A) and sometimes also on the exterior (#2/4.4-4.5A; similar to #1/4.2-4.3 and #2/4.8-4.9)—see parallels from other studies listed in Table SA1.

The number of beer jar fragments declined between 3.4 and 4.0 m, and almost no pottery was recovered from between 3.0 and 3.4 m depth (37.6–38 m + msl), hampering any age inference for this level. The lack of pottery may relate to a chronological change or to a temporal shift in local occupation or use of this site. Overlying pottery fragments, between 2.0 and 3.0 m depth (38–39 m + msl), were, however, still roughly attributable to the OK, based on their similar characteristics as material from deeper strata. This included beer jars, bread moulds and fine red-slipped and polished body fragments of open vessels, and diagnostics that were comparable with some discussed above (#2/2.3–2.4 being similar to #2/4.4–4.5A; Figure 6b).

The amount of pottery remained low in the upper 2.5 m of the borehole. No coarse Nile C diagnostics or body fragments of bread moulds and beer jars were identified. However, a few fragments of finer open vessels with red slip and polish were found up to a depth of 1.9 m. While the material found above 1.8 m was different from that below, a specific age assignment was difficult; the sherds do not appear to be as late as the NK or later, but there were no unequivocal MK material present. A single diagnostic (#2/1.7–1.8) of the base of a hand-modelled and trimmed closed vessel with a fine version of Nile B2 fabric might indicate a FIP to early MK date based on its manufacturing technology. This could not, however, be confirmed as no exact external parallels are yet known for this type of vessel.

Borehole #3 contained a total of 114 diagnostics, amidst hundreds of nondiagnostic pottery fragments, of which 41 were drawn (Figure 7). At depths between 4.8 and 7.7 m (33.8–36.7 m + msl), red-slipped and polished pottery of a Nile B1–B2 fabric were found together with Nile B2/C1 fragments. The former belong to plates and dishes, and the latter belong to bread moulds and beer jars. The pottery assemblage suggests a date in the (late) OK, in accordance with the finds in borehole #2. The first indisputable OK diagnostics supporting this date were a rim fragment of a ‘Maidûn’ bowl (#3/6.4–6.6) and a rim of a dish with a polished red slip on the interior.

**FIGURE 7** Pottery drawings of borehole #3—see Supporting Information SC for grouping per pottery type
and exterior (#3/5.8-6.0) (Table SA1). Other fragments supporting the late OK date include a partially preserved spout (#3/5.4-5.6), which is typical for several OK vessel types (Table SA1) - though spouted forms continued to be used into the MK and later (e.g., Aston, 2004, pp. 28-32; Czerny, 1999, pp. 153-154). The highly quartz-tempered marl clay body fragments found at this interval resembled the Marl C fabric of large handmade storage jars, of which parallels were found at Saqqara and Ilnasiya al-Madina (Bader, 2009, figs. 7e,f, 12b; Rzeuska, 2006, pp. 122-125). This fabric occurred in the OK at Giza and Dahshur, but its use continued later as well (e.g., Bader, 2001, p. 41; Bader, 2002, p. 29; Bader, 2009, p. 34; Nordström & Boutriaux, 1993, pp. 179-181; Owby, 2009, pp. 120-122).

Between 4.6 and 6.0 m (35.5-36.9 m + msl), body fragments of red-polished dishes and rough bread moulds or beer jars were found in association with fragments of a suggested FIP to early MK date. These were fragments of uncoated dishes and body fragments with scrape marks on the exterior. The scrape marks were clearly identified as a FIP to early MK style, as they are hardly ever observed on OK pottery (cf. Rzeuska, 2006 and at other hallmark OK sites). Hence, this interval represents an overlap of periods or a transition from the late OK to FIP and the early MK. Above this interval, most of the diagnostics and the documented vessel technology of the body fragments suggest a post-OK date; polished open vessel types, handmade pottery and potential rough bread moulds or beer jars are absent.

Between 3.4 and 4.6 m (36.9-38.1 m + msl), many diagnostics and body fragments, with red slip on both inner and outer sides, appeared to belong to a transitional phase in pottery-making traditions during the FIP and early MK: #3/4.4-4.6B, #3/4.2-4.4, #3/3.8-4.0A, #3/3.4-3.6A, #3/3.4-3.6C, #3/3.4-3.6D (Table SA1). They are not polished, which is rather uncommon for OK open vessel types. A considerable number of pottery fragments of open vessels showed red slip on only one side and/or scrape marks on the exterior, which are clear indications for a FIP to early MK date, of which examples were found up to 1.5 m. Among the diagnostics were several direct rims from plain cups/bowls (#3/4.6-4.8A, #3/4.4-4.6E, #3/3.8-4.0C, #3/3.8-4.0F), a rim of a carinated bowl with a groove inside (#3/4.6-4.8B), a rim of a red-slipped (interior and exterior) carinated bowl (#3/4.4-4.6A), open vessel types with red slip inside and a flattened rim (#3/4.4-4.6C/D) and a bowl with a flaring rim (#3/3.4-3.6B) (Table SA1). The base fragment of a miniature tubular bread mould (#3/4.4-4.6F) and body fragments presumably of the same vessel type were found at a depth of 4.6 m. Parallels for these vessels are hitherto only known from nearby Dayr al-Barshā (Table SA1). Also, a modelled rim fragment of a larger tubular bread mould (#3/3.8-4.0E) was found, of which parallels are known from FIP to early MK contexts at Ilnasiya al-Madina, Dayr al-Barshā, Dandara, Izbat Rashid and Asyūt (Table SA1).

Diagnostic pottery finds from 0.8 to 3.4 m depth (38.1-40.7 m + msl) represent MK types. The assemblage included hemispherical cups or their precursors (#3/3.2-3.4C, #3/2.4-2.6A, #3/2.2-2.4A, #3/2.0-2.2; their fragmentary nature does not allow to relate them to regional typo-chronologies), rim fragments of tubular bread moulds (#3/3.2-3.4A, #3/2.6-2.8), necked jars (#3/2.8-3.0B), a jar with a rounded lip rim (#3/1.3-1.5) and a Marl C rim of a large storage jar (#3/2.2-2.4B) (Table SA1). The latter is diagnostic for the classic MK (Twelfth Dynasty; c. 1985-1773 BC). Several diagnostics belonged to dishes that were only slipped on the interior (#3/3.2-3.4B, #3/1.8-2.0), excluding the top of the rim, of which some examples have been found in MK shaft burials at Dayr al-Barshā (e.g., the shaft tomb of Ahanakht I; unpublished). The fabrics and surface treatments of pottery in the upper 0.7 m indicated an LP to LRP age, for example Marl A5 jars, LRP Amphora 7 and greenish marl clays.

Borehole #7 produced 18 diagnostics that were well enough preserved for drawing (Figure S6) -13 of these belonged to bowls and dishes of types that have already been discussed for other boreholes. Other diagnostics were present, but were generally less useful for dating purposes compared to those discussed above, as most diagnostics related to Nile C1/C2 body fragments, which could be related to (late) OK beer jars. From these were fragments of red-slipped and polished open vessel types, present from 7.0 to 3.4 m. Despite these finds, it was not possible to unequivocally determine whether the material found in the deeper part of this borehole is attributable to the OK or the FIP.

Pottery from 8.4 to 4.8 m depths (33.1-36.7 m + msl) included Nile C1/C2 body fragments, which could be related to (late) OK beer jars. Found with these were fragments of red-slipped and polished open vessel types, present from 7.0 to 3.4 m. Despite these finds, it was not possible to unequivocally determine whether the material found in the deeper part of this borehole is attributable to the OK or the FIP.

Pottery from 4.8 m and continuing upward to a depth of 2.7 m (38.2-40.3 m + msl), pottery fragments with red slip on the interior and rough scraping on the exterior began to appear in combination with late OK types. The pottery assemblage was tentatively dated as transitional to the FIP or the early MK. Scraped pottery fragments with red slip on the interior continue up to 1.2 m (36.7 m + msl), where earlier material is considered to be residual. Unfortunately, securely datable MK specimens were rare. Diagnostic material included two fragments of dishes (Nile B2) with red slip on the interior, and one of a Nile C2 fabric with red slip on the interior and a rope impression on the exterior (#7/2.0-2.2A). Schiestl and Seiler (2012) dated comparable specimens to the full span of the MK, while Bader (2009) attributed roughly similar specimens to a more confined range of the FIP to early MK, which was possible due to the specific context of their finds (Table SA1). Two Nile B2/C1 fragments (#7/7.6-7.8B and #7/3.8-4.0B) were identified as probably belonging to tall stands, based on the manufacturing technology. No exact parallels are available for this specific type, although stands were common during the MK (Table SA1). Pottery fragments in the top of the borehole (0.2-0.4 m depth) were determined as LRP Amphora 7 (c. third to eighth century AD) and a single assumed ex situ Marl A2 rim of an NK jar.

5 | DISCUSSION

5.1 | The origin of al-Ashmūnayn

The occupational history revealed by qualitative analysis of the pottery provides an OK to late OK age in borehole #1 below c. 37 m + msl,
while borehole #7 shows a similar age below c. 36.5 m + msl and borehole #3 below c. 36 m + msl (Figure 5). Borehole #2 reached late OK pottery at c. 37 m + msl (Figure 5). Hence, the newly uncovered cultural material from al-Ashmūnayn provides clear evidence of human activity during the OK period, particularly during the Fifth–Sixth Dynasties (c. 2494–2181 BC). Boreholes #1–3 and potentially also #7 produced thick sequences of up to c. 4 m, packed with pottery, that can be associated with this age, suggesting a focal area of human activity of this period roughly in the same zone as where MK deposits had been found earlier (and excavated) at higher levels (Roeder, 1959). To the north and northeast of the Amun temple of Seti II and near the FIP cemetery (boreholes #4–6), the amount of OK finds diminished to an extent that did not allow a clear age assignment or to infer intensive human usage of this area.

A transition from the late OK to the early MK can be observed in the material from boreholes #3 and #7. Both have an overlap of late OK and FIP material for c. 2 m (#7 at 36.5–38.5 m + msl; #3 at 36.2–38.2 m + msl), with FIP and MK pottery from 38.5 m + msl upwards in borehole #7 and from 38.2 m + msl upwards in borehole #3. Boreholes #1 and #2 did not cover these chronological transitions because post-OK material had already been excavated. The gradual transition from the late OK period pottery into the early and later MK material, possibly without hiatuses, suggests that there may have been continuous human presence (and likely occupation) at al-Ashmūnayn during the FIP. This is an important observation considering the ongoing debate on the severity of cultural decline and depopulation in the Nile Valley following climatic instability at the end of the OK and early FIP (cf. Butzer, 1984, 2012; Moeller, 2005; Moeller & Marouard, 2018).

**FIGURE 8** Pottery drawings of borehole #7—see Supporting Information SC for grouping per pottery type

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The current survey covered only a limited part of al-Ashmûnayn; other sections are difficult to access due to modern settlement and the thick cultural deposits of the last four millennia. Therefore, it was neither possible to estimate the size or extent of the former OK town nor to pinpoint various functional areas based on the current information. Furthermore, the mix of cultural material consisted mainly of pottery and charcoal fragments, while somewhat surprisingly, common settlement waste material such as animal bone was missing. Nonetheless, the chronological continuity in the archaeological material suggests a prolonged concentration of human activities, although its exact nature and expanse are hard to interpret from the current data.

To understand the environmental context of the cultural deposits, the local borehole lithologies at and near al-Ashmûnayn were compared with the sedimentary units from the two transects. This only applied to strata found in the lower parts of the boreholes placed on the tell, as the upper sections were heavily disturbed by human activity. Sandy deposits found in borehole #2 resemble Unit B (Figures 4 and 5), and are found at comparable levels: 37.5 m + msl at al-Ashmûnayn versus c. 36–37 m + msl in the transects to the south. The laminated fines found in borehole #1 fit well with Unit C and the sands further down again with Unit B. Units B and C were found to intercalate at borehole #3, before reaching Unit B in its basal part. Based on the similarity to deposits found in the transects, the environmental context of the investigated zone at al-Ashmûnayn can be interpreted as channel deposits; the heterogeneous deposits with frequent layering between sands and silty clays relating to the infill of residual channel depressions, while homogeneous sand units, as found for example at Nectanebo I’s Thoth temple, are more likely to represent bars in the channel zone. Although markedly different in appearance—representing the variability that is possible at a local scale—both form integral parts of the same overall geomorphological setting.

Boreholes #10 and #11 provide further understanding of the configuration of the fluvial setting at al-Ashmûnayn. Their overall fine-grained deposits with some laminated loamy intervals link them to Unit D or E, reflecting a distal part of the levee or proximal floodplain setting (Figure 4). Following the reconstructed channel belt architecture to the south of al-Ashmûnayn, such deposits are expected at either side of the main sandy channel belt. Moreover, basal sands occur below c. 33 m + msl at either side of al-Ashmûnayn, thus matching the level of the regional substrate (Unit A). As channel sands (Unit B) are missing at boreholes #10 and #11, these locations thus demarcate the westernmost and easternmost limits to the possible location of the channel belt at al-Ashmûnayn.

Assuming that the extensive cultural deposits reflect the presence of a nearby settlement, these results broadly confirm the hypothesis that ancient Khemenu was founded on the banks of a river channel (cf. Butzer, 1976). The deposits are, however, more characteristic for an active channel zone rather than its (finer-grained) levees where human activity would have concentrated, and it seems therefore unlikely that the encountered pottery fragments belong to in situ settlement strata. As almost no pottery fragment showed evidence of abrasion or erosion, the pottery does not seem to have been exposed to transport in water and must have come from a source very close to the borehole locations.

5.2 Development of the fluvial environment and links with the cultural landscape

Based on the borehole survey and information from the pottery analysis, it seems likely that a major channel of the Nile was active at al-Ashmûnayn during the OK (Figure 9a). The MK gate of Amenemhat II (c. 1911–1877 BC) and later monuments at al-Ashmûnayn were built directly on top of what used to be the active channel zone (Units

FIGURE 9 Palaeoenvironmental reconstruction of the Nile Valley landscape and hypothetical travel routes. (a) Old Kingdom setting with an active channel belt that is assumed to have connected al-Ashmûnayn (1) with upstream al-Shaykh Sa’id (2). (b) The Middle Kingdom setting with an active channel belt located between Rairumun (3) and Dayr al-Barshâ (4). (c) Successive channel belts of the Nile in the eastern section of the valley (after Verstraeten et al., 2017) with periods of activity roughly between the New Kingdom and the Graeco-Roman period and the last millennium [Color figure can be viewed at wileyonlinelibrary.com]
B and C). Therefore, it can be concluded that the active Nile had largely shifted its position before the 19th century BC.

When the channel was active, it must have run in close proximity of the modern towns of Qulubba and Mallawi. These towns have not been associated with occupation before the GRP and Byzantine period based on a study of their toponyms and isolated surface finds (Kemp, 2005; Willems et al., 2017). Yet, based on their configuration alongside the OK channel route, these places could have been suitable settlement locations since the OK as the levees would have remained relatively high locations out of reach of annual Nile floods. Therefore, earlier occupation levels may have been preserved at the basal levels of their high tells (Figure 9), coinciding with the top levels of the channel sands and levee deposits (Units B and D; Figure 4).

The modern urban sprawl of Mallawi did not allow us to trace the channel belt in an upstream direction. Extending the channel belt in the same general direction to upstream regions, however, does bring it to the location of the late OK nomarchs’ tombs at al-Shaykh Sa’id (Figure 9a). Albeit unconfirmed by actual observations, this situation would imply that apart from a cultural connection between al-Shaykh Sa’id and Khemenu, they were also physically connected in the riverine landscape of the OK. The dated silting up of the channel, before 19th century BC, roughly corresponds with the shift of high-status burials away from al-Shaykh Sa’id, suggesting that pivotal changes in the landscape influenced travel routes and the ritual connection between sites in the region.

The current survey also did not extend to the north of al-Ashmûnayn, so the downstream continuation of the OK river channel remains unclear. Suspected OK sites on the western side of the valley, such as Ḥūr and Balanṣūr (Willems et al., 2017) (Figure 1b: 14, 15), could potentially mark a continuation of its north-western direction. Yet, this suggestion remains largely speculative without further detailed geoarchaeological study.

For the last two millennia, it has been amply demonstrated by archaeological finds, from textual sources and historical maps (Willems et al., 2017) and by geological surveys near Dayr al-Barshâ (Verstraeten et al., 2017), that the Nile was located at the eastern limit of the valley (Figure 9c). A few pottery fragments dated to the NK found in channel deposits near Dayr al-Barshâ also suggest an earlier presence of the Nile in the eastern part of the floodplain (Verstraeten et al., 2017). The tomb of Djehuthopet (c. 1900 BC) at Dayr al-Barshâ potentially provides even earlier evidence, as the colossal monolithic statue depicted on one of its murals is mentioned to overlook a channel of the Nile (Willems et al., 2005). This early date for channel activity fits well with the suggested date of channel abandonment at al-Ashmûnayn (Figure 9b).

