INTRODUCTION

This volume describes the results of excavation in the upper part of the Olduvai sequence, in Beds III, IV and the Masek Beds, carried out from the end of 1968 until 1971 (see Pl. 1). The delay in publication has been due to a number of factors. Chief among these were the Laetoli field seasons which took place from 1975 until 1981 and the delay in receiving chapters from other contributors. Analysis of the cultural material and identification of the fauna as well as the preparation of figures had been virtually completed by 1973 but it was clearly inadvisable to publish the volume without including these contributions.

During the excavations sites were selected for exploration as far as possible in successive stratigraphic levels following the method used for Beds I and II, published in Volume 3 of the Olduvai series (Leakey 1971). A total of twelve different sites was excavated comprising twenty-two archaeological occurrences. Twenty were within the Olduvai stratigraphic sequence, ranging from JK in Bed III to FLK in the Masek Beds. Two additional sites, that yielded the most elegant and highly finished of the bifacial tools, were in disturbed contexts and could not be fitted into the sequence although it is evident that they postdated the Masek Beds and perhaps included material derived from the Lower Ndutu Beds. Figs. Int.1 and Int.2 show the locations of sites excavated and provide a diagrammatic summary of the overall sequence of the upper beds at Olduvai. The twenty occurrences are as follows:

Post Masek Beds	TK Fish Gully
	HK
Masek Beds	FLK
Upper Bed IV	HEB West Level 1
	PDK Trenches I–III
	WK East C
	WK East A
	WK Upper Channel
Lower Bed IV	WK Intermediate Channel
	HEB West Level 2b
	HEB West Level 2a
	HEB
	HEB Level 3
	HEB Level 4
	HEB East
Base of Bed IV	WK Lower Channel
	PDK Trench IV
	WK Hippo Cliff
Bed III	JK clay above siltstone
	JK pink siltstone
	JK ferruginous sand
	JK grey sand

Preliminary results of the excavations in the upper part of the Olduvai sequence have been given in various papers at symposia and conferences (Leakey 1975a, 1978). These results were based on samples only and are superseded by the data published in the present volume in which the entire collections have been reviewed.

In describing the excavations the earliest site of JK in Bed III is discussed first and the remainder in ascending order. When a locality had more than one level or site the description is given when it is first mentioned in the text or preceding the most important archaeological occurrence. This follows the same system used for describing Beds I and II and permits the introduction of new elements in the stone industries to be assessed in their correct sequence. The bifacial tools from those sites in which there is an adequate sample are described and analysed in chapters 8 and 9 by Dr D. A. Roe and Dr Paul Callow, with the exception of the JK bifaces from Bed III since these are clearly a mixed assemblage with many derived specimens. For completeness Drs Roe and Callow have also included bifaces from Bed II and those from the two most recent sites, HK and TK Fish Gully. In my descriptions only the

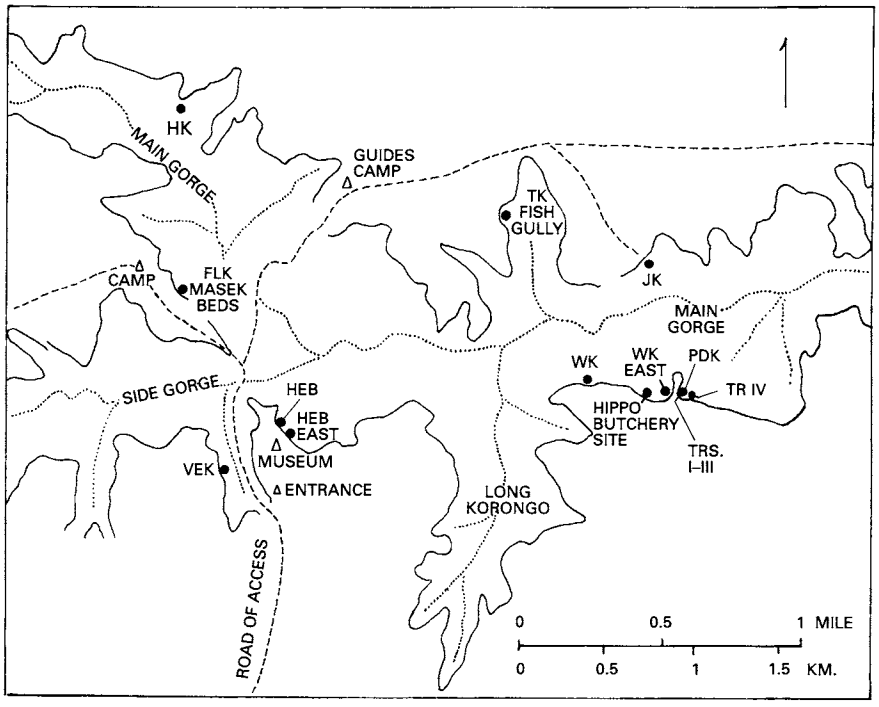

Fig. Int.1 Sketch map showing the sites excavated in Beds III, IV and the Masek Beds

numbers of bifaces in relation to the industries as a whole are noted, except in those cases where they were not described by Drs Roe and Callow.

For convenience Bed IV has been divided into three parts, the base, at the contact with Bed III, and Upper and Lower units demarcated by siltstones which occur in certain areas. Two marker tuffs, IVa and IVb, are recognised but are of little practical use for stratigraphic correlation of different sites owing to their localised distribution and absence in certain key areas. However, the combined evidence of the siltstones, marker tuffs and Dr Hay's geologic and mineralogic study has enabled the relationships of the more important sites to be established satisfactorily.

Dating of Beds III, IV and the Masek Beds is based on palaeomagnetic readings and rates of sedimentation. None of the three beds has yielded uncontaminated tuffs suitable for K-Ar dating. It is estimated that Bed III probably spans the period between 1.15 to 0.8 m.y., Bed IV from 0.8 to 0.6 m.y. and the Masek Beds from 0.6 to 0.4 m.y.

When excavation in the higher levels of the Olduvai sequence was begun in 1978 it was believed that only the Acheulean industrial complex would be found in Bed IV although the possibility that the Developed Oldowan technology of biface manufacture persisted into Bed III had been suggested by unpublished material recovered from site JK by Dr M. R. Kleindienst. In fact the first site with bifacial tools to be excavated in Bed IV (HEB East) was described as Acheulean but detailed analysis has since shown that it should more correctly be assigned to the Developed Oldowan (chapters 8–10). Sites later excavated on the south side of the Gorge in the WK area have proved of importance in demonstrating the contemporaneity of the Acheulean and Developed Oldowan technologies.

Dissimilarities noted between the bifacial tools from Acheulean sites not separated by any appreciable time interval were puzzling at first and considered possibly to be due to individual styles of biface manufacture or traditionally preferred methods (Leakey 1971). Experimental biface manufacture by Mr P. R. Jones (described in chapter 10) using the same rocks has shown that the different techniques were more likely

