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KANDA FAULT: A MAJOR SEISMOGENIC ELEMENT WEST OF THE RUKWA RIFT (TANZANIA, EAST AFRICA)

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Abstract—The NW–SE trending Rukwa Rift, part of the East African Rift System, links the approximately N–S oriented Tanganyika and Nyassa (Malawi) depressions. The rift has a complex half-graben structure, generally interpreted as the result of normal and strike–slip faulting. Morphological and structural data (e.g. fault scarps, faceted spurs, tilting of Quaternary continental deposits, volcanism, seismicity) indicate Late Quaternary activity within the rift. In 1910 an earthquake of M=7.4 (historically the largest felt in Africa) struck the Rukwa region. The epicentre was located near the Kanda fault, which affects the Ufipa plateau, separating the Rukwa depression from the south-Tanganyika basin. The geomorphic expression of the Kanda fault is a prominent fresh-looking scarp more than 180 km long, from Tunduma to north of Sumbawanga, that strikes roughly NW–SE, and dips constantly northeast. No evidence for horizontal slip was observed. Generally, the active faulting affects a very narrow zone, and is only locally distributed over several subparallel scarps. The height of the scarp progressively decreases towards the northwest, from about 40–50 m to a few metres north of Sumbawanga. Faulted lacustrine deposits exposed in a road cut near Kaengesa were dated as 8340±700 and 13 600±1240 radiocarbon years. These low-energy deposits now hang more than 15 m above the present-day valley floor, suggesting rapid uplift during the Holocene. Due to its high rate of activity in very recent times, the Kanda Fault could have produced the 1910 earthquake. Detailed paleoseismological studies are used to characterize its recent history. In addition, the seismic hazard posed by this fault, which crosses the fast growing town of Sumbawanga, must be seriously considered in urban planning. © 1997 Elsevier Science Ltd

INTRODUCTION

This contribution focuses on the characterization of recent tectonic and paleoseismic activity along the Kanda fault (southwestern Tanzania), as part of a research project concerning the recent environmental and tectonic evolution in the Mbeya–Lake Rukwa region. This fault, obvious in the field but not on satellite images, lies in the Ufipa plateau west of the Rukwa rift. Although well mapped on available geological maps (Van Loenen and Kennerly, 1962), nobody has considered its possible activity in recent times. In this work we provide the first evidence showing the relevance of this tectonic system for constraining the recent geodynamics of this

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complex area and evaluating the seismic hazard in densely populated zones such as Mbeya and Sumbawanga towns.

TECTONIC SETTING

The northwest-trending Rukwa basin connects the Tanganyika and Malawi (Nyassa) rift valleys (Fig. 1), within the western branch of the East African Rift System (McConnell, 1972). Seismicity, active volcanism and geological–geomorphological evidence indicate the active tectonism of this area, although the actual kinematics and geodynamical processes are still under debate. The south-Tanganyika–Rukwa–north-Malawi lineament is interpreted by many authors as an intracontinental transform fault zone, where the basins open as pull-aparts due to oblique, NW–SE extension (e.g. Chorowicz and Mukonki, 1980; Kazmin, 1980; Tiercelin *et al.*, 1988;