The sedimentary archive supports a fairly rapid relocation of the main channel of the Nile, but cannot be explained using Butzer’s (1976) eastern migration premise. Both borehole transects are dominated to the east by fine-grained deposits that accumulated as overbank material during floods. In the absence of sandy channel deposits, a gradual eastward shift by lateral channel migration can be ruled out. Instead, the process of avulsion fits the observed configuration of geomorphological units (Smith et al., 1989). Low-relief floodplains of large river systems do often develop a convex topography due to the relatively high rates of sediment accumulation in areas approximate to the main channel and lower rates of deposition in distal backswamp areas (Lewin & Ashworth, 2014). Eventually, this promotes the establishment of alternative flow paths with a more favourable gradient compared to the existing one. The trigger for such changes to occur is generally a levee-breaching flood. Larger floods and/or periods of enhanced flood activity with higher rates of sediment accumulation would have increased the chances of occurrence of an avulsion; the changes observed in the al-Ashmûnayn region coincide broadly with such a phase during the FIP and early MK (Hassan et al., 2012; Macklin et al., 2015; Seidlmayer, 2001; Toonen et al., 2018).

The time required to complete a full diversion of discharge to a new channel route may be very short—for example several decennia—but it may also be a very gradual process that takes several centuries (Kleinhans et al., 2011). It is, therefore, possible that al-Ashmûnayn temporarily retained a connection with the relocated main channel of the Nile through a small residual channel. The resultant geomorphology of post fluvial activity would continue to offer advantages for cultural activity; the sandy deposits at al-Ashmûnayn were suitable as foundations for later monuments, and the relatively high levees of the channel belt would still be suitable for overland travel (Figure 9b). The new course of the Nile and existing overland routes may thus have made Dayr al-Barshâ an attractive place for burials. The location and suggested pharaonic origin of the town of Rairamûn (Willems et al., 2017) fit the revised configuration of the natural and cultural landscape, as it would have been an ideal waystation between settlement and necropolis, and a suitable place to embark and cross the river (Figure 9b).

6 | CONCLUSIONS

The main goals of this study were to establish the presence of Old Kingdom settlement remains at al-Ashmûnayn, to reconstruct the local environmental setting and to compare changes in the regional landscape with changes in the configuration of cultural sites that are associated with al-Ashmûnayn. Diagnostic pottery fragments and the wider assemblage provided evidence for continuous human activity at the site of al-Ashmûnayn since at least the late Old Kingdom. The densely packed pottery fragments occurred in a sediment matrix of what was interpreted as river channel deposits. Based on the minimal abrasion of pottery fragments and their sheer quantity, it seems likely that Old Kingdom settlement activities were located very close to the position of the boreholes, likely on local river banks.

Previous claims of al-Ashmûnayn’s origin at the banks of an active channel can thus be considered valid. The channel sands found at the site occur at similar depths and in a roughly similar configuration as off-site research locations. In two transects, all geomorphologic elements of a channel belt (i.e., channel sands, levees, residual
channel fills) and adjacent floodplains were identified based on the architecture of lithological units. The 800–1000 m width of the channel belt, forming a maximum estimate for the contemporary active channel, is comparable to that of the main active channel of the (present) Nile.

The abandonment of the river channel at al-Ashmûnayn is dated to have happened at some time between the late Old Kingdom and the early Middle Kingdom. This range is constrained by the lithological context of late Old Kingdom pottery in an infilling residual channel and the age of monuments that were founded on top of the palaeo-channel sands, which implies that there was no imminent threat of fluvial erosion or flooding at the time of their construction. From our regional survey, it can be concluded that the relocation of the active channel was relatively fast and forced by an upstream avulsion. This interpretation is at odds with traditional models that infer a gradual lateral eastward river channel migration in the Egyptian Nile Valley. A major implication of an avulsive migration model is that substantial areas across the valley that were previously thought to have been disturbed by fluvial erosion can still have in situ archaeological remains preserved. The revised configuration of the past landscape equally sheds new light on the potential ancient origins of several towns in the region based on favourable settlement locations along fluvial routes in the past.

The rapid transition of the fluvial environment is likely to have triggered substantial changes in the cultural and ritual landscape, as contemporary shifts in preferred burial locations at satellite locations of al-Ashmûnayn are observed. Such coincidental dynamics may indicate that the ancient Egyptian riverine civilization was closely connected to the fluvial environment and not only susceptible to large-scale climate-driven changes in hydrology but also to the dynamics of the regional fluvial landscape.

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