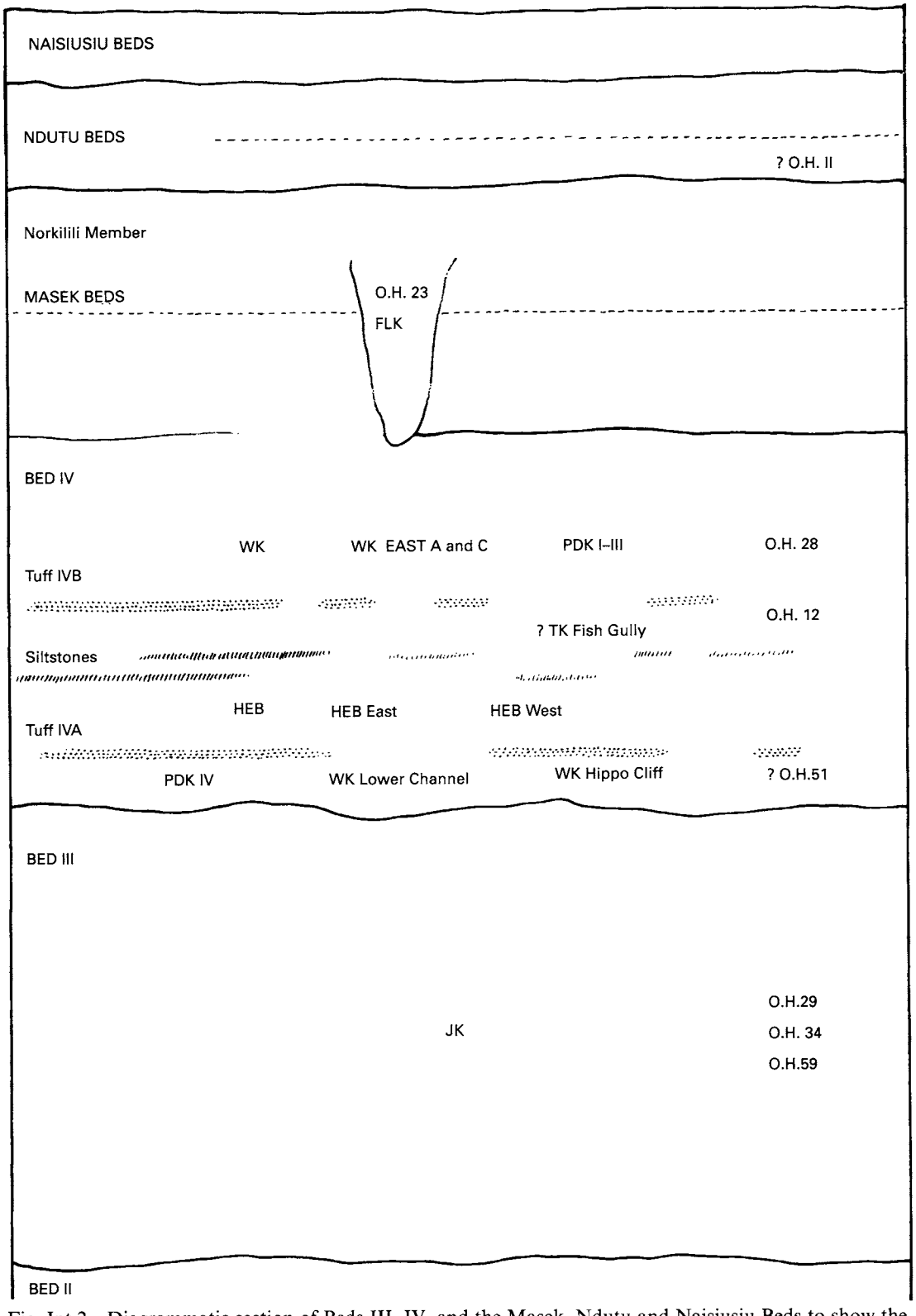

Fig. Int.2 Diagrammatic section of Beds III, IV, and the Masek, Ndutu and Naisiusiu Beds to show the stratigraphic positions of the excavated sites and hominid remains

practised in order to obtain the optimum results from rocks with different flaking properties (Jones 1979). If flaking techniques were specially adapted to particular rocks, it is not surprising that the bifacial tools from sites separated by a substantial time interval should sometimes closely resemble each other, such as those from EF-HR in Middle Bed II and WK in Upper Bed IV. In the descriptions of artefacts given in this volume an attempt has been made to identify the raw material of each specimen. This has been on a visual basis only and some erroneous identifications may have been made, especially when the rocks are heavily weathered.

In Bed III the only site excavated was JK, also partially excavated by M. Kleindienst in 1962. It consists of a relatively deep channel within the main Bed III drainageway (see chapter 2). Artefacts and faunal remains were abundant only in the lower part of the channel, where they were widely dispersed vertically and horizontally. The variable physical condition of the specimens indicates that they are probably not a homogeneous assemblage. A siltstone in the upper part of the channel, above the principal artefact-bearing levels, contained a complex of pits and furrows that have been the subject of speculation and discussion since their discovery in 1971. Even now their interpretation must be regarded with some reserve but the discovery of analogous pits and runnels within a small crater in northern Kenya, used today for salt extraction, suggests that the JK pits may have served a similar purpose (see chapter 2).

The three sites at the base of Bed IV, just above the III–IV interface – WK Lower Channel, WK Hippo Cliff and PDK IV – have yielded only very scanty material. The artefacts from both the WK sites are in conglomerates but those at PDK IV appear to be in undisturbed context. Sites HEB and HEB West in Lower Bed IV yielded a series of Acheulean industries in which the bifacial tools differed markedly in technology and were made from a variety of raw materials, while as noted above the industry from HEB East, also in Lower Bed IV, appears to be of Developed Oldowan facies. The series of artefacts obtained from the Intermediate Channel at WK, within the same stratigraphic unit, is too limited to be of value. Excavations in Upper Bed IV were carried out mainly in the WK and WK East area where both Acheulean and Developed Oldowan sites occur within one or more former river channels which have cut into Tuff IVB. The upper or main channel at WK yielded an abundant Acheulean industry associated with postcranial remains of *Homo erectus*. The WK East sites and PDK I–III that lie less than 1 km east of WK have yielded a Developed Oldowan industry in which the technique of making bifaces on large flakes, so characteristic of the Acheulean from the WK upper channel, is totally lacking.

The prevalence of pitted anvils and hammerstones in all sites of Upper Bed IV indicates the widespread use of the bipolar technique. It has resulted in large quantities of shattered quartzite debris as distinct from the whole or broken flakes found at sites where lava was the principal raw material. Only one site is known in the Masek Beds. It is situated at FLK and has yielded an Acheulean industry with large, elaborately trimmed handaxes. Site HK which was partially excavated during the 1931–2 expedition to Olduvai (Leakey 1951) yielded many finely retouched quartzite handaxes and cleavers. Test trenches dug in 1969 revealed that the artefacts were in a disturbed deposit postdating the Masek and the Lower Ndutu Beds although the artefacts may perhaps have been derived from the latter. Dr Roe has analysed material from the 1931–2 expedition as well as that recovered in 1969 but in the description of the industry as a whole only the more recent collection has been reviewed. Similar disturbed conditions prevailed at one level in TK Fish Gully excavated in 1962 by the late Dr J. Waechter, where elaborately retouched bifaces also occurred in a relatively recent deposit. These tools have been analysed by Dr Roe and, although there is no question that most were contained in a recent hill wash, it is possible that some specimens from other excavated levels may also be included in the series since the field notes are now lost. In view of the possibility that this may be a mixed assemblage a description has not been included.

With the exception of PDK IV the sites excavated in Beds III, IV and the Masek Beds were in river or stream channels where the artefacts and faunal remains had probably been transported and displaced by water action. Sites with virtually undisturbed remains, such as were uncovered in Bed I, were not found in these beds with the possible exception of PDK IV. In this volume plans are published only of sites where a relatively large area was exposed or where a reasonably complete section across a channel was preserved, for example WK Upper Channel and WK East, Area A.

Definition of terms

The terminology for the artefacts defined in Volume 3 of the Olduvai series is retained in the present volume with some additions and modifications. For example, the subdivision between polyhedrons and spheroids/subspheroids is less distinct in the Beds III–IV industries than in those from Beds I and II. Polyhedrons are also much less common and there are relatively few that can confidently be separated from the more angular of the subspheroids. The question of revising these tool categories to approximate more closely to the Beds III–IV material was considered but it was deemed preferable to retain the same terms as for Beds I and II in order to facilitate comparison between the industries. The grouping of the artefacts into tools, utilised material and debitage is retained and both tools and utilised material have again been subdivided into heavy and light-duty categories. The term manuport applied to the unmodified cobbles found on the Oldowan lake margin sites has been omitted, since it was not applicable to cobbles in the stream and river channels of Beds III and IV, where it was impossible to determine whether such cobbles had been introduced by man or were a natural element of the conglomerates. Terms for artefacts connected with the bipolar technique of flaking, that is the pitted anvils/hammerstones and punches, are defined for the first time in this volume since none was noted in Beds I and II with the exception of two anvils. Other tool types remain virtually the same, although there is a reduction in both the numbers and varieties of choppers, only side and end choppers occurring in Beds III–IV.

Tools

1. *Awls* These tools are characterised by short, rather thick, pointed projections, generally at the distal ends of flakes, but sometimes on a lateral edge. In the majority the points are formed by a trimmed notch, on either one or both sides, but occasionally by straight convergent trimmed edges. The points are often blunted by use and have sometimes been snapped off at the base.

2. *Bifaces* Handaxes and cleavers are dealt with comprehensively by Drs Roe and Callow in chapters 8 and 9. Readers are referred to these sections of the book.

3. *Burins* Although rare, burins occur at a proportion of the sites. Angle burins are the usual form and are made on transverse broken edges or on trimmed edges, which are usually slightly concave and flaked from the primary surface. Some specimens are double-ended and there are a few with a working edge on either side.

4. *Choppers* These are usually made on cobbles with rounded cortex surfaces forming the butt ends. When they are made from blocks of quartzite the butts are often formed by a flat vertical surface, trimmed and blunted along the upper and lower edges. In the majority the trimming is bifacial, with multidirectional flaking of the working edges. These are essentially jagged and lack secondary trimming, although utilisation has often resulted in the edges having been chipped and blunted.

Side The maximum dimension is transverse, exceeding the length from the working edge to the butt; they are often made on oblong cobbles with the working edge along one lateral edge. Bifacial

examples with alternative flaking predominate but there are also a few unifacial specimens and some in which there is multiple flaking on one face of the working edge and a single scar on the obverse.

End The maximum length is from the working edge to the butt; they are usually made on oblong cobbles with the working edge at one extremity.

5. *Discoids* These are often irregular, but a bifacially flaked working edge is present on the whole or the greater part of the circumference. Specimens made from cobbles are usually plano-convex in cross section with an area of cortical surface retained in the central part of the convex face.

6. *Laterally trimmed flakes* The flakes are generally elongate and end-struck with one or both lateral edges trimmed for the whole or part of their lengths. The retouch is usually somewhat uneven and the flakes are not symmetrical.

7. *Outils écaillés* Both single and double-ended specimens occur. They exhibit the scaled utilisation characteristic of these tools. The edges are blunted and one face is usually slightly concave, whilst the opposite is straight or slightly convex.

8. *Picks* These are massive tools with thick, heavy butts tapering rapidly to relatively narrow, sharply pointed tips.

9. *Polyhedrons* Angular tools with three or more working edges, usually intersecting. The edges project considerably when fresh but when extensively used sometimes become so reduced that the tools resemble subspheroids.

10. *Punches* These are small and rod-shaped, never more than a few centimetres long, invariably of quartzite and battered at both ends. They may be either tools or the final stages of bipolar cores before being discarded. In view of their conformity in size and shape they are classed here as tools, perhaps used for punching through tough hides.

11. *Scrapers* Most of the light-duty scrapers are made from flakes and other small fragments of quartz and quartzite. Many of the heavy-duty scrapers are impossible to assign to any particular type and consist merely of amorphous pieces of lava or quartzite with at least one flat surface from which steep trimming has been carried out along one edge. The light-duty group may be subdivided into the following categories but it is doubtful whether the various forms are of any great significance and it might be more realistic to lump together end, side and discoidal, retaining nosed and hollow scrapers as separate groups.

End. These are almost exclusively within the light-duty group. They are made on flakes or oblong fragments with a working edge at one extremity. The edges are generally curved, but are sometimes nearly straight and often exhibit small projections at the intersection of the trimming scars, or else a slight spur at one side.

Side. This is one of the most common forms of scrapers in both the heavy and light-duty groups. The working edges vary considerably with either shallow or steep trimming. They are usually curved but some are nearly straight and there is sometimes a slight medial projection, as in nosed scrapers.

Discoidal. These occur in both the heavy and light-duty groups. The general form is discoidal although the tools are seldom entirely symmetrical and they are usually trimmed on only part of the circumference.

Nosed. These are mainly confined to light-duty scrapers. There is a medial projection on the working edge, either bluntly pointed, rounded or occasionally spatulate, flanked on either side by a trimmed notch or, more rarely, by straight, convergent trimmed edges.

Hollow. Specimens in which the notch is unquestionably prepared are relatively scarce in both the heavy and light-duty groups, although light-duty flakes and other fragments with notches apparently caused by utilisation are common. In the few specimens which have been deliberately shaped the notches tend to be wide and shallow rather than deeply indented. They are variable in size.

12. *Spheroids/subspheroids* These include some stone balls, smoothly rounded over the whole exterior, but faceted specimens in which the projecting ridges remain or have been only partly removed are more numerous. Subspheroids are similar to the spheroids but less symmetrical and more angular. They grade into worn polyhedrons and it is often difficult to distinguish the two categories.

Utilised material

1. *Pitted anvils/hammerstones* These occur at both Acheulean and Developed Oldowan sites and are clearly an essential element of the bipolar flaking technique. They range in size from small boulders to fist-sized cobbles bearing pecked depressions which are either oblong or circular, occurring singly or in pairs and sometimes with as many as eight on the same stone. The diameters are variable but the majority are between 1 and 1.5 cm in diameter and a few millimetres deep. Pits usually occur on water-worn cobbles but are also present on some heavy-duty tools and quartzite blocks. It is assumed that the boulders with pits served as anvils resting on the ground and that the fist-sized cobbles were held in the hand and used as hammerstones.

2. *Anvils* These consist of cuboid blocks or broken cobblestones with edges of approximately 90° on which there is battered utilisation, usually including plunging scars. Rarely found in Beds III and IV but common in Beds I and II.

3. *Hammerstones* The hammerstones consist of water-worn cobblestones (generally lava) with bruising and slight shattering at the extremities or on other projecting parts. Common in Beds I and II, they are relatively scarce in Beds III and IV and at FLK Masek.

4. *Cobbles and blocks* These are water-worn cobbles, weathered nodules and angular fragments that have some evidence of utilisation, either chipping and blunting of the edges or smashing and battering, but no evidence of artificial shaping.

5. *Light-duty flakes and other fragments* Flakes and other small fragments with chipping and blunting on the edges are quite abundant. They fall into three groups; with straight edges, with concave or notched edges and with convex edges. At a few sites there are some in which the utilisation tends to be scaled, recalling *outils écaillés*.

Debitage

The term debitage has been employed in preference to 'waste' for the unmodified flakes and other fragments, since there are indications at certain sites that some, at least, are not merely discarded by-products of tool manufacture but were made expressly, presumably to serve as sharp cutting tools.

1. *Flakes* The flakes are almost exclusively irregular. They may be subdivided into three groups, as follows: (a) divergent, splayed outwards from the striking platform (the most common type); (b) convergent with the maximum width at the striking platform; (c) approximately parallel-sided (rare). Broken flakes are far more numerous than whole flakes.

2. *Core fragments* Angular quartzite fragments are the most abundant debitage at sites where the bipolar technique was practised.

3. *Cores* There are few clearly recognisable cores with well-defined striking platforms from which flakes have been detached. These are mostly from Acheulean sites but are rare owing to the fact that the bifacial tools appear to have been blocked out at the quarry sites. In bipolar flaking many of the jettisoned blocks are cores by definition but it has been impossible to distinguish the parent blocks from other cuboid fragments and the majority of all angular waste has been placed in the heterogeneous category of core fragments.

1

GEOLOGY AND DATING OF BEDS III, IV AND THE MASEK BEDS

R. L. HAY

The geology of Beds III, IV and the Masek Beds (see Fig. 1.1) has been described in detail by Dr R. L. Hay in his volume on the geology of the gorge (Hay 1976). For convenience, an abbreviated version of his text is printed here by courtesy of the University of California Press.

Beds III and IV

Stratigraphy and distribution

Beds III and IV are distinguishable stratigraphic units only in the eastern parts of the Main and Side Gorges. Here they are the same units described by Reck (1951). The cliffs at JK can serve as a type section for both Beds III and IV. The contact between Bed II and Bed III is in most places disconformable and easy to locate. Beds II and III can, however, be very difficult to separate to the east, where both are chiefly reddish-brown in colour. Beds III and IV are generally easy to distinguish as far west as FLK and JK where Bed III interfingers over a broad zone with sediments similar to those of Bed IV. The interfingering was first demonstrated at JK through a series of excavations (Kleindienst 1964). Farther west, where Bed III is lithologically indistinguishable from Bed IV, the two units are combined into Beds III–IV undivided.

Bed III. Bed III is dominantly a reddish-brown deposit, chiefly of volcanic detritus which is about 85 per cent claystone, and most of the remainder is sandstone and conglomerate. Its thickness ranges from 4.5 to 11 m and varies systematically where deposited on different fault blocks, pointing to contemporaneous fault movements. Within the same fault blocks, it is thicker on the south side of the Main Gorge than it is on the north. Four different tuffs were found at more than one locality in the eastern part of the Main Gorge. They are numbered from 1, the oldest, up to 4, the youngest. Only the lowermost has aided appreciably in correlating, and the rest have thus far been recognised in only a few places.

Bed IV. Bed IV is chiefly claystone (68 per cent), most of which is soft-weathering and grey to brown. The remainder comprises sandstone (19 per cent), siltstone (7 per cent), conglomerate (4 per cent) and tuff (2 per cent). The contact with Bed III is generally an erosional surface, and the basal bed of Bed IV is in most places a sandstone or conglomerate. The contact of Bed IV with the Masek Beds is sharp, and in a few places the Masek Beds fill channels eroded into Bed IV or through Bed IV into Bed III. Bed IV generally ranges from 2.4 to 7.3 m in thickness in the Main Gorge, and it is as much as 10 m thick in the Side Gorge. The variation in thickness is a result of fault movements during the deposition of Bed IV as well as post-depositional erosion.

Within Bed IV are two marker tuffs, termed Tuffs IVA and IVB. Tuff IVA is the lower of the two and is present at widely separated localities in the Main and Side Gorges. Tuff IVB is found only in the vicinity of WK and JK.

Tuff IVA is a fine-grained vitric trachyte tuff 15 to 30 cm thick. It is typically laminated and yellowish-grey, but is massive and reddish-brown at one locality, TK. The principal primary minerals are biotite and feldspar, and analcime is the

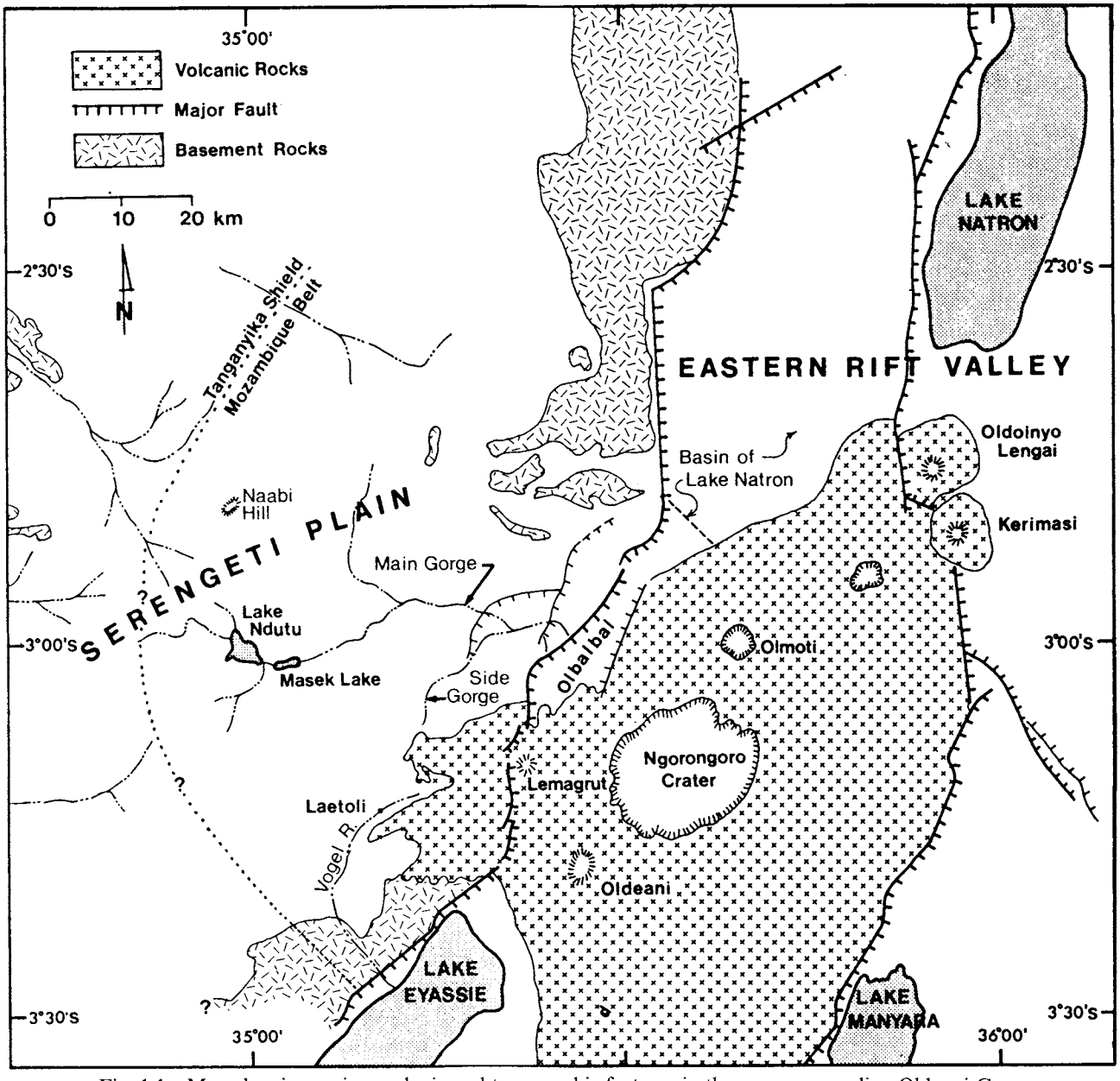

Fig. 1.1 Map showing major geologic and topographic features in the area surrounding Olduvai Gorge (By courtesy of R. L. Hay and the University of California Press)

alteration product of the glass. The tuff lies in the lower part of Bed IV at two localities, whereas it is in the middle of Bed IV at FLK and GTC. This difference suggests that Bed IV accumulated more rapidly below the tuff towards the east than it did towards the west.

Tuff IVB is a fine to medium-grained crystal-lithic tuff of probably trachyandesite composition which is 15 cm to 2 m thick. It is hard and reddish-brown, and where thickest it is laminated or thin-bedded and contains thin layers of claystone. Its crystals are chiefly angular fragments of plagioclase and augite originating in the explosive fragmentation of crystalline lava. The tuff contains a high proportion of zeolites (analcime and chabazite), which may be reaction products of

fine-grained vitric ash whose texture has been lost in the alteration process.

Siltstone and silty sandstone are widespread in the Main Gorge and have proved useful in correlating the various sites and exposures. Most of these silt-rich deposits lie in the lower half of Bed IV, and a thick bed underlies Tuff IVB at both JK and WK and very likely extends eastwards at the same level. A thin siltstone locally overlies Tuff IVB at JK.

Beds III–IV (*undivided*). Beds III and IV are combined in a single unit not only to the west of FLK and JK, but to the south, near Kelogi, and to the north along the east–west extension of the Fifth Fault. Beds III–IV undivided range in thickness from about 4 to 29 m, with the thickest sections in the graben between the FLK fault and the Fifth Fault. The variation in thickness is controlled largely by structural position, but it is also determined to some extent by the depth of erosion into Bed II, and the depth to which Beds III–IV undivided have been eroded beneath the Masek Beds.

Age of Beds III and IV

Magnetic stratigraphy is presently the only geophysical method to provide information about the age of Beds III and IV. Polarity studies were first undertaken by A. Brock, who made laboratory measurements on eight samples from Bed III, eight from Bed IV, and four from Beds III–IV (undivided). Drs F. H. Brown and M. D. Leakey were largely responsible for the field sampling. Most of the samples are of hard, reddish-brown zeolitic claystone, and the remainder are of limestone. Three of the eight Bed III samples have reversed polarity, four are normal, and one is magnetically unstable. The reversely polarised samples were collected both high and low in Bed III, demonstrating that Bed III was deposited during the Matuyama epoch, more than 700,000 years ago. The reversely polarised rocks probably acquired their polarity penecontemporaneous with deposition, as they did their reddish-brown colour. The normal polarity of the other samples is probably a result of the continued growth of haematite crystals in a later period of normal polarity. Four of the Bed IV samples have normal polarity, and the other four were magnetically unstable or of low magnetic intensity. These preliminary results led to the tentative conclusion that Beds III–IV contact coincided approximately with the Matuyama-Brunhes boundary at 700,000 years before the present (Brock, Hay and Brown 1972).

Dr A. Cox in 1972 initiated a more detailed sampling programme in Bed IV and the upper part of Bed III with the aim of locating the Brunhes-Matuyama boundary more precisely. The most significant result is the discovery of reversed polarity in three samples from the siltstone beneath Tuff IVB at the hominid excavation of WK. Tuff and calcrete samples from various levels in the Masek Beds, measured by both Brock and Cox, have normal polarity, and presumably they were deposited during the Brunhes normal epoch. Thus, the Brunhes-Matuyama boundary probably lies within Bed IV, and no lower than Tuff IVB.

The contact between Beds II and III is estimated as about 1.15 m.y.a. on the basis of stratal thicknesses in the gorge and dated fault movements to the east. If Tuff IVB is taken as 0.7 m.y. old, then relative stratal thicknesses in Beds III and IV can be used to obtain an age of about 0.8 m.y.a. for the top of Bed III. The top of Bed IV is about 0.6 m.y. old if one assumes that Bed IV sediments above Tuff IVB accumulated at the same rate as the underlying Bed IV sediments. If the Brunhes-Matuyama boundary lies above Tuff IVB, then the age limits of Bed IV should be slightly older than 0.6 to 0.8 m.y.a.

Environmental synthesis and geologic history

A widespread episode of faulting affected the Olduvai basin about 1.15 m.y.a., causing erosion of Bed II and drastically changing the palaeogeography. Renewed faulting about 0.8 m.y.a. shifted the drainage axis of the basin southwards