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The Development of the Giza Necropolis: The Khufu Project

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(Tafeln 1–3)

Within four generations, from the reigns of Sneferu to Menkaure, nine million cubic meters of stone were quarried, transported, and constructed into the largest of the Old Kingdom pyramids. When graphed against time, this brief period of the most monumental architecture stands out as a sharp peak dwarfing the material invested for royal constructions prior and subsequent to the reigns of these kings (Fig. 1, based upon Stadelmann 1980, 438; cf. Kemp 1983, 88).

The effects of this marshalling of human and natural resources on the evolution of the Egyptian state and culture have yet to be adequately assessed. Archaeology at the pyramid sites has been either on too massive a scale of excavation, with losses of major catagories of

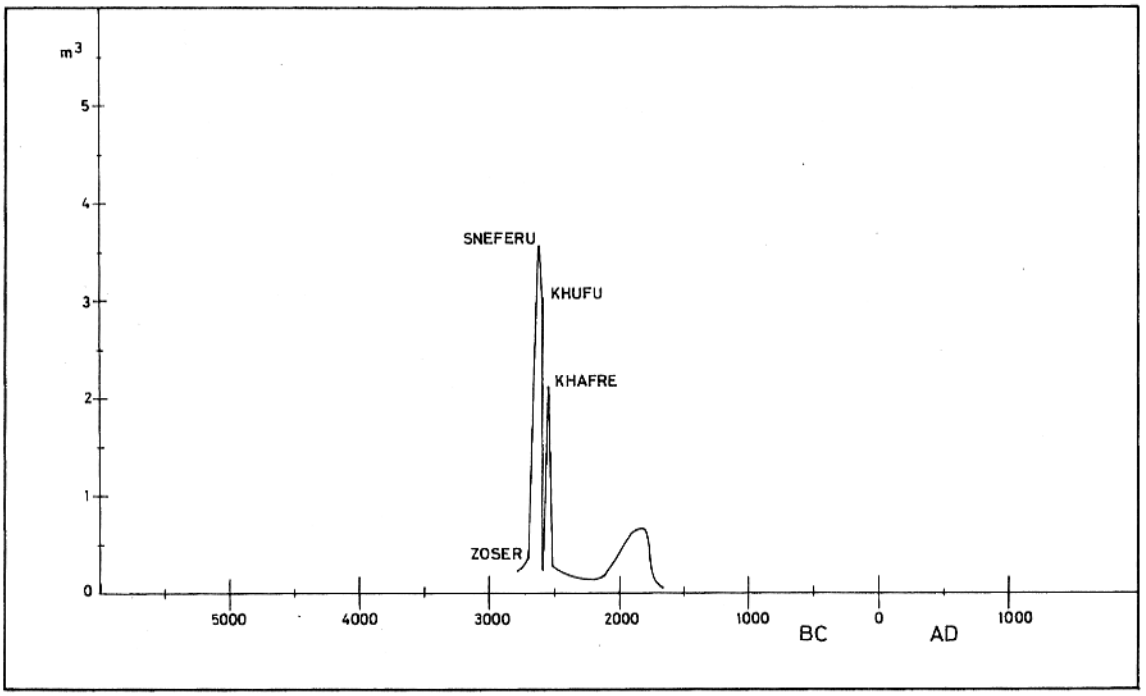

Fig. 1. Estimate of cubic meters of material which make up the superstructures of the pyramids of Zoser, Sneferu (Medum and Dahshur), Khufu, Djedefre, Khafre, Menkaure, the pyramids of the 5th and 6th Dynasties and the pyramids of the Middle Kingdom plotted according to their chronological sequence. Based in part on Stadelmann (1980, 438) and Kemp (1983, 88).

information, or has been focused too narrowly on individual pyramids, tombs, and temples to assess what role the actual construction processes played in the religious, political, economic, and possibly ecological changes long discussed or recognized for the Old Kingdom.

Kemp (1983, 89) has suggested that as the sheer bulk of the pyramids was scaled down following that of Khafre,

> the surplus capacity for organization and for the utilization of resources was absorbed by the provinces, whose level of prosperity and local identity seem to have risen in the later Old Kingdom. In a sense the continued history of the Old and Middle Kingdom civilization contained an important element of freewheeling on the apparatus created through the building of the early pyramids, enabling skills and administrative machinery to be more widely and variably diffused.

Such later "free wheeling on the apparatus created" for building the largest pyramids might be better understood if a clearer and more unified picture of that apparatus at the local level of the pyramid sites was in hand. Questions about the organization of the workforce for the colossal pyramid projects must be based not only upon textual information. They must also be site-specific, framed in terms of the local geology, geomorphology, and topography – for these were the broad constraints the ancient builders faced. When the physical limitations and opportunities are clarified for each pyramid site, combined with the identification of spatial distributions of monuments and *all* other cultural deposits, many of the particular questions about pyramid building become more resolved.

In addition to the pyramid itself, four great deposits or landscape changes must have resulted from building the largest pyramids. It is inconceivable that these four major 'stratigraphic units' disappeared without a trace in the archaeology, topography, or the "geology of human disturbance on a massive scale" (Kemp and O'Connor 1974, 115) of the site. These are 1. the main supply ramp; 2. the quarry; 3. settlement for workmen and support people; and 4. a harbour for the introduction of supplies and non-local building material. At Giza, the identification of these principal features also clarifies the sequence of quarrying and construction for the separate pyramid complexes of Khufu, Khafre, and Menkaure, and their ancillary cemeteries.

In order to illustrate more clearly the geomorphology at Giza, and to assess its interplay with the architecture, an isometric projection of the Giza Plateau was produced (Figs. 3 A–C). Although preliminary survey data from the Giza Plateau Mapping Project was used, the isometric projection was, for the most part, based upon the 1 : 5,000 topographic maps of the general Cairo region which were photogrammetrically produced for the Egyptian Ministry of Housing and Reconstruction. Fig. 2 is a formline map traced from the contoured 1 : 5,000 sheets showing the Giza Plateau. The plotting of the isometric drawing was done by hand. Points were transferred from the 1 : 5,000 map to the isometric projection at scale 1 : 2,500. The contour lines (at 1 m intervals on the map) were left out of the isometric projection, and relief was rendered impressionistically. At the same time, the outlines of the major features are true to scale. This allows spatial and quantitative assessment in three dimensions of some of the questions about the building of the Giza Pyramids.

The topographic evidence for the layout of the workforce for building the Khufu Pyramid is presented, with some interpretation, in three versions of the isometric projection of the Giza Plateau. The first projection (Fig. 3 A) is an attempt to visualize the Giza Pyramids site before the 4th Dynasty quarrying and construction began. All the architecture is removed, and quarries are 'erased' by interpolation of the trend of the geological formation. The second projection (Fig. 3 B) renders, to scale, those culturally produced features which are actually found

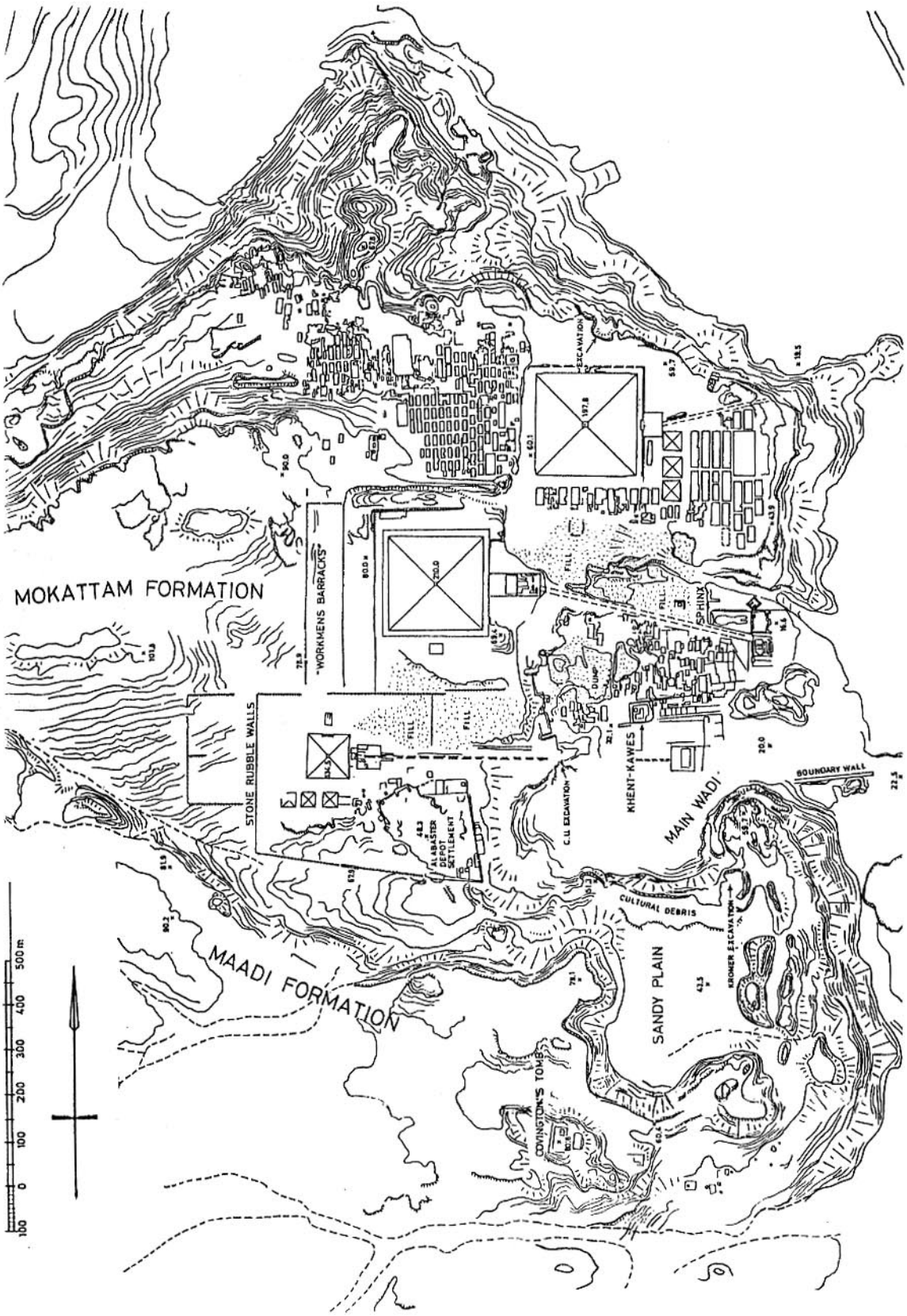

Fig. 2. Form-line map of the Giza Pyramids site traced from the 1:5,000 topography map sheets produced by photogrammetry for the Egyptian Ministry of Housing and Reconstruction.

on-site, and which, with some interpretation, are likely to date to the final years of Khufu's reign. The third projection (Fig. 3 C) is an attempt to reconstruct the organization of the site in the final years of building the Khufu Pyramid. This is based upon the evidence supplied in Figs. 3 A and 3 B, or upon parallels from other sites. While the forms of some of the features are conjecture based upon parallels and direct evidence for the sake of discussion, the principal elements, e. g. the pyramid, direction of the supply ramp, quarry location, harbour, and areas of settlement, probably could not have happened in any other spatial configuration.

The field research and collecting of literary documentation continues. The material presented here comprises preliminary, working hypotheses which will be useful in constructing the emerging overall picture of the development of the Giza Necropolis.

Giza Before the 4th Dynasty: Fig. 3 A

A 1. Position of the Khufu Pyramid.

A 2. Position of the Khafre Pyramid.

A 3. Position of the Menkaure Pyramid.

A 4. Position of the Great Sphinx. It has long been considered that the Sphinx was carved out of a nodule of rock left from quarrying this area of the plateau for the pyramids – particularly that of Khufu (Reisner 1942, 26) and that the top of the Sphinx's head marks the original surface of the plateau (Ibid. 11). Another suggestion is that the head was formed from a natural knoll or hummock (el-Baz 1981, 116–22). At the same time there is evidence that considerable forethought went into the location of the Sphinx in relation to the rest of the Khafre complex (Lehner 1984). In Fig. 3 A I have reconstructed a ridge, or minor cliffline, at the location of the Sphinx's head. This runs in a curve to the SW as an extension of the original ground which actually shows today immediately north of the Khent-kawes monument. This could have been a southerly continuation and phasing out of the upper ridge on the eastern border of the plateau to the north of the Sphinx (cf. Aigner 1983 b, 315). Given the dip of the geological formation, if the original ground was once to the level of the top of the Sphinx's head, a tremendous amount of stone was quarried away from the area of the Khafre valley complex. In Fig. 3 A I have reconstructed the eastern cliff on the N to pass the Sphinx on the E at about the line of the Sphinx Temple and Khafre Valley Temple facades (see Lehner 1984 n. 22).

A 5. The Giza Plateau is an outcrop of the Middle Eocene Mokkatam Formation, extending about 2.2 km from E to W, and about 1.1 km from N to S. Except for two cliff lines forming an upper and lower terrace to the NW of the outcrop (Aigner 1983 b, 315), the surface of the Mokkatam Formation at Giza is fairly regular. It is said to dip to the SE at 5° to 10° (Ibid., 314; and forthcoming; Said and Martin 1964, 115 state 10° to 12° which seems too steep). This gives a NW-SW strike (lines perpendicular to the dip direction at which points are on the same elevation). The plateau is part of the NE-SW striking "brachy anticline" which is part of the Abu Roash complex. It is built up of massive limestone and dolomite (Aigner 1983 b, 313–14). The references to the geological study of the Giza Plateau are summarized by Aigner (1983 c). Reisner (1942, 10–19) described the topography of the Giza Plateau, albeit not in geological terms.

According to Aigner's (1983 c) model, the Pyramids Plateau began as a bank of nummulites seen to exceed 30 m in thickness in the northern escarpment. A shoal and reefal facies was

Fig. 3A. Isometric projection of the Giza Pyramids site before 4th Dynasty quarrying and construction. Quarries are "erased" and the original outlines of the Mokkatam Formation outcrop are reconstructed by interpolating from the trend of the limestone formation. Basin and high areas in the valley floor are reconstructed on the basis of the 1:5,000 topographic map and old photographs. The features of the site are otherwise true to scale.

laid over the southern slope of the nummulite bank. A "back bank" facies was, in turn, laid over the shoal reef, forming a series of limestone/marl beds which 'lense out' over the shoal reef to the N. In practical terms, this left the very hard and brittle limestone of the nummulite bank to the NNW part of the Pyramids Plateau, and the softer thickly bedded layers to the lower SSE area of the plateau (see AIGNER 1983c, 363, Fig. 11; or LEHNER 1984, Fig. 1).

A6. The highest part of the Mokkatam Formation at Giza is 725 m W of the Khafre Pyramid where the elevation is 105.80 m above sea level. This, and all such distances and elevations to follow, are from the 1:5,000 topographical map of this area.

A7. The lowest part of the formation would have been about 23 m above sea level, at the far SE corner of the rock exposure. The surface of the formation has been reconstructed in Fig. 3A by extrapolating the trend of its dip to the SE. This area lies about 300 m E of the Khent-kawes monument. The original ground here was quarried away during the 4th Dynasty. The distance from point 6 to point 7 is about 1.5 km in which the surface of the rock formation would have dropped about 82 m, giving a dip of about 3.5°.

A8. An outcrop of the Upper Eocene Maadi Formation borders the Pyramids Plateau on the SSW. The stratification of this outcrop is best seen in the prominent knoll rising 400 m due S of the Sphinx. The semi-circular face of the knoll, called *Gebel Heit el-Gurob* or *Gebel Qibli el-Ahram,* was quarried away in historical times to reveal thinly bedded limestones. SAID (1962, 98) characterized these as "hard, brown, siliceous limestones" (see also SAID and MARTIN 1964, 115–16, Fig. 6). AIGNER (1983b, 315) called this a "sequence of soft marly limestones and sandy marls with some intercalated shell beds and sandstones." The Maadi Formation here is capped by a thick Pliocene deposit which dips down along the east slope at 10° to 20°. This upper layer is characterized by a loose conglomerate of boulders, "clasts bored and encrusted by oysters" and, toward the top, sandy shell accumulations (Ibid., 317–18). This eastern cliff was the shoreline for a Pliocene sea (Ibid.). Large, dark colored blocks of stone protrude here and there upon the surface of the Maadi Formation, as seen at the very top of the ridge which runs from the knoll to the S. These are part of the Ain Musa bed:

> The "Ain Musa Bed" is mostly not in situ within the Eocene sequence, but became disintegrated into isolated large blocks, each of which being several meters to a few tens of meters across. These Ain Musa blocks lie discordantly and with variable strike and dip within the Pliocene deposits, or on the partly eroded Maadi Formation (Ibid., 317).

On the ridge, these blocks "represent slip blocks that moved seaward due to Pliocene coastal erosion" (Ibid.).

In practical terms, the rough and irregular surface of the Maadi Formation in the southern field at Giza is not nearly so suitable as the adjacent Mokkatam Formation for founding monuments as large as the Giza Pyramids. The thin bedding and marly composition of the Maadi Formation limestones, in addition to the irregular blocks of the Ain Musa Bed and the conglomerate Pliocene cap, make this formation far less suitable for quarrying large blocks of stone (see AIGNER 1983a).

A9. 950 m due south of the Khufu Pyramid there is a wide sandy bowl-like depression within the surface of the Maadi Formation. This feature, rendered in the maps of PERRING (1839), VYSE (1840, op. p. 1), and LEPSIUS (1849, Bl. 14), measures 400 m N-S by 300 m E-W. The floor of the bowl is about 35 m lower than the top of the highest peaks around its perimeter. It is rendered here as existing to this depth before the 4th Dynasty, but there is some question about this. The sandy floor of the bowl shows scatters of culturally produced limestone

chips, some bits of pottery here and there, as well as fragments of granite. The bowl gives the appearance of having been partially deepened by quarrying (see B 21, and LEHNER 1984).

A 10. The prominent knoll 400 m south of the Sphinx rises 40 m above the sandy wadi which separates the Mokkatam from the Maadi Formation outcrops. The top of the knoll is 59.7 m above sea level – nearly equal in elevation to the base of the Khufu Pyramid. Standing at the point of the knoll, one commands a view of the entire Mokkatam Formation outcrop which slopes down to the wadi at the base of the knoll. This position also commands a view of the entrance to the wadi, the low desert and valley to the east, and the bowl-like depression just behind the knoll. This is the best place for a visual survey of the Giza Plateau with the idea of planning the first, or Great Pyramid. I owe to JOHN SWANSON the insight that Khufu's Overseer of Works might well have stood here for just this purpose.

A 11. A bank of sand and debris, 65 m wide and about 350 m long, rises about 2 or 3 m above the northern side of the sandy bowl. The bank drops about 30 m to the north in a gentle slope to the wadi. While this is rendered in Fig. 3 A, the bank might have been culturally created from settlement, quarry, and construction waste during the 4th Dynasty (KROMER 1978, 20–21). In the view in LEPSIUS (1849, Bl. 18) to the SE from the Khafre Pyramid, the bank is accentuated by the angle of light. In this artist's rendering, the bank looks very much like an artificial ramp sloping from the W up to the knoll.

A 12. A reconstruction of the 3rd Dynasty mudbrick mastaba, "Covington's Tomb" (COVINGTON 1905, PETRIE 1907, 7–8, Pl. vii). Immediately to the E of this mastaba there is a stone construction in the form of a rectangular outline. This must be the remains of "the picturesque ruins of a large bluish-grey stone mastaba (about 28×12 m) excavated by Mariette" (COVINGTON 1905, 193). Earlier (LEHNER 1984) I stated that, on the basis of the 1 : 5,000 map, this feature is aligned to the axis of the Khufu Pyramid. This alignment was checked during the 1984-85 season of the Giza Plateau Mapping Project. The stone platform lies about 38 m W of an alignment with the N-S axis of the Khufu Pyramid.

A 13. This large sandy wadi, forming the route of the modern Fayum Road, borders the Giza Plateau (Mokkatam Formation) on the NW. "This road runs northeast to southwest in a gentle syncline paralleling the Pyramids Plateau anticline" (SAID and MARTIN 1964, 115). The lower of the two escarpments bordering the wadi marks the shoreline of a Pliocene sea (AIGNER 1983 b). With the shoreline also evidenced on the east slope of the Maadi Formation at Giza (A 8), "the contours of the present Giza Plateau still preserve the outline of the 'peninsula' which the area formed during the Pliocene" (AIGNER, forthcoming).

A 14. A large sandy wadi separates the Mokkatam Formation from the Maadi Formation, created by the SE dip of the former. The wadi was originally about 150 m wide at its mouth. Today the wadi appears much less pronounced. The N side of the wadi, or the southern line of the Mokkatam Formation outcrop where it dips into the wadi, was extensively quarried away during the 4th Dynasty. Today, the quarries and the entire area from the S side of the Khafre and Menkaure Pyramids to the wadi and foot of the Maadi Formation are covered by anciently dumped debris, modern excavator's dumps, and wind-blown sand. The original ground surface of the Mokkatam Formation and its contact with the Maadi Formation are well exposed toward the W-SW of the Menkaure Pyramid where the wadi phases out. The surface of the Mokkatam Formation is also well exposed to the W of the three pyramids. On the basis of these exposures, the line of the escarpment N and E of the Khufu Pyramid, and points of original ground exposed at the quarries south of the pyramids, it was possible, through interpolation with the contours of the 1 : 5,000 map, to reasonably restore the original

surface of the Mokkatam Formation S of the pyramids. However, the quantity of eolian sand that filled the wadi at the time when 4th Dynasty construction began remains somewhat speculative (cf. BUTZER 1959, 66–67).

A 15. A large wadi defines the southern limit of the salient Maadi Formation outcrop at Giza, though the formation continues on to the S. The "wadi-like morphology" (AIGNER, forthcoming) of the Maadi Formation in this area is a major reason why it is not suitable for founding monuments on the scale of the Giza Pyramids.

A 16. This line indicates the bottom of the steep slope along the E of the pyramids site, as formed by debris or sand deposited against the base of the escarpment. It corresponds to the 20 m above sea level contour line on the 1:5,000 map, except at the N side of the Khufu Pyramid, where the 25 m line is rendered. The 20 m contour line has been reconstructed across the mouth of the central wadi, which is filled today with sand banks and the modern cemetery of Nazlet es-Samman.

A 17. Low desert between elevations 25 or 20 and 18.5 m above sea level.

A 18. In designing the isometric projections of the Giza Plateau, I did a preliminary and very rough catchment analysis of the floodplain at the base of the plateau. This was mostly based on the 1:5,000 map, but also with reference to old photographs of the site during the annual flooding before, or between the building of the dams at Aswan. The line marked no. 18 roughly encloses land higher than elevation 18.5 above sea level. At the same time, this does not strictly follow the contour lines of the map, since the highs along the canals, or those obviously created by recent installations, were excluded. Fig. 4 represents a step in this analysis, where the general trend of elevation 18.5 is drawn over individual spot heights on the map. The resulting three principal high areas within the view of the isometric drawing are assumed to have remained above the annual inundation waters and to be possible vestiges of natural highs which existed at the time of the 4th Dynasty. These are also indicated, where possible, on Pls. 1 and 3. BUTZER (1976, 17) pointed out that on the average the floodplain exhibits relief of 2 m or less. It is assumed that the areas left blank in Fig. 3 A would have been basin land, *ḳ3yt* (BAER 1962, 40 n. 98), covered during an average Nile flood. The possibility of alluvial aggradation must be considered in such a reconstruction. While there is evidence of considerable build-up of alluvium in the flood plain at some places since ancient times (KEMP and O'CONNOR 1974, 116, 127), the former assumption that there has been a regular rise to the alluvial plain (BALL 1939, 173–76) is no longer accepted (KEMP and O'CONNOR 1974, 127). Citing the fact that declining flood levels in the Archaic Period would "lead to floodplain incision, not progressive alluviation," BUTZER states:

> The new and lower floodplain eventually created in Egypt and Nubia during the middle of the third millenium has persisted, with relatively minor or local modifications, until the present day. In other words, the modern floodplain has existed in its essentials since the Old Kingdom (BUTZER 1976, 28).

Near the Giza Plateau, some build-up of drift sand seems to have occurred in the low desert areas at the base of the plateau. For example, at the eastern base of the Maadi Formation, Old Kingdom deposits have been exposed where sand has been mined for nearby construction during the last few years (Fig. 4). Here there appears to be an Old Kingdom surface at about 17.5 m above sea level. Most of the high areas out on the floodplain are now heavily built over with modern housing and other installations (nevertheless, the contours of the surface are those of ground level). This phase of the reconstruction of the 4th Dynasty topography remains tenuous and requires more ground survey.

A 19. A slight rise to the surface above the floodplain spreads out N and S from the salient NE point of the Mokkatam Formation outcrop. While this rise is rendered in Fig. 3 A, it must be cautioned that the center of this high area is about where the Khufu Valley Temple must have been situated (B 6, B 7). Could the rise result from excavations and dumping from making a temple harbour? The eastward protrusion from the escarpment of the 20 m contour line at this point, while drawn in Fig. 3 A, is likely to have been caused by the remnants of the Khufu causeway, which was buried at the time of the aerial photography for the 1 : 5,000 map. The high area spreading to the N and S ranges from 18.6 to 19.9 m above sea level.

A 20. In this area at the northern foot of the Pyramids Plateau I have not followed the spot heights on the map as elsewhere. Those readings range from 17.6 to 19.5 m above sea level for what I am rendering as basin land. I do so mainly on the basis of old photographs, including some of the earliest postcards of the Giza Pyramids, which show this area flooded during the inundation (Pl. 2). Surfaces as high as 19.5 m above sea level in this area may have been created in recent years. Part of the Mena House Hotel golf course now occupies this area.

A 21. To the north of the area of A 19 there is a small place where the surface sinks to 17.3 m above sea level from the high at A 19 of 19.9. This low area also seems to be indicated in Pl. 3, a photograph taken before the Mansoureyah Canal was laid out near the base of the plateau. The view in the photograph is to the SE from the top of the Khufu Pyramid, apparently just after the flood waters have receded leaving pools behind in catchment basins. The early houses of Nazlet es-Samman are crowded close against the escarpment. The low area is indicated by pools at about the center of the photograph.

A 22. The Mansoureyah Canal passes along the E side of the high area designated in A 19 (see C 29). Otherwise, the floodplain levels off for an area of 400 × 500 m with little more than 30 cm of relief (elevations from 17.7 to 18.0).

A 23. A high area has been omitted here in Fig. 3 A on the suspicion that, rather than being a natural feature, it may have been built up during the 4th Dynasty constructions (see B 18 and C 27).

A 24. Today this high area takes in much of the village of Nazlet el-Batran. It is seen in the early photographs of the area during the Nile flood (Pls. 1, 3) and ranges in elevation from 18.5 to 20.4 above sea level.

A 25. This high area under the E-NE part of Nazlet el-Batran ranges from 18.6 to 23.0 m above sea level, and is also visible in the early photographs (Pls. 1, 3).

A 26. The low area between A 24 and A 25 is also seen in old photographs, particularly Pl. 3, as part of a gathering stream, or semi-circular basin which retains water after the flood has withdrawn (see B 17, C 28). This channel is apparent in early artists' renderings of the valley at the foot of the Pyramids Plateau (Lepsius 1849, Bl. 18).

Vestiges of the Khufu Work Layout: Fig. 3 B

In Fig. 3 B I have added to the reconstruction of the geomorphology at Giza those features which may result from the building of the Khufu complex, actually to be found on-site. These features have been drawn in to scale. It is fairly certain that all the features indicated date to the 4th Dynasty. More interpretation is required to isolate those features belonging to

the final years of Khufu's reign, presumably when the first pyramid project on the Giza Plateau was nearing its final stages.

B 1. The Khufu Pyramid. Even without artificial levelling for the base of the pyramid, the site chosen may have been the most naturally level place on the plateau. The base of the pyramid, after levelling, is around 60 m above sea level (Cole 1925). The fact that a great deal of rock did not have to be cut away to achieve a level base–perhaps 7 m at most–is indicated by the absence of a deep cut through the natural rock on the NW, such as can be seen along the N and W sides of the Khafre Pyramid. The contours of the plateau flatten out naturally in the area of the Khufu Pyramid, perhaps as an eastward extension of the terrace between the two cliffs which are 350 m W of the Pyramid at the W edge of the Western Cemetery. The escarpment is only about 70 m from the center N side of the pyramid, and about 120 m N of the NE corner. The E escarpment is about 350 m from the E side of the pyramid. In placing his pyramid here, Khufu's builders chose the far NE end of the *strike* of the formation. According to Aigner's (1983 c) depositional model of the plateau, the pyramid was based on the harder, more massive nummulite bank which swells up along the N-NW part of the formation (Aigner, forthcoming).

B 2. Mastaba tombs comprising the Western Cemetery of the Khufu Pyramid, which were completed (as core mastabas), according to Reisner (1942, 83–4), by year 20 of Khufu. Included are the nucleus cemeteries G 4000, arrayed E-SE of tomb 4000 of Hemiunu, and nucleus cemeteries G 2100 and G 1200, respectively E and W of the large mastaba G 2000. A space, 140 to 150 m wide, was left between the Khufu Pyramid and cemeteries G 4000 and G 2100. This space was later filled with the Cemetery *en Echelon* (Porter, Moss, and Malek 1974, 83 f., Pls. viii, xvi, xii). At the W side of the Khafre Pyramid, the so-called Workmen's Barracks are 100 to 190 m from the side of the pyramid. Another spatial configuration worth noting is that cemetery G 1200, and the expansion of this field (G 1000, 1100, 1300, 1400, 3000, and the Abu Bakr cemeteries), occupy a spatial relationship to the large mastaba G 2000 resembling that of G 4000 and G 2100 to the Khufu Pyramid.

B 3. Queens' pyramids and mastaba tombs comprising the Eastern Cemetery (G 7000) of the Khufu Pyramid which were completed by year 20 of Khufu (Reisner 1942, 84).

B 4. Location of the Mortuary Temple, probably finished at the completion of the pyramid (Maragioglio and Rinaldi 1965, 60–5, 162–71, Tv. 9–10; Lauer 1947; Ricke 1950, 43–47, 53–60, Abb. 13, 20–22).

B 5. I have argued that Khufu may have intended a fourth subsidiary, or satellite pyramid north of GI-a as indicated by the so-called "trial passages." These may have been the beginning of the substructure intended for the unbuilt pyramid (Lehner 1985).

B 6. The masonry-built foundation for the Khufu causeway ran from the point of the escarpment (locally known as Senn el-Agouz) to the location of the Valley Temple. In Fig. 3 B the causeway was graphically reconstructed on the basis of topographic indications on the 1:5,000 map (see Fig. 4). An elongated rise projects from the corner of the escarpment to the NE, probably created by the buried remains of the causeway foundation. A line bisecting this rise from the corner of the escarpment describes an angle of 24° 30′ (measured graphically) N of E. That the causeway departs from this point is readily seen on-site; this is also established from previous investigations (Lauer 1947, 246–48; Goyon 1969, 49–68; 1977, 138–47). A line from the center E face of the Khufu Pyramid to the point on the escarpment established the axis of the causeway between these two points as being oriented about 10° N of E (measured off the map). Lauer gave an angle of 14° and Goyon 14° to 15° N of E for the axis of the

Fig. 3B. Isometric projection of the Giza Pyramids site with landscape changes and architecture interpreted as dating to the final years of the Khufu Pyramid project.

causeway. The angle to the N, and the increased angle to the N after the escarpment, are shown in 18th and 19th Century plans of the plateau, when much of the causeway foundation east of the escarpment yet existed (NORDEN 1757, I, Pl. XLIII; JACOTIN (*Descr. Ant.*) 1822, V(A), Pl. 6; PERRING 1839; VYSE 1840, Pl. op. p. 1; LEPSIUS 1849, Bl. 14). GOYON (1969, 61–2; 1977, 140) denies that the axis of the causeway made a second turn, and located his trenches in the valley to search for its termination accordingly on a straight extrapolation of the first axis. However, as seen in Fig. 4, there is no way to strike a straight line from the center of the E face of the pyramid to the valley end of the projecting rise, which must surely indicate the course of the causeway, while keeping to the axis of the rise. The topographic evidence is that the early mappers of the site were correct in seeing a turn to the NE after the escarpment. GOYON's excavations exposed the base of the causeway foundation in trenches near the escarpment. His findings indicate that here the foundation had a height of 20 to 22 m (see also GOYON 1977, 141–42; Figs. 45–6). I have given this height to the causeway at the foot of the escarpment, though where it actually passes the cliff, the height is increased to 30 m in the drawing. In Fig. 3 B the causeway has a width of about 14 m. GOYON offers 14.80 as the width of the top of the foundation, and 18.35 as the width of the base. He calculated the slope of the causeway from the temple to the promontory as 3°, and from the promontory to the valley as 4°. The actual ground surface drops from about 60 to 55 m above sea level from the base of the pyramid to a point 180 m along the causeway axis, from 55 to 45 m from this point to the promontory, and from elevation 45 to 20 m from the promontory to the probable end of the causeway. The resulting slopes are about 1° 30′, 5°, and 5° for the three sections, though the actual surface of the causeway foundation could have decreased the slope of the latter two sections.

B7. The end of the causeway should also mark the location of the Khufu Valley Temple, which has been indicated in Fig. 3 B. This is established, again, on the basis of the 1:5,000 map. The temple is located where the contour lines flatten out into the 1 to 2 m rise to the surface which spreads out N and S of this point. The assumption is that if substantial remains were located further east, they would be indicated by the surface contours. On the isometric drawing, the Valley Temple is located a little further east than the 20 m contour line (the end of the projecting swell), giving a distance for the causeway of 430 m from the base of the pyramid to the turn to the N, and 230 m from there to the Valley Temple, for 660 m total length. The 1:5,000 map, strictly, gives lengths of 390 m to the turn, and 220 m to the end of the swell (20 m contour line), for a total of 610 m. Maps of the area produced in the 18th and 19th Centuries show the stone remains of the causeway foundation extending almost to the line between the cultivation and the sandy plain stretching from the base of the escarpment (now completely covered with modern settlement). Using their respective scales, these plans offer the following lengths for the sections of the causeway: JACOTIN (*Descr. Ant.*, 1822, V(A), Pl. 6), 433 m + 201 m = 633 m; VYSE (1840, Pl. op. p. 1), 475 m + 300 m = 775 m; LEPSIUS (1849, Bl. 14), 500 m + 150 m = 650 m. GOYON (1969, 62–3) established a length for the causeway on the basis of a probable slope from the promontory to the valley floor and arrived at lengths of 322.60 m from the pyramid to the promontory, and 336 m from there to the Valley Temple, giving a total length of 658.60 m. Because GOYON located his trenches to search for the Valley Temple on a line extrapolated from the first axis of the causeway, before its turn to the NE, his trenches 1 and 2 were located roughly 45 m W and 95 m S of the center of the Valley Temple as reconstructed in Fig. 3 B (Ibid., plan). However, his trench no. 4 at the north end of Street Sidi Hammed el-Westani in Nazlet es-Samman should be very close to the location of the Valley Temple as reconstructed in Fig. 3 B.

B 8. There is a small basin quarry about 170 m W of the NW corner of the Khafre Pyramid, measuring about 140 (N-S) × 80 m (E-W). This is the largest of a series of small quarry excavations in the rock surface west of the Khafre Pyramid and the Western Cemetery. Another has been drawn in both Figs. 3 A and 3 B just to the W of A 8. Today the government rest house lies on the flat high ground between these two quarries. That to the E appears to date earlier than Khafre's reign because the NW corner of the so-called 'Workmen's Barracks' is partially built over this quarry. It is assumed that this installation is contemporary with the building of the Khafre Pyramid (see MARAGIOGLIO and RINALDI 1966, 96–7, 132–33).

B 9. Parallel stone rubble walls, bonded with calcareous tan clay (*tafla*) have been excavated south of street G 7000 in the Eastern Cemetery and N of the modern road which passes from the Khufu Pyramid down to the Sphinx. The excavations remain unpublished, but the walls were described by SALEH (1974, 137). The walls are spaced 5.40 to 5.70 m apart. The eastern wall is doubled, or two walls built against one another, measuring a total of 2.50 m in width and 2 to 2.30 m in height. The walls are built in sections of 10 to 21 m in length. The sides are coated with clay. It may be that the debris which was excavated from between the walls was part of the original construction which formed a supply ramp or roadway (Ibid., 140). The walls show a very slight slope up to the Eastern Cemetery. It was reported that "a few mud seal impressions bearing the name of Cheops" were found in the debris between the walls (Ibid., 137). Construction embankments formed of clay and stone rubble are known elsewhere at Giza (Ibid.; REISNER 1931, 76, Pl. 10b; for construction embankments in general see CLARKE and ENGELBACH 1930, 91–3). It appears that the area in which the walls are situated has been quarried and then refilled with construction debris, exactly like that from which the walls are composed. The walls rest on thick layers of such debris, which can be seen in holes excavated near the bases of the walls.

B 10. A large basin quarry is located from 300 to 600 m S of the Khufu Pyramid in the western part of the Central Field. The quarry measures about 230 m E-W at its widest, and at least 400 m N-S as indicated by the extension of its western edge exposed by Cairo University excavations (Fig. 2; SALEH 1974, 140 n. 9). According to the 1:5,000 map, the center of the quarry is up to 30 m deep. A deeper excavation for stone blocks was cleared on the floor of the quarry near the tomb of Khnum-ba-f during HASSAN's 1935–36 season (HASSAN 1953). This deeper cutting in the quarry floor is drawn to scale in Fig. 3 B, as are the outlines of the quarry, from the 1:5,000 map. In this drawing, great piles of stone rubble and debris have been 'removed' from the basin quarry. This debris was only partially excavated by HASSAN along the edges of the quarry where the piles were as high as 23 m (Ibid., xi–xii). It is probably because of these vast deposits of debris that this area remains largely a blank on plans of the Central Field (e.g. PORTER, MOSS, and MALEK 1974, Pl. XX). The mounds have been trenched without revealing much development of the cemetery here, no doubt, because of the labor that would have been necessary to remove the debris down to the rock floor of the quarry for building tombs. At the N, the floor of the quarry appears to slope up to the Khafre causeway, which passes about where number 11 is located in Fig. 3 B. The E and W sides of the quarry roughly line up with the E and W sides of the Khufu Pyramid (LEHNER 1984). The width of the quarry multiplied times its length (230 × 400 m), and this multiplied by a depth of 30 m, gives 2,760,000 m^3. The Khufu Pyramid has been estimated to contain some 2,590,000 m^3 of stone (STADELMANN 1980, 438). The quarry is not, however, rectangular, and it must be remembered that the floor of the quarry is not uniform, but appears to slope up to the N. Allowance must also be made for waste of rock in the channeling necessary to extract the stone blocks. It is

hoped that more accurate calculations of the quarry volume will be obtained in future seasons of the Giza Plateau Mapping Project.

B 11. Although the floor of the quarry slopes gradually up to the N, a small incline or ramp of debris was left at the NW corner of the quarry, just E of the long-known tomb of Neb-em-akhet (LG 86; PORTER, MOSS, and MALEK 1974, 230–33). Today this slope gives access to the Cairo University rest house complex. The Khafre causeway passes the quarry on the N.

B 12. The western face is the most pronounced and exposed side of the quarry. It was already being cleared of debris in the later 4th Dynasty (BADAWY 1954 a, 53) in preparation for work on the rockcut tombs of Neb-em-akhet (LG 86), Ni-kau-re (LG 87), Sekhem-ka-re (LG 89), Neussere, Personet (LG 88), and Debehen (LG 90; PORTER, MOSS, and MALEK 1974, 230–38).

B 13. The eastern part of the Central Field, situated at the low end of the Mokkatam Formation outcrop, was never as deeply quarried as the western part. It, therefore, still shows the way in which the rock was divided during quarrying into a series of large rectangles, or quarry cubes, by series of large removal channels (AIGNER 1983 a, 384–86; LEHNER 1984). The largest of the quarry cubes is that at the far SE corner of the main quarry (B 10). This cube was later used for the base and core of the Khent-kawes monument (PORTER, MOSS, and MALEK 1974, 288–89). On the 1 : 5,000 map, the axis of this cube looks to roughly align with the E side of the Khufu Pyramid. More stone might have been quarried for the Khufu Pyramid from the area E of the Khent-kawes cube. However, this area may have been exploited later for the Menkaure Pyramid.

B 14. Excavations by ZAHI HAWASS and Ministry of Irrigation core drillings in 1980 in the area E of the Sphinx Temple indicated the existence of a ledge or drop-off to the rock surface at about 56 m E of the temple. These probes indicate that the drop-off is at least 16 m deep (HAWASS and LEHNER, unpublished; LEHNER 1984).

B 15. There is a large wall composed of limestone blocks extending to the E from the S side of the mouth of the central wadi. The wall is about 178 m long, measured off the 1 : 5,000 map (GAUTHIER 1933, 71 gives 200 m; MARAGIOGLIO and RINALDI 1967, 196 give 180 m; GOYON 1971 b, 146 gives 181 m), and 7 to 7.5 m wide. There is a gateway, 3 m wide, at the center of the wall, covered by large limestone slabs (ROSTEM 1948). Test trenches somewhere near the S side of the wall showed that the wall is founded upon a bed of limestone rubble paved with clay (HASSAN 1943, 42). While it has been suggested that the wall was built as part of Khafre's layout (GOYON 1971 b, 146; STADELMANN 1981, 72), it is placed in Fig. 3 B as part of the total Khufu work layout. As seen in the 19th Century plans of Giza (JACOTIN, *Descr. Ant.*, 1822, V(A), Pl. 6; PERRING 1839; VYSE 1840, Pl. op. p. 1; LEPSIUS 1849, Bl. 14), this wall, like the Khufu causeway, is oriented slightly N of E (GOYON 1971 b gives 4° N of E). Together, the two constructions enclose the entire area at the foot of the Pyramid Plateau, the natural district for the valley installations which must have once serviced the huge project (see C 20).

B 16. A canal leading to the worksite for the Khufu Pyramid is suggested here on the basis of topographic lows seen on the 1 : 5,000 map, and a slight depression observed from the large southern wall (B 15) looking to the E-SE along the edge of the village of Nazlet es-Samman.

B 17. See A 26. This semi-circular depression seems to be a continuation of an old, disused canal, only partially filled with water. The channel is labelled *Zeyarat Zaghloul* on the 1 : 5,000 map. This appears to continue as a street into Nazlet el-Batran. BACHATLY (1932)

visited this area in 1930 during and after the inundation. He reported that the depression was "une profonde cuvette, reste d'un ancien étang. On ne remarque nettement cette dépression qu'à la période des basses eaux; elle se transforme alors en un réservoir dans lequel puise journellement un rudimentaire instrument élévatoire le *chadûf*" (Ibid., 99). The E-W canals indicated to the N are based on the *Collecteur al-Sissi* which curves around the E and S sides of the mound on which the village of Nazlet el-Sissi is situated N of the view in Fig. 3B (see Fig. 4). The canal indicated just S of this, and ending on the W at the *Zerayat Zaghloul* channel, is part of the *Collecteur Nazlet el-Batran.* All of these appear to be older canals within long existing gathering streams. The two running E-W point general toward the mouth of the central wadi separating the Mokkatam and Maadi Formations.

B 18. A high area on the floodplain is located E of the mouth of the central wadi (Fig. 4, Pls. 1, 3). It measures about 400 m (N-S) × 450 m (E-W). This was excluded from Fig. 3A on the suspicion that it was formed during the 4th Dynasty (see C 27).

B 19. Patches of mudbrick walls and concentrations of pottery, apparently Old Kingdom, have been exposed in this area after 1 to 2.5 m of surface sand was removed for nearby village construction. Selim Hassan (1943, 42) sank test trenches in the area to the S of the large wall (B 15) in order to find a place free of antiquities to move the contemporary village cemetery which partially covers the ancient settlement attached to the Menkaure and Khent-kawes valley complex. In trenches close to the wall, a pavement upon a bed of limestone rubble was exposed. Trenches located as far as 300 to 450 m to the S of the wall exposed mudbrick walls. Gauthier (1933, 298) seems to speak of this work by Hassan when he wrote: "Les maisons ont donné une motte de terre portant les cartouches de Khéops et de Khéphren, des utensiles en silex, ainsi que des vases en argile, dont beaucoup étaient encore dans leur position d'origine."

B 20. A large deposit of cultural debris, covering 12.5 square acres and up 6.5 m thick, was excavated by the Austrian expedition under Kromer (1978). Kromer believes that a long-term settlement was razed from the site of the Menkaure Pyramid, and that the debris was transported a kilometer to the knoll of the Maadi Formation. Some scant crude walls were found at the bottom of the deposit. Mud seal impressions of Khufu (*Ḥr Mḏdw*) were also recovered, though there were more such seals of Khafre. The excavation has been criticized for lack of control over the provenience of the finds (Butzer 1982a, 140–41; 1982b, 93–5). Without details of stratigraphy the date of the scant architecture which was found is left undetermined.

B 21. During his excavations of this area, Petrie (1907, 9) probed the floor of this sandy bowl and reported that it was covered by a deep cultural deposit, albeit one that resembled quarry waste. This included many chips of red granite.

B 22. The prominent knoll of the Maadi Formation has been extensively quarried away on the W, N, and part of its S face. This seems to have been done in ancient times, though Maragioglio and Rinaldi (1967, 196) mention that the knoll served as a quarry "up to a few years ago." The knoll is shown in Denon's drawing of the Sphinx seen looking S (Denon 1803, p. 269, Pl. IX). There it is depicted cased off with masonry at the bottom like a pyramid. In his haste, Denon may have mistaken the thin stratification exposed on the face of the knoll by quarrying as courses of masonry. The strata here are too thin and laminated to have served for large building blocks. Aigner characterized the layers as "a sequence of soft marly limestone and sandy marls with some intercalated shell beds and sandstones" (Aigner 1983b, 315–17), and "sandy and marly limestone and largely barren gypsiferous marl and claystones ('*tafla*')" (Id., forthcoming). The knoll may have been quarried for *tafla* and ramp material during the

4th Dynasty. Local villagers say that the area around *Heit el-Gurob* is still occasionally mined for *tafla*.

B 23. Remains of a rough stone wall, included in the plans of PERRING (1839), VYSE (1840, Pl. op. p. 1), and LEPSIUS (1849, Bl. 14), still exist on top of the prominent knoll marking the NW corner of the sandy bowl.

B 24. Although the contours of the material lying against the north escarpment are drawn into Fig. 3 A much as they are today, it is clear that a great amount of this material is culturally deposited. It is likely construction debris from building the Khufu Pyramid, as PETRIE (1883, 85) recognized. He was impressed at the stratification of this material which, he said, indicated the kinds of materials being worked at different stages of the pyramid project. The debris contains fragments of baskets, tools, and pottery (Ibid.). The area to the S of the Khufu Pyramid, beyond cemetery GI-S (dated to Menkaure and later, PORTER, MOSS, and MALEK 1974, 216–88), also contained dumped debris which apparently fills an extensive quarry limited on the S by the Khafre causeway and on the east by the Sphinx depression. While this quarry may have been started under Khufu, it is likely that it was mostly exploited by Khafre because 1. a ramp of natural stone was left for the Khafre causeway between this quarry and the large basin quarry farther S (B 10), and 2. this area would have been covered by Khufu's main supply ramp running from the Central Field quarry to the pyramid.

A Reconstruction of the Khufu Work Layout: Fig. 3 C

(Note: Several of the items are repeated from Figs. 3 A and 3 B due to the fact that Fig. 3 C was designed as a separate piece, and thus has designations for items covered in Figs. 3 A and 3 B.)

C 1. See A 5.

C 2. See A 8.

C 3. See A 13.

C 4. See A 14.

C 5. See A 15.

C 6. See A 2.

C 7. See A 3.

C 8. See A 4.

C 9. See B 2. The ramps, or 'construction planes', surrounding the Western Cemetery of Khufu on the S and E are inspired by the remains of just such a construction embankment which still exists against the large unfinished southern boundary wall of the Western Cemetery (PETRIE 1883, 33). This wall was probably started under Khafre's reign. Today, one actually drives up onto this construction plane when taking the asphalt road past the N side of the Khafre Pyramid. The embankment which yet exists appears to have been partially removed, or left incomplete, at its SE corner where it turns to the N to slope down toward the NE corner of the Western Cemetery while passing the Cemetery *en Echelon* to terminate just short of the Senezemib complex (G 2378–2391; PORTER, MOSS, and MALEK 1974, 87–92, Pl. XII). Along the E side of the Western Cemetery, the embankment is retained by a stone rubble wall. The construction embankment which yet exists is, of course, farther S and E than that rendered in Fig. 3 C to accommodate the expansion of the cemetery.

C 11. See B 3.

C12. This quarry is construed as supplying stone for the construction of the Eastern Cemetery. The zone N of the Khafre causeway and W of the Sphinx ditch is extensively quarried. Much of this must have been done under Khafre (see B24). However, the E half of this quarry could have been begun under Khufu just behind the Sphinx which was made later. The limestone rubble/clay mortar walls (B9) might be the remains of supply ramps. Here they have been extended along their orientation up to queen's pyramid GI-c and street G7000 to service the construction of the large mastabas. If the reconstruction of the main supply ramp for the pyramid is nearly correct, this quarry could have furnished stone for the main pyramid as well. The eastern and southern limits of this quarry are drawn on the basis of rock edges which still exist, while the western and northern sides are reconstructed. There is a kind of bridge or ramp left in the natural stone forming the W side of the Sphinx depression. It slopes to the N at the natural dip of the Mokkatam Formation. In Fig. 3C the W side of this natural stone ramp is just being created, the Sphinx depression not yet having come into existence. Another ramp is reconstructed here for supplying the mastabas of the Eastern Cemetery.

C13. See B6.

C14. This reconstruction of the Khufu Valley Temple is conjectural, patterned after the Valley Temple of Khafre. There is some doubt as to whether the Khufu Valley Temple would have assumed such a form. During the reign of Khufu the pyramid temples began to expand and to become more elaborate than the small chapels attached to the Meidum Pyramid and the Dahshur Bent Pyramid (LAUER 1936, I, 6). Pending the results of STADELMANN's excavations on the site of the Mortuary Temple of the North Dahshur Pyramid, it can be said tentatively that the Mortuary Temple expands for the first time, since the reign of Zoser, in Khufu's reign. At the same time, it is unlikely that the Khufu Valley Temple contained the corework of huge monolithic limestone blocks like the temples of Khafre and the Mortuary Temple of Menkaure (LAUER 1947, 256). This type of masonry (see RICKE 1970, 6–8) determines, to some extent, the architectural form of the temple. In addition to other indications that the Khufu Mortuary Temple was not constructed in this way (LAUER 1947, 256), it seems unlikely that such huge coreblocks could have been removed entirely without a trace, considering that the standing core walls of the four Giza temples which were constructed with this kind of masonry still exist (Khafre Mortuary and Valley Temples, Sphinx Temple, Menkaure Mortuary Temple). One of GOYON's trenches in the vicinity of the Khufu Valley Temple (B7) exposed *in situ* parallel walls forming a kind of corridor 1.40 m wide and oriented E-W at the same angle as the causeway. The blocks, up to 1.10 m in length and .55 m in thickness, are certainly not the kind forming the cores of the Khafre Temple walls. The blocks exposed in the trenches are both limestone and basalt (GOYON 1969, 63–66, Figs. 7–8). It may be that GOYON's trenches exposed parts of constructions which are ancillary to the Valley Temple (see B7). The basalt blocks are significant because the pavement of the Khufu Mortuary Temple was composed of basalt. (In the plans of PERRING (1839) and VYSE (1840) basalt fragments were noted about 160 m S of the Valley Temple area and near the base of the escarpment. On top of the escarpment, on line with these fragments, a "basalt foundation" was noted.)

It may be that the Khufu Valley Temple was more in the form of an open court (STADELMANN, personal communication), or a modest building similar to the so-called Valley Temple of Sneferu (FAKHRY 1959, 1961). One might question whether this is a Valley Temple proper (RICKE in FAKHRY 1959, 106–10), particularly since it is located some distance from the valley and has a second causeway leading from it toward the valley. It is possible there was an additional enclosure, in the form of an open court, connected to this second causeway at the edge

Fig. 3C Key. Schematic version of Fig. 3C with the principal features numbered.

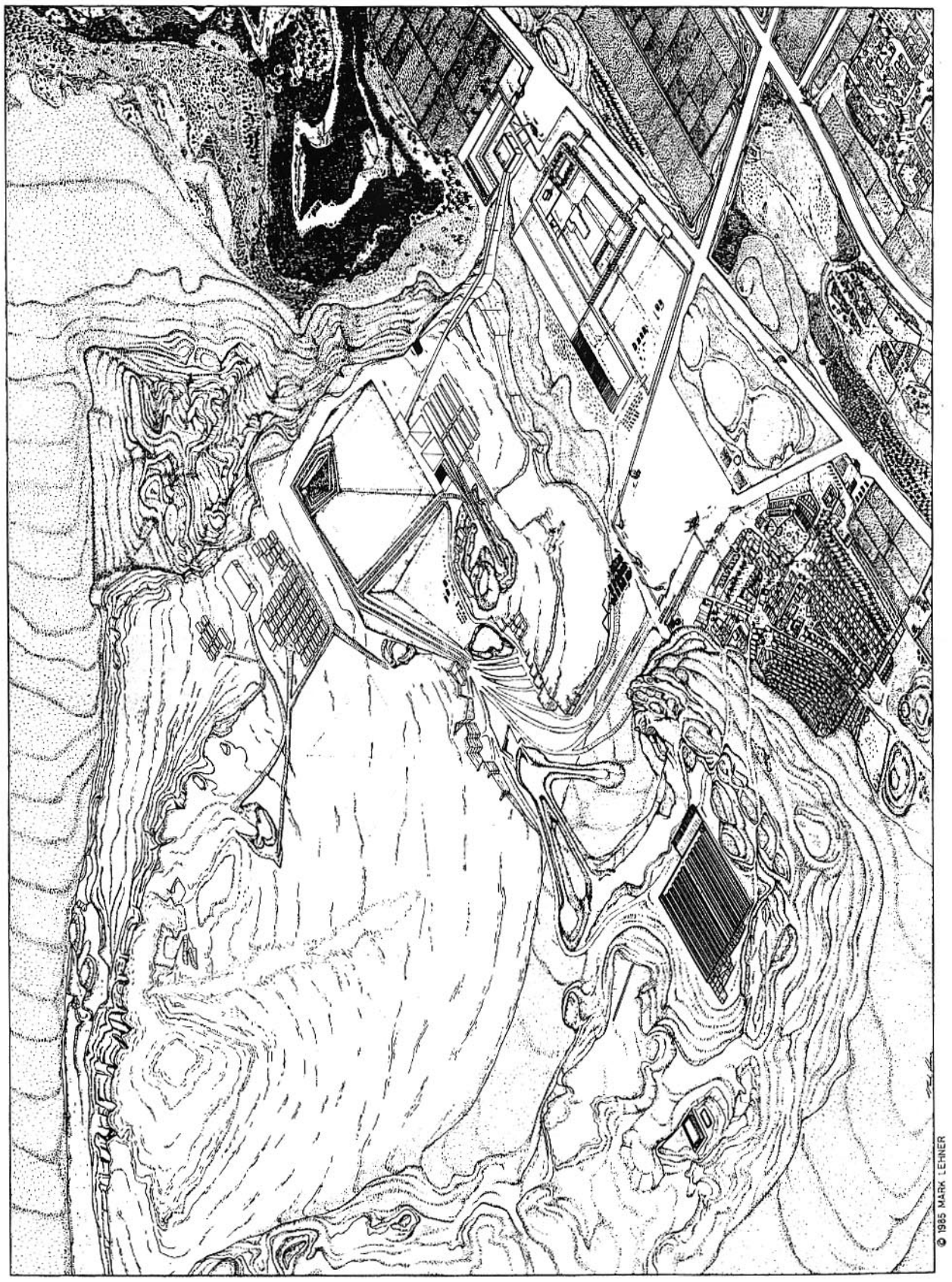

Fig. 3C. Isometric projection of the Giza Pyramids site with a reconstruction of the organization of the site in the final years of the Khufu project, based upon evidence rendered in Figs. 3A and 3B, parallels from other sites, Egyptological information, and some conjecture.

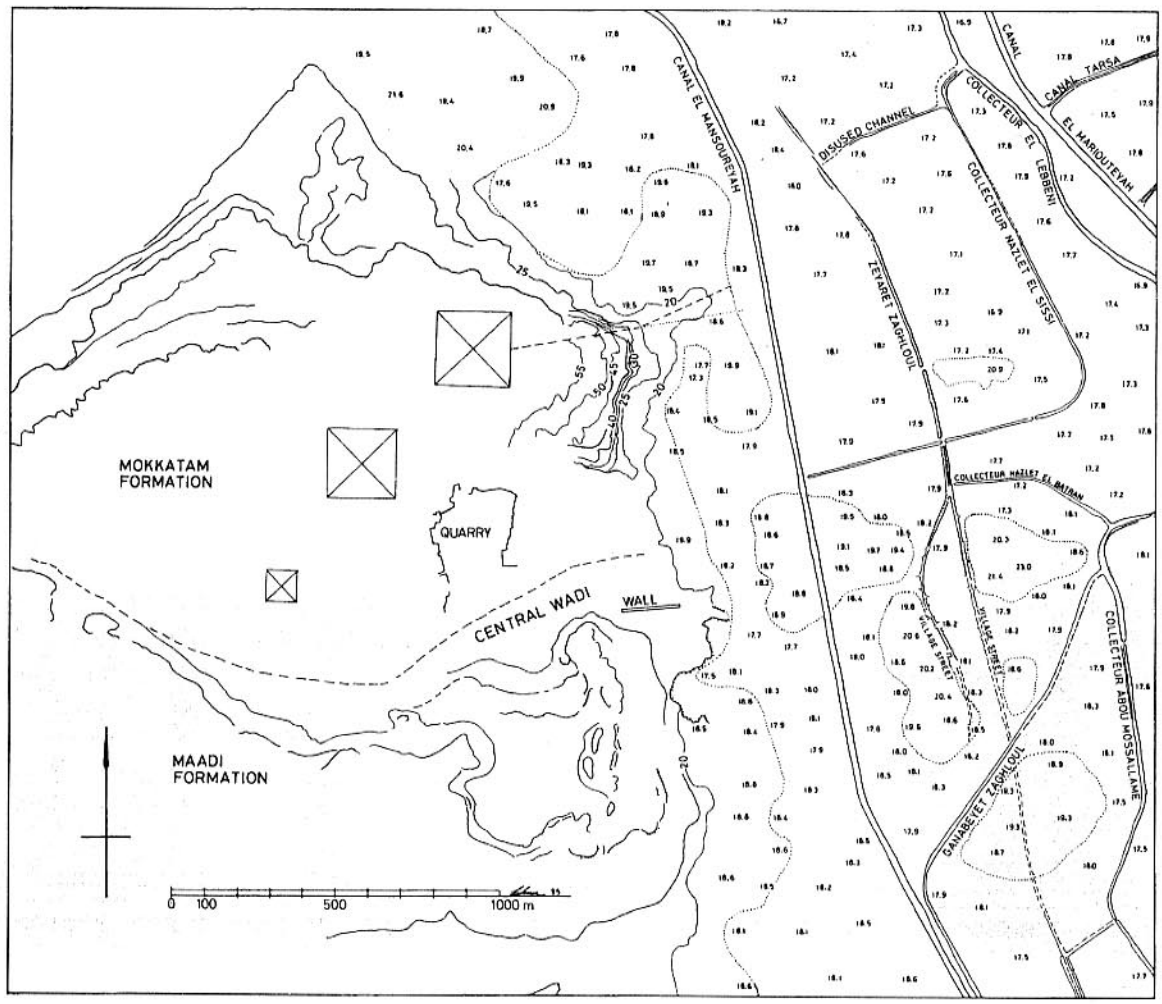

Fig. 4. Canals and spot heights above sea level in the valley floor east of the Giza Pyramids plateau, based upon the Egyptian Ministry of Housing and Reconstruction 1:5,000 topographic map sheets. The probable axis of the Khufu Pyramid causeway is indicated by a dashed line.

of the floodplain. Such a valley enclosure was attached to the North Dahshur Pyramid (Borchardt 1905, 1–3, Abb. 1; Fakhry 1959, 9). This must have been for a cult emplacement or portal to the complex that was an early form of the more classic Valley Temple (Stadelmann 1981 b, 70–71).

The reconstruction of a harbour fronting the Khufu Valley Temple is much like that of Goyon (1977, 27, Fig. 2, 139, Fig. 43 – unfortunately reversed). Access to the harbour is via a canal reconstructed on the basis of the present Mansoureyah Canal (see C 29). The harbour as reconstructed measures 125 × 120 m.

C 15. It is not possible here to review the many theories about how the stones were elevated for building the upper parts of the pyramid. Most of these involve the use of some kind of ramp (see Edwards 1972, 203–207; Goyon 1977, 51–86). What is certain is that the question

must be addressed in terms of the topographic situation of any given pyramid. There had to be a main supply ramp from the quarry which supplied the greater part of the core stone to the pyramid, if the quarry was in the area of the pyramid. As far as we know, no large quarry sufficient to the bulk of the Khufu Pyramid exists to the W, N, or E of this pyramid. Furthermore, to the W and E Khufu was constructing cemeteries during his reign. A 25 to 30 m escarpment exists a short distance to the N (B 1). The large Central Field quarry (B 10) is to the S of the pyramid. In exploiting this the builders took advantage of the thickly bedded softer limestones of the south part of the Mokkatam Formation, while founding the pyramid on the hard nummulite bank to the north (see A 5). The natural slope of the formation already provided an inclined plane from the quarry to the pyramid. It is also clear that, in whatever way the ramp ascended the pyramid as it was being built, it had to do so in the space between the pyramid and the cemeteries to the E and W, and the escarpment to the N. Several problems have been pointed out for the idea of a straight-on ramp up one side of the pyramid (GOYON 1977, 67–81). At Giza, such a ramp running from the quarry to the south face of the Khufu Pyramid would have covered much of the quarry if the ramp was to retain a practical slope (see LEHNER 1984, Fig. 15).

In Fig. 3 C a solution was attempted in the form of a ramp which wraps around the superstructure of the pyramid. This kind of ramp seems to be required by the limited space around the base of the pyramid, and the disposition of the pyramid to the main quarry. One of the main objections to this form of ramp in the previous reconstruction of DUNHAM (1956) is that the casing of the pyramid, even when left initially undressed, would not support ramps on the faces of the pyramid (EDWARDS 1972, 206). GOYON (1977, 174–82) attempted to resolve these and other problems with a modified reconstruction of a "hélioïdale" ramp. Yet another version is reconstructed in Fig. 3 C, though I am not convinced it resolves the question better than that of GOYON.

The first stretch (Fig. 5,A) begins at the mouth of the quarry, where an incline down to the quarry floor was left in the natural rock (B 11). It extends 320 m at a slope of 6° 36′ to 30 m above the SW base of the pyramid. The roadway has a width of 30 m which may be more than necessary (cf. GOYON 1977, 178, Fig. 62). Reducing the width would also reduce the volume of the ramp. However, this might be compared with the specifications for an embankment in Papyrus Anastasi I (GARDINER 1911, 16–17) which called for a width of 55 cubits (28.82 m); length, 730 cubits (382.50 m); height, 60 cubits (31.44 m); and a side batter of 15 cubits (7.86 m).

The second stretch, B, leans against the W side of the pyramid for a distance of 250 m at a slope of 7° 18′ rising to a height of 62 m above the pyramid base. The third section, C, leans against the N face of the pyramid and slopes at an angle of 10° 39′ for 180 m to a height of 95 m above the pyramid base. At this height the pyramid contains nearly 96% of its total mass. The fourth stretch, D, leans against the E face of the pyramid and slopes at an angle of 12° 58′ for 100 m to a height of 118 m above the pyramid base. Very near the top, the ramp leans against the S face of the pyramid. The accretion on which it is founded rests on lower accretions with a doubled width allowing for a secondary roadway. Stretch E slopes at an angle of 14° 30′ for 60 m to a height of 133 m above the pyramid base. The final stretch, F, is against the W face, at a slope of 18° 39′ for a length of only 40 m to the top of the pyramid at 146.5 m above the base.

As seen in cross-section (Figs. 6–7), the support for the roadway is in the form of accretions leaning against the faces of the pyramid. The faces and diagonals of the ramp accretions

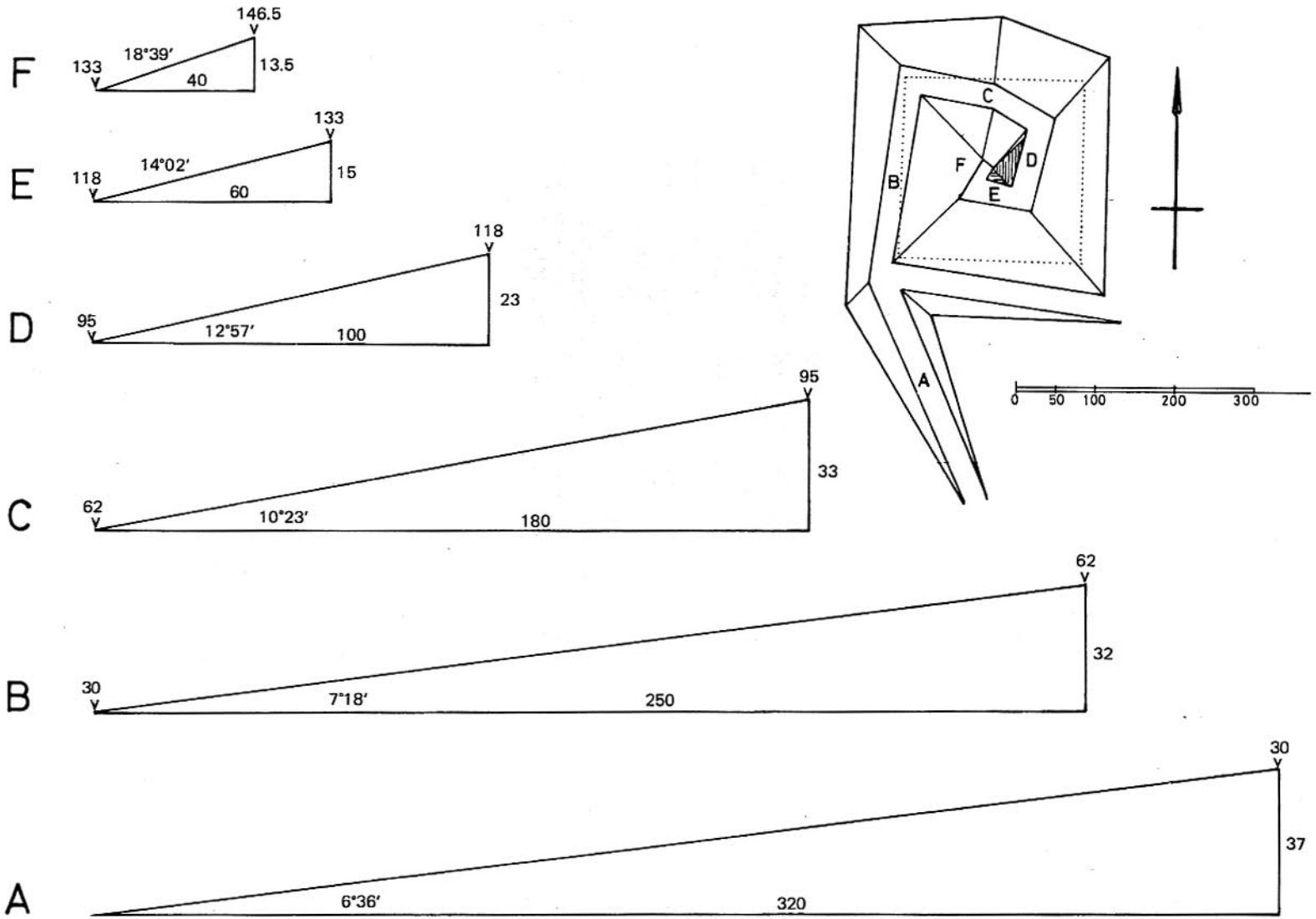

Fig. 5. Plan of the pyramid construction and supply ramp shown in Fig. 3 C. The length, rise, and angle of slope of the six ramp sections (A–F) are illustrated at a larger scale. Numbers at the top of the slopes indicate meters above the pyramid base.

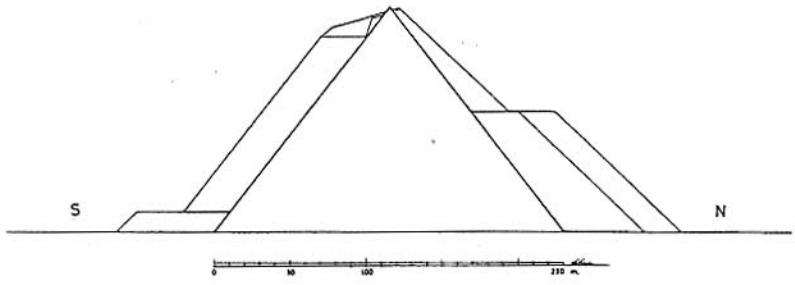

Fig. 6A. Pyramid and accretion construction ramp in cross-section on the N-S axis of the pyramid.

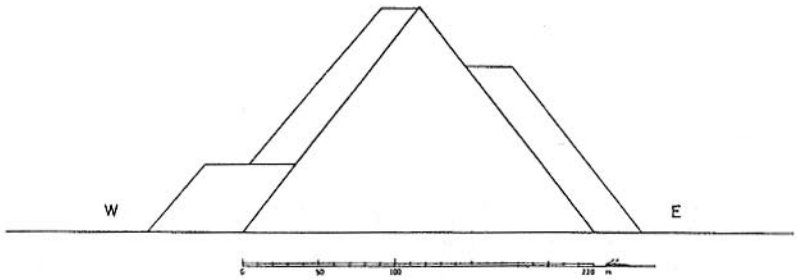

Fig. 6B. Pyramid and accretion construction ramp in cross-section on the E-W axis of the pyramid.

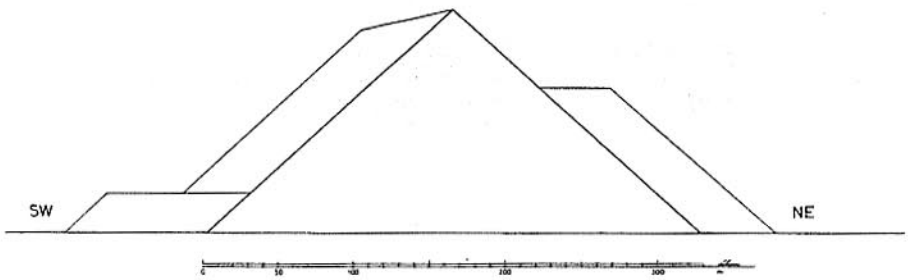

Fig. 7A. Pyramid and accretion construction ramp in cross-section of the NE-SW diagonal of the pyramid.

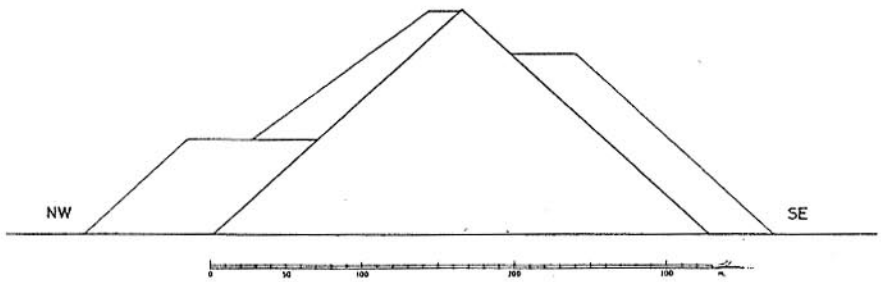

Fig. 7B. Pyramid and accretion construction ramp in cross-section on the NW-SE diagonal of the pyramid.

have the same outer slope as the faces (about 52°) and diagonals (41° 59′) of the pyramid. If the ramp had been built in this form, the ancient Egyptian builders could have been taking advantage of long experience in constructing accretions within the superstructures of earlier pyramids.

A ramp of the final form shown in Fig. 3 C would necessarily have been planned from the beginning of the project. It would have been successively built up on all sides as the pyramid rose during construction, the roadway gradually increasing in slope at the top of the accretions. While the slope becomes steeper toward the top, fewer and fewer stones are being raised. Since the accretions would have covered all four faces, control of the diagonals and the slope of the faces would have been a problem. According to CLARKE and ENGELBACH (1930, 125), "two possibilities present themselves; one is that the size of the square at the height of the course was calculated, and a square of the calculated dimensions was described on the already established diagonals and axes; the other is that it was found by plumbing and measurement." These authors reject the former possibility and describe a method of backsights for the axes and diagonals, and references to "facing surfaces" lower on the pyramid faces for plumbing and measuring the slope (Ibid., 126–28, Fig. 136). There is a possible way in which reference points on a layout square around the base (LEHNER 1983) could have been transferred up to the course under construction for control of the square for a given height (LEHNER 1984). The details of this must be left for a more lengthy discussion on this point.

Although it has often been said that the pyramid construction and supply ramp would have been built of Nile alluvial mud (GOYON 1977, 115), there are no great deposits of mud or mudbrick on the Pyramids Plateau to the extent one would expect from the removal of the ramp, even if much of the material was carted away. The quarries along the S of the Mokkatam Formation at Giza are filled with great dumps of limestone debris, gypsum, and calcareous tan-colored clay (*tafla*). A great embankment along the northern enclosure wall of the Western Cemetery is composed of such material filling walls forming compartments; the walls are built of the same material (see C 9). Parallel walls which may be the sides of a ramp SE of the Khufu Pyramid are also built of this variety of material (B 9, C 12).

C 16. Tracks run from the Central Field quarry walls to the foot of the supply ramp. These may have been formed of limestone chips, gypsum, and *tafla* with the surface lubricated by water to facilitate the transport of stone (see CHEVRIER 1970, 19–25). In the reconstruction, quarry waste is being removed to the S across the central wadi in long embankments and tip lines.

C 17. An often repeated notion is that the pyramid causeway (C 13) was the main access for the delivery of materials to the site. But since the bulk of material for the pyramid core was raised from the S, non-local materials such as Turah-quality limestone for the casing and granite for the burial chamber could also have been delivered from this direction, utilizing already existing routes of supply and access. The wadi separating the Mokkatam and Maadi Formations becomes the natural conduit for these materials to pass through the quarry and up onto the construction ramp. Tracks lead from the harbour through the wadi. Here, and on the pyramid ramp, the tracks are shown with spaced transverse wood beams, much like DUNHAM's (1956) reconstruction. Tracks, or slipways, for moving stone and boats have been found which indicate the use of parallel runners (VERCOUTTER 1965, 68–9; 1970, 204–14; CHEVRIER 1970, Pl. 2). Palm logs placed close together as rollers have also been suggested for hauling tracks. Wider spacings of (reused) wood beams have actually been found on construction tracks at the Pyramid of Sesostris I at Lisht (LANSING 1924, 39, Fig. 8). One of these has recently been exca-

vated by ARNOLD during the 1985 season at Lisht on behalf of the Metropolitan Museum of Art (personal communication). Thin layers of white gypsum and dark alluvial mud passing over the beams may indicate that the beams are a bedding for a slicked track of either gypsum or mud. The beams, therefore, might not have shown as indicated in Fig. 3C.

The knoll rising above the mouth of the wadi (A 10) would have offered an excellent vantage to supervise and monitor everything coming and going to and from the construction site.

C 18. The logical position for the harbour or quay for the introduction of non-local materials is at the mouth of the central wadi, the principal access to the site during construction. The front edge of the harbour is aligned to the position of a subsurface drop-off indicated by excavation and drilling in 1980 to the front of the Sphinx Temple (see B 14). Here, the harbour has yet to be extended that far to the N (which may have been done in Khafre's time). The back (E) edge of the harbour has been delimited by a topographic high (B 18) which has been construed as the vestige of dumps from the dredging of the harbour. This is also inspired by the 'Birket Habu' at Malkata, the creation of which produced great mounds of earth which still define the boundaries of the harbour (KEMP and O'CONNOR 1974). The harbour in Fig. 3C measures 210 (N-S) × 350 m (E-W). This is quite large in comparison to known temple harbours (Ibid., 107) but much smaller than the rectangular basin described by the mounds of the Birket Habu, 2.4 × 1 km (Ibid., 108). The Birket Habu was certainly useful for the delivery of goods and materials to the Malkata complex and there is evidence that it facilitated the transport of the colossal statues of Amenhotep III ('Colossi of Memnon') to the mortuary temple of this king (HEIZER et al. 1973). Nevertheless, the size of the Birket Habu "is out of all proportion to purely practical considerations" (KEMP and O'CONNOR 1974, 130) and was probably motivated as much by other aesthetic, cultural, and religious reasons.

A harbour similar to that in Fig. 3C was proposed by GOYON (1971 b, 145–46, Fig. 5; 1977, 135–39, Figs. 42–3). GOYON would have this harbour servicing the complexes of Khafre, Menkaure, and Khent-kawes, making it even larger than the harbour of Fig. 3C. While the harbour might have been extended northwards by Khafre to the area in front of his Valley and Sphinx Temples, it is not likely that it extended as close to those temples as GOYON suggested, or that the water would reach to the S and W sides of the Khafre Valley Temple. It is also doubtful that it extended right up to the large southern boundary wall (B 15), though this may have been built to delimit the harbour area as well as to enclose the pyramid settlement (C 20). The harbour would also not have approached so close to the Menkaure Valley Temple as GOYON suggested, since HASSAN's (1943, 41) test trenches in the modern cemetery extending E of the temple indicate that the Old Kingdom settlement must extend for some distance in this direction, and it is unlikely that the harbour was filled in so quickly. It must be admitted that the harbour as reconstructed in Fig. 3C does seem much larger than necessary for providing quay space for unloading even the amount of material required for the Khufu Pyramid. Finally, it might be noted that the edge of the harbour would probably have had a much greater slope than indicated here, and it may have been revetted, to avoid the edges being undermined by the seasonal fluctuations of the water level (KEMP and O'CONNOR 1974, 124–26).

C 19. This is a purely hypothetical reconstruction of a workmen's village. Workmen's quarters here would have been in a natural basin surrounded by the peaks of the Maadi Formation, similar to the topographic situations of the New Kingdom workmen's villages of Deir el-Medineh (BRUYERE 1939) and Tell el-Amarna (WOOLLEY 1922, 48–60; PEET and WOOLLEY 1923, 51–91; KEMP 1984, 7, Fig. 1.3). The site is just to the S of the main quarry and supply ramp, affording a direct retreat for the workmen after the day's work. Like the main access to

the construction areas, it could be supervised from the prominent knoll of the Maadi Formation rising above the wadi, as well as from the other peaks surrounding the sandy bowl. KROMER's excavation in the NE corner of the bowl exposed some scant architectural remains (KROMER 1978, 100–111), although he suggests that the overlying debris is from a settlement originally located elsewhere, intentionally razed, with the debris transported to the site of his excavations.

The form of the settlement in this drawing is copied from the workmen's village at Tell el-Amarna, for the purpose of a population estimate. The Amarna village contained 73 standard-sized units measuring 5 × 10 m (PEET and WOOLLEY 1923, 53). BADAWY (1968, 61) multiplies 4.18 persons – "the average number of members for the rural family in modern Egypt" – × 75 units (counting the large Overseer's mansion as two) to arrive at a population of 313 for the Amarna village. The square village in Fig. 3C has 442 standard sized units (5 × 10 m) and two double units, giving 446 × 4.18 = 1,864 persons. The area covered by the hypothetical village is 200 × 220 m. Divided by BADAWY's coefficient of population of 15.65 square meters per person, this allows 2,811 persons, disregarding space between housing units.

It might be questioned whether a 4th Dynasty worker's settlement would be as orderly and planned in its layout as an equivalent village of more than a millenium later at Amarna. The workmen's village of Sesostris II at Illahun dates to a period some 600 years later than the time of Khufu, and has the form of a walled square enclosure containing densely grouped houses (PETRIE 1891, 5–8, Pl. 14). However, in the Illahun enclosure there are several different house sizes, from mansions comprising 2,400 m² to smaller houses of 95 m² (BADAWY 1966, 22). The smallest are still almost double the area of the Amarna workmen's houses of 50 m². A planned, rectilinear, dense ordering of houses within thick enclosure walls is seen in the 4th Dynasty settlement (for priests?) laid out parallel to the Khent-kawes causeway at Giza (HASSAN 1943, 35–50, Fig. 1). The smaller houses are 4 × 5 m (only 20 m²). While this certainly indicates that the 4th Dynasty was capable of such a planned layout, it is questionable that this would have been the form of settlement for thousands of workers (STADELMANN 1981 b, 67–8), particularly if these men were recruited on a rotating basis from the provinces. The workmen's village at Amarna may have been initially reserved for specialized workers and artisans employed at the royal tomb and nearby North and South tombs of noblemen, particularly the South tombs, which are quite near (KEMP 1984, 1–4). They may have been settled with their families in the town enclosure, which might not have been the case with men forming the bulk of the raw, unskilled labor force for the pyramid.

It may be that the architecture which accommodated the bulk of the workforce, if it did not comprise mostly perishable shelters which would not leave very obvious traces in the archaeological record, would have resembled the structures found in the settlement SE of the Menkaure Pyramid (SALEH 1974), or at the Old Kingdom dam in the Wadi Gerawi (DREYER and JARITZ 1983, Abb. 2–6). In both cases, thick walls or embankments of stone rubble bonded with *tafla* describe large enclosures with open courts and smaller rooms built against the inside and outside of the large walls. It is likely that accommodations for workmen at Giza were built from stone rubble and marl clay, rather than alluvial mudbrick. The marl, as at the Amarna Village (KEMP 1984, 5), could have been quarried very nearby from the Maadi Formation deposits.

In Fig. 3C the storage galleries and redistribution enclosure in front of the village are inspired by the 'commodity delivery area' in front of the Amarna Village (Ibid., 6–7; HULIN 1984, 60–80). The animal pens to the rear of the village are similarly inspired (SHAW 1984, 40–59), though here they are attached to the back of the village, as at the Amarna site X1.

Though an eightfold increased Amarna workmen's village may look out of place in the topography south of the pyramids, some form of extensive accommodations for thousands of workers should lie in this area. Excavation could resolve whether more of the redeposited settlement debris, or standing architecture, exists under quantities of dumped construction debris on the N slope of the Maadi Formation and back on the sandy bowl. The bowl could have accommodated from 2,000 to 3,000 people. Perhaps more temporary housing was arranged on the rock surface of the unexploited parts of the Mokkatam Formation (C 1) just W of the main quarry. These might have been razed later for the layout of the Khafre and Menkaure Pyramids (KROMER 1978).

C 20. A larger settlement has been reconstructed S of the large southern boundary wall (B 15, B 19). The form of the settlement is, of course, entirely conjecture, though some of the larger houses are based on house models from the 6th to the 12th Dynasties (PETRIE 1907, 14–20; Pls. XIV–XXII). The housing units are designed to be much larger than those in the workmen's village, with more space between units.

The location of the settlement, and its extent, are based on mudbrick walls now showing after sand has been taken off part of the site, and on the trial trenches of HASSAN (1943, 42) which exposed mudbrick walls as far as 450 m S of the large wall, a distance marked by the southern limit of the village in Fig. 3 C. As reconstructed, the village is 300 m from N-S, about the width of the low desert here (Fig. 3 A). If this total area was settled it would support a population of 8,620 for 135,000 m² on the basis of BADAWY's (1968, 61) coefficient of population of 15.65 m² per person. This compares to the workmen's village at Illahun, which was 136,900 m² and, using BADAWY's calculation, could have had a population of 8,747 – although this does not allow for space between housing units. Solely in terms of area, the settlement in Fig. 3 C would have been one of the larger towns, as far as is known, from the Old Kingdom (see KEMP 1983, 102–103, Fig. 2.8).

In the reconstruction, the large wall (B 15) not only delimits the quay area of the harbour, but also acts as a kind of town wall (STADELMANN 1983, 11). The only access to the harbour and work area is through the central gate in the wall.

STADELMANN (1981 b, 67–9; 1983, 11) has argued that the accommodations for workmen did not develop into the settlement which serviced the cult of the pyramid, and that the true *Pyramidenstädte* developed around the Valley Temples. The topography at Giza indicates that the quay or harbour of the Khufu Valley Temple may have been separate from that which serviced the construction layout. One would expect that settlements grew up around both installations. If present-day contours are at all indicative of the floodplain 4,600 years ago, there is a high area around the proposed location of the Khufu Valley Temple, and another on the low desert to the south of the large wall (see A 17, A 19). If there were settlement agglomerations at these two locations, they may have been those referred to as the "*grgt* of the north of Khufu," and the "*ẖnjw* of the south of Khafre" (HELCK 1957, 92–3; STADELMANN 1981 b, 69, 71–2; 1983, 11). STADELMANN placed the latter settlement S of the Khafre Valley Temple. If the service harbour for construction deliveries was at the mouth of the southern wadi under Khufu, it may have been extended to the N for the Khafre valley complex. During the building of the Khafre complex, the wadi would have still served as a main access to the quarries, which were extended S of the Khafre Pyramid. Khafre must have quarried much stone to the E and N of his causeway as well (LEHNER 1984). Being located next to the construction harbour, which later also served as the Valley Temple quay for Khafre, the large settlement south of the boundary wall (B 15) may have become identified more with Khafre, as his '*ẖnjw* to the south,'

while a settlement specially founded next to the Khufu Valley Temple was called the '*grgt* to the north of Khufu' (C 30). While the accommodations for the broad masses of the workforce may not have developed into the pyramid city proper, more permanent and more spacious settlement of craftsmen and overseers may have formed a nucleus which could have been preserved for the service of the cult itself after the construction processes had shifted elsewhere.

At the same time, a large settlement here, close to the harbour and access canals, might have formed part of the referent for the term, *r'-š*. STADELMANN (1981 a) has argued that *š* here, as in *ḫntjw-š*, refers to the entire district of the royal funerary layout. More than just "L'embouchure de l'étang" (JACQUET-GORDON 1962, 231), "*r'-š* wäre dann das Gebiet, das sich am Übergang von Fruchtland und Wüste als 'Randstreifen', 'Eingang' oder 'Anfang' des *š*-Bezirks erstreckt und Bewohnern der Pyramidenstadt als Garten- und Ackerland dient. *R'-š* ist auch der Anfang des Kanals, der vom Taltempel aus zum Fruchtland führt, der Taltempel selbst liegt deshalb auch im *r'-š* . . ." (STADELMANN 1981 a, 163–64). As the *r'-š* was an area of deliveries, storage, and redistributions, I have added granaries, magazines, check-points, and docking areas for supplies and commodities separate from the quays designed to receive materials for the construction of the pyramid and valley temple.

It is tempting to see the entire area generally defined by the large southern boundary wall and the northern causeway foundation of Khufu as the referent for the *r'-š Ḫwfw* (GAUTHIER 1926, 127; JACQUET-GORDON 1962, 231; POSENER-KRIÉGER 1976, 302, 304, 618, 621–22). Could a settlement S of the wall have been specified "*ṯnjw* of the south of Khafre" while being, at the same time, part of a broader *r'-š* of Khufu?

C 21. "Acacia desert grass, scattered trees and shrubs, and savannah vegetation" may have existed on the low desert from Predynastic to early Old Kingdom times, or near the end of a subpluvial phase of c. 5,000 to 2,350 B.C. (BUTZER 1959, 74–5; 1976, 26–7). More research might determine whether such conditions, possibly a primary ecological niche for hunting, did obtain at this specific locality during the 4th Dynasty. The intention here is to represent graphically these conditions as part of the overall ecological context for the large pyramid projects.

C 22. Another principal ecological niche during the 4th Dynasty may have been "areally limited back-swamps (with) an association of papyrus, lotus, sedge, and reeds" (BUTZER 1959, 53–55). As the Nile valley is a convex floodplain, the back-water marshes and swamps would have been at the margins of the valley, "or in the cutoff, oxbow lakes of abandoned meanders" (BUTZER 1976, 17–18). Again, the intention here is merely to illustrate a basic ecological niche of this period, and whether the valley at the foot of the Giza Plateau would have exhibited these features during the 4th Dynasty has not been determined. BUTZER (1959, 47) noted that "the extent of perennial swamps and lakes in the valley was small, almost unimportant, even in early settlement times." At the same time he noted "the persistence of fishing parties, fowling excursions, and spear hunts in the back swamps of the Nile floodplain until the close of the New Kingdom . . ." (Ibid., 55).

C 23. In Fig. 3 C there is an attempt to illustrate the "subdivision of the floodplain into manageable, in part special purpose, units" (BUTZER 1976, 47). The basin lands (GARDINER 1948; BAER 1962, 40 n. 98; BUTZER 1976, 48) are surrounded by artificial dikes or levees, assumed here to be formed of soil from the dredging of the canals. The dimensions of the cultivated plots are, of course, arbitrary. The largest rectangular plot is a scale rendering of a "field of 10 rods (*ḫt*) by 2 rods" (1,000×200 cubits; 524×104.8 m) given in the Rhind Mathe-

matical Papyrus (PEET 1923, 49; GARDINER 1969, 266, 199). The small square plots in this enclosed area are each a *st3t* (one square *ḥt*) while the small rectangular plots are each two *st3t* (Ibid., 200). Here, as elsewhere in Fig. 3 C, palm trees are shown growing on, or at the edges, of levees and high areas. A greater abundance and variety of trees, in addition to bushes and brush, probably grew on the higher areas during the 4th Dynasty (BUTZER 1959, 54).

C 24. Land set aside for pasture. According to BUTZER (1976, 86), though "extensive pastoral use of the floodplain was declining" through the Old Kingdom, there were "equal proportions of pasture and crops by 2,000 B.C." BUTZER cites BAER's study of the Hekanakht letters (BAER 1963). Where they were not cultivated, the "seasonally inundated alluvial flats" would have contained "low shrub with a lush grass and shrub vegetation . . ." (BUTZER 1959, 55).

C 25. Conjectural reconstruction of a village concerned with pastoralism, placed at an actual topographic high (A 24) at the site of Nazlet el-Batran.

C 26. Conjectural village reconstructed on an actual topographic high (A 25) at the site of Nazlet el-Batran.

C 27. This topographic high (B 18) is interpreted as mounds resulting from the dredging of the harbour. This interpretation is inspired by the great mounds produced by the dredging of the Birket Habu at Malkata (KEMP and O'CONNOR 1974; see C 18).

C 28. The reconstruction of the canals in Fig. 3 C is not meant to portray true perennial canal irrigation, which, according to BUTZER (1976, 43–51), did not develop until the 19th Century A.D. in Egypt. BUTZER does state that "major transfers of limestone blocks *across* the floodplain from the quarries on the Eastern side of the valley can only have been reasonably achieved by a large, transverse canal" (see C 29 below).

The canal which curves across the lower right of Fig. 3 C is based on the Zerayet Zaghloul channel (Fig. 4; see A 26, B 17). The canals approaching from the E to the harbour at the mouth of the central wadi are based upon the *collecteur Nazlet el-Sissi* and the *collecteur Nazlet el-Batran* (Fig. 4). Today, the water widths of these channels are less than 10 m measuring off the 1 : 5,000 map. The canals have been reconstructed as having a water width of 30 m. This may be too wide. GOYON (1971 a, 14–15) calculates that small but sturdy barges shown on the walls of the Unas causeway transporting the granite columns for the pyramid temples had a length of 22 to 24 m and a width of 5.50 to 6.0 m. The Khufu funerary boat found at the southern side of the Khufu Pyramid has a maximum width of 5.66 m (ABUBAKR and MUSTAFA 1971, 2). A canal with a water surface 30 m wide would more than allow for two of these vessels to pass through any point at the same time. The Khufu boat has a draught of 1.48 m, and one would expect a canal approaching the necropolis to be deeper than this. BUTZER (1976, 45) pointed out that the general depth of the flood waters would have been about 1.5 m. A Middle Kingdom canal at the First Cataract was 150 cubits (78.75 m) long, 20 cubits (10.5 m) wide, and 15 cubits (7.87 m) deep (SCHENKEL 1980, 311). The Darius Canal in the Wadi Tumilat was 45 m wide and 5 m deep (BUTZER 1980, 312–13), while segments of another ancient waterway between el-Qantara and Pelusium had a water width of 70 m (SNEH, WEISSBROD, and PERATH 1975; BUTZER 1976, 46 n. 2; 1980, 312–13). The Suez canal of 1869 had a width of 60 m (at 10 m below water-level) and a water depth of 13 m (BALL 1939, 9). The width of the canal feeding into the extremely large Birket Habu harbour at Malkata is unknown, but it may have been 2.5 to 3 km in length (KEMP and O'CONNOR 1974, 109). Most irrigation canals of the last century in Upper Egypt ranged in bed width from 5 to 20 m. The Sohagiya Canal had a bed width of 70 m, and the Ibrahimiya Canal had a bed width of 60 m from its head to Deirut,

"though it is cleared on a width of 35 m only; below Deirut the width is 30 m, and about 20 m at Minya" (Willcocks 1889, 72–3, 81). The depth was 5 to 9 m during the flood and 2 to 3 m at other times.

Finally, it should be pointed out that the slope of the sides of the embankments down to the canals should be greater than indicated in Fig. 3 C (Kemp and O'Connor 1974, 123–24; cf. Barois 1904, 261–290).

C 29. A canal has been reconstructed running parallel to the E border of the Giza Plateau, and serving the southern settlement, construction harbour, and Khufu Valley Temple harbour. Goyon (1971 b, 148–53; 1977, 131–35) has pointed out the advantages of a canal connecting to the Bahr Youssef and running parallel to the Western Desert for servicing the pyramid complexes from Hawara to Abu Roash, to continue northwards as far as Lake Mariout. Though an artificial canal network of this route and magnitude was criticized by Butzer (1976, 46), some form of N-S communication near the Western Desert would not only facilitate the construction of the pyramid complexes, it would also provide a route for commerce between them (e.g. see Posener-Kriéger 1976, 621). Goyon's perspective drawings which reconstruct his "grand canal de Memphis" show the canal passing in close proximity to the harbour by the southern boundary wall and that of the Khufu Valley Temple, much as in Fig. 3 C (Goyon 1977, 26, Fig. 2, 139, Fig. 43). The problem is that the N-S canal in Fig. 3 C is plotted exactly on the route of the modern Mansoureyah Canal, which cuts through the village of Nazlet es-Samman about 580 m E of the Khafre Valley Temple and about 170 m E of the approximate location of the Khufu Valley Temple (Fig. 4; see B 7). The course of Goyon's "grand canal de Memphis" on the other hand, is identified with that of the old *collecteur Lebbeni* (called Bahr el-Lebbeni farther south at Mit-Rahinah) which follows the course of the newer and larger Mariouteyah Canal (Fig. 4). As it passes Giza, the Lebbeni Canal is 1.1 km E of the probable location of the Khufu Valley Temple at its nearest approach. A bit to the S, it passes nearly 2 km E of the Khafre Valley Temple, measured off the 1 : 5,000 map sheets. The closer Mansoureyah Canal seems to be fairly recent. At the time of writing this article, I have not ascertained its history (but see Pl. 1 where it exists, and Pl. 3, an older photograph, where it has yet to be made). At the far southern tip of Nazlet el-Batran the Mansoureyah Canal runs beside the Ganabeyet Zaghloul channel (Fig. 4). However, the latter does not continue on the course of the former, but swings to the NE to link up to the *collecteur Abu Mossallame* and the *collecteur Nazlet el-Batran,* the whole nearly encircling the mound of Nazlet el-Batran.

As for deliveries of stone for the pyramid casing from across the Nile Valley at Tourah and el-Massara, Goyon (1977, 132, Fig. 41) traces a N-S route along the Tamieh Canal parallel to the Nile, connecting to the Tarsa Canal which angles NW and then turns sharply to the W, running parallel to the modern Pyramids Road, in the direction of the Khufu Valley Temple. The 1 : 5,000 map sheets do show the Tarsa Canal running in the direction of the probable Khufu Valley Temple location. However, they show no traces of a channel immediately W of the juncture of the Tarsa Canal with the Mariouteyah and Lebbeni, 1.2 km E of the Khufu Valley Temple location (Fig. 4). However, 250 m farther N along the Lebbeni, the *collecteur Nazlet el-Sissi* cuts off from the Lebbeni for about 100 m W, at which point it makes a sharp turn to run about 1 km S. From here the *collecteur Nazlet el-Sissi* makes a rounded turn to the W to run 800 to 900 m to the more recent Mansoureyah Canal. At this point it enters the frame of Fig. 3 C where I have extended it farther W to feed into the large harbour at the mouth of the central wadi. It must be added that, according to the 1 : 5,0000 map, just where the *collecteur* Nazlet el-Sissi turns to the S 100 m from the Lebbeni, there is what appears to be

an old dry channel running approximately 400 m further W from the turn, roughly in the direction of the Khufu Valley Temple location.

Clearly, more ground survey and research of irrigation records are necessary to clarify the extent to which ancient canal courses can yet be traced by disused channels, the basin irrigation feeder canals of the last centuries, or other topographic features.

C 30. A hypothetical settlement, especially founded for servicing the Khufu Pyramid complex, has been reconstructed around the Khufu Valley Temple. This, like the reconstruction of the Valley Temple (C 14), telescopes a later stage in the development of the complex, since it is likely that the Valley Temple was the last major element to be constructed, as was the case at the Menkaure Pyramid complex (REISNER 1931). The form of the settlement is conjectural, though it was designed with the settlement of the Giza Khent-kawes complex in mind (HASSAN 1943, 35–50, Fig. 1). This reconstruction is also inspired by references to "the *grgt* of the north of Khufu" (see C 20). STADELMANN (1981 b, 71–2) sees this installation as "sise au nord-est de son temple de la vallée, légèrement en contrebas de la localité moderne de Nazlet es-Saman . . ."

C 31. A conjectural reconstruction of a royal residence has been included in Fig. 3 C mostly to represent graphically a longstanding notion that there may have been a royal residence in the proximity of the reigning king's pyramid construction project. The hypothesis has been argued recently by STADELMANN (1981 b, 76–7) who suggests that the construction of the large pyramids, involving the forces of the entire country, would require the close supervision of the king and the entire court. He responds to the objection that a royal residence would never have been laid out next to the din of a construction site by saying that the principal mass of material was brought to the site from the W. This may have been the case at other pyramid sites, but it has been shown how this was not the case at Giza (C 15). The delivery of the principal mass of the Khufu Pyramid was from the south. In this reconstruction, the royal residence is around the corner of the eastern escarpment from the quarry, and separated from the main access to the worksite by a large harbour. GOYON (1969, 66; 1977, 139, Fig. 43) has also hypothecized a royal residence at this approximate location, though it must be admitted that this is conjecture based upon proximity to the Valley Temple.

The royal residence in Fig. 3 C is surrounded by a palace facade enclosure wall with recessed panelling (BADAWY 1948, 67–73; 1954, 51–3). Large estates with groves of trees, lakes or pools, and vineyards are attested for the Old Kingdom from the 4th Dynasty biographical inscriptions of *Mṯn* (PORTER, MOSS, and MALEK 1978, 493–4; SETHE 1932–3, I, 1–7; GOEDICKE 1966, 64–5; BADAWY 1954, 51), and Harkhuf of the 6th Dynasty (SETHE 1932–3, I, 120–7; BADAWY 1954, 51). The royal residence enclosure in Fig. 3 C is designed as 270 × 150 m (40,500 m²). The palace newly laid out for Isesi was said to be 220 cubits (115.28 m) long and 120 cubits (62.88 m) wide, making 7,248.80 m² (SETHE 1932–3, I, 62–3).

In arguing that a royal residence was in proximity to the pyramid settlement, STADELMANN (1981 b, 77) suggested that it played an administrative role through the three generations of building at Giza:

> Très probablement à Giza la Résidence et le palais de Chéops ainsi que le centre administratif ont servi également à Chéphren et à Mykérinus, même s'il existait à côté, comme nous l'avons vu, une ville de pyramide de Chéphren et une de Mykérinus. La proximité de la Résidence à la ville de pyramide expliquerait peut-être pourquoi c'est seulement à Giza, pendant la IVe dynastie, que les villes de pyramides s'appellent *grgt* et *ḫnjw* et sont gérées par un administrateur *ʿḏ-mr*: les premières villes de pyramide n'étaient pas des villes proprement dites, mais faisaient partie du *š* du roi: elles dépendaient alors directement de l'administration du Palais et ne sont devenues villes qu'à l'époque où la Résidence fut transférée à Abousir.

The *š* of the king, of which the attested settlements formed a part, is the total district of the king's pyramid and temple complex and all its dependencies in the nearby valley (STADELMANN 1981 a). One of the major features of the district was a harbour, around which the settlements were naturally clustered. In the case of the Khufu complex, there was a service harbour for delivery to the construction site, and another for the Valley Temple (the former was probably used for both functions by Khafre). The harbour basin could, in itself, be termed *š* (ERMAN and GRAPOW 1930, 397–8; FAULKNER 1962, 280; GARDINER 1969, 593; KEMP and O'CONNOR 1974, 105; but see STADELMANN 1981 a, 157–8). In either sense of the term *š*, those naturally settled around the harbour are literally the *ḫntjw-š*. While formal titles incorporating *ḫntj-š* appear only at the end of the 5th Dynasty (BAER 1960, 272–3, 297), the institution must begin with the organization and layout pattern of the workforce in the 4th Dynasty pyramid complexes (POSENER-KRIÉGER 1976, 580).

C 32. This reconstruction of storage magazines is based, to scale, on the magazines (otherwise called 'workmen's barracks') W of the Khafre Pyramid (HÖLSCHER 1912, 70; PETRIE 1883, 34; MARAGIOGLIO and RINALDI 1966, 142). The dimensions of this enclosure, obtained by measuring off the 1 : 5,000 map, are about 440×86 m. The interpretation of this installation as magazines (cf. BADAWY 1948, 125–32) raises the question of why, in the Khafre layout, they are out to the W of the pyramid. The galleries are reconstructed here, near the royal residence, simply to illustrate that pyramid building implies extensive facilities to collect, store, and redistribute materials, tools, and commodities (BUTZER 1976, 88), and the fact that much of this kind of redistribution concerned magazines and stores connected with the palace (POSENER-KRIÉGER 1976, 619–24). If the galleries W of the Khafre Pyramid were for commodities, the location may have been favored because it was far from the growing workers' installations of the *r'-š*, affording greater supervision and control. If they are contemporary with the building of the Khafre Pyramid, this must be figured into the arrangement of the supply and construction ramps for this project. PETRIE found fragments of alabaster and diorite statues, along with Old Kingdom pottery, amongst these ruins. Perhaps the galleries were used for royal cult objects (MARAGIOGLIO and RINALDI 1966, 132), along with provisions for the permanent settlement, after the major construction activities had moved on to Abusir. In Fig. 3 C the galleries of the northern part of the enclosure are shown roofed. The open E half of the long enclosure may have been for more temporary storage, or for sorting and accounting as items were moved in and out of the galleries, analogous to the commodity delivery areas at the Amarna workmen's village (KEMP 1984, 6–8; HULIN 1984, 60–80).

C 33. In the hypothetical reconstruction of the royal enclosure and storage galleries, an area like this might have been set aside for industry, e.g. tool manufacture, woodworking, pottery making. Woodworking would have been necessary for making sledges, rockers (CLARKE and ENGELBACH 1930, 94–5, 102–103), track beams, and, possibly, transport barges. The reservation of space here in the reconstruction for this kind of industry is inspired by Papyrus Reisner II, in which the dockyard workshop (*wḫrt*) was a dependency of the palace (SIMPSON 1965, 17). While the palace and magazine galleries are built on a raised terrace, this open area is protected from the inundation by dikes.

C 34. Third Dynasty mudbrick mastaba tomb (see A 12).

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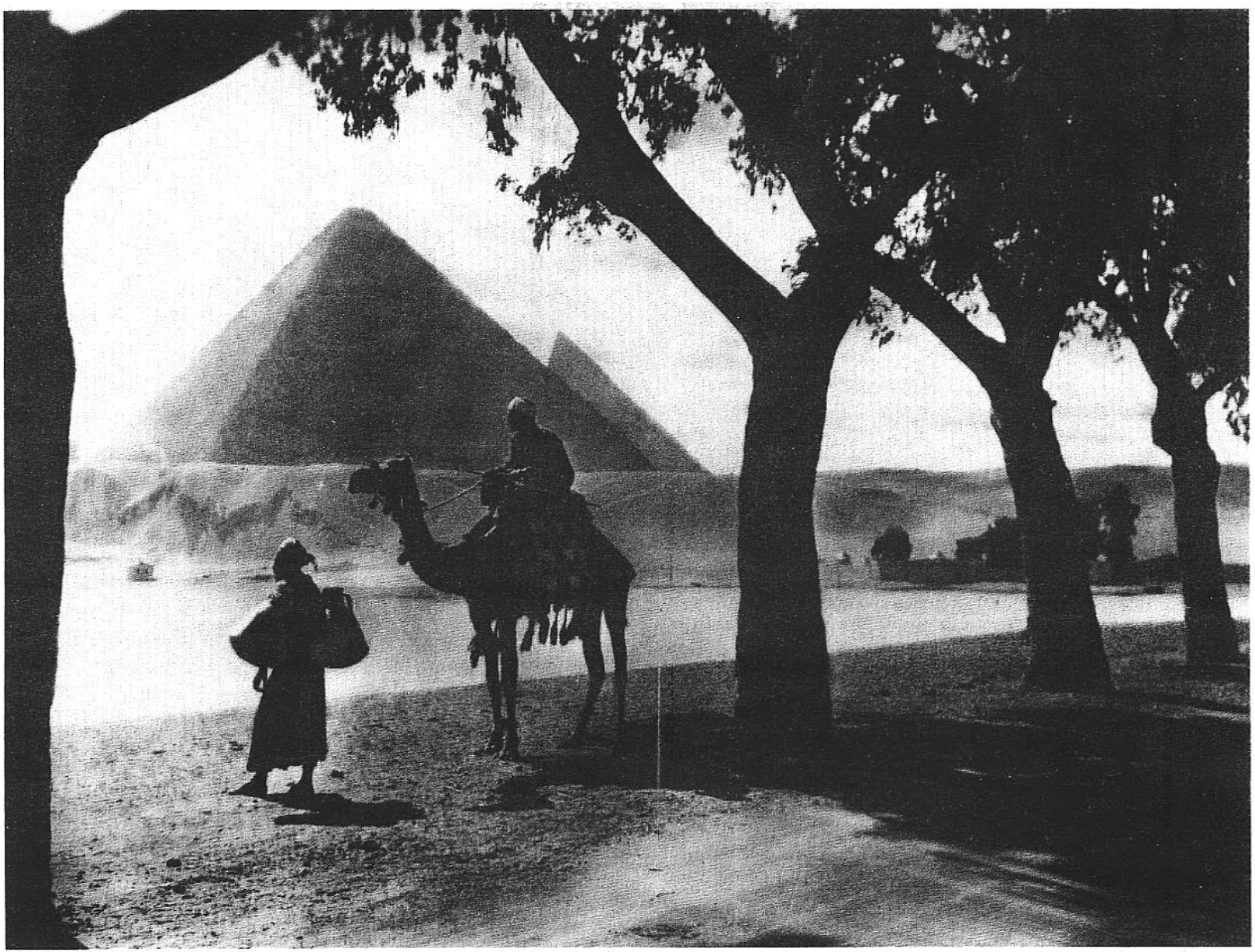
The Giza Pyramids site and the valley floor to the E at the time of the Nile flood in the mid 1930's. The Mansoureyah Canal (C29) is that closest to the edge of the plateau. The highland at the bottom of the photograph (A25) is surrounded by water (A26). The patches of highland to the W are indicated by A24 and B18.



Basin land (A 20) near the N escarpment of the Giza Plateau flooded during the annual Nile inundation, seen from the route of the contemporary "Pyramids Road."
(Lehnert and Landrock photograph.)

Early (pre-1900?) photograph of the valley floor after the Nile inundation, seen from the top of the Khufu pyramid. Water remains in pools and gathering streams which indicate low areas. The semicircular channel (A 26, B 17) defines high land (A 25) which now hosts part of the village, Nazlet el-Batran. The Lebbeni channel is seen faintly at the top of the photograph.