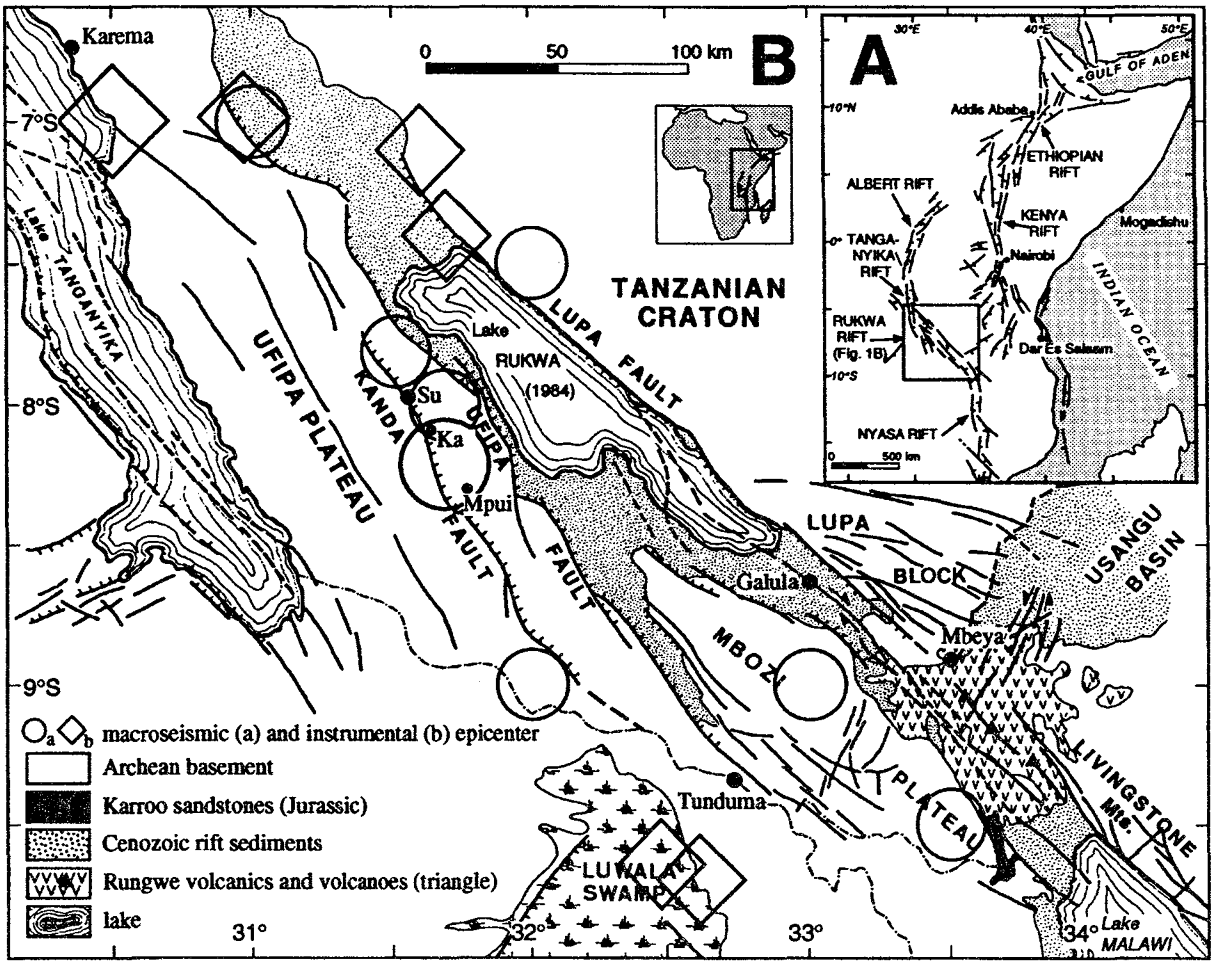


Fig. 1. A—Outline of the Cenozoic East African Rift System. The box delimits the study area (Rukwa Rift), located in the western branch between the Tanganyika and Nyassa (Malawi) rifts (modified from Smith and Mosley, 1993). B—Tectonic map of the Rukwa depression. The Kanda fault is located west of the rift, inside the Ufipa plateau. Macroseismic epicentres of historical earthquakes in the period 1900–1930 (from Ambraseys, 1991, and Ambraseys and Adams, 1992) are also shown. Instrumental epicentres ($M \geq 4.9$) from NEIC database (yr 1964–1987). The largest symbols locate epicentres of the main shock that occurred in 1910 ($M = 7.4$). Su: Sumbawanga town; Ka: Kaengesa village (shown in more detail in Fig. 3).

Kilembe and Rosendahl, 1992; Wheeler and Karson, 1994). Morley *et al.*, (1992) favour an opening of the Rukwa basin in a NE–SW direction, sub-orthogonal to its general trend, due to a tensile stress field.

The Rukwa rift is limited on its northeastern side by the Lupa border fault and the Tanzanian craton, and by the Ufipa border fault and the Ufipa uplifted block on its southwestern side (Fig. 1B). The Ufipa and the Lupa plateaux are cratonic areas that have undergone differential vertical movements since the Middle Miocene, registered by the African 1 laterite peneplain (King, 1963), recognized in both areas (Delvaux *et al.*, 1995).

The availability of a good number of seismic lines allows a detailed reconstruction of the stratigraphy and structure of the Rukwa depression (Peirce and Lipkov, 1988; Wescott *et al.*, 1991; Morley *et al.*, 1992; Kilembe and Rosendahl, 1992). Above the Precambrian basement (up to 11,000 m deep) periods of continental sedimentation occurred at various stages (Karroo beds in the Early Carboniferous–Early Triassic, the Red Sandstone group of controversial Early Cretaceous or Early Neogene age) (Dypvik *et al.*, 1990; Wescott *et al.*, 1991; Kilembe and Rosendahl, 1992; Mbede, 1993), and from the late Miocene to Present (dominant fluviatile and lacustrine environment, Older and Younger Lake Beds) (Quennell *et al.*, 1956; Wescott *et al.*, 1991; Mbede, 1993). An important volcanic centre has been active in Rungwe province since the Late Miocene, with predominantly explosive eruptions (the last one took place 150–200 yr ago: Harkin, 1960; Ebinger *et al.*, 1989; Williams *et al.*, 1993).

The structure of the rift is that of a symmetric graben in the northern part of the depression, grading into two inward-facing half-grabens in the southern part, tilted towards the border faults. At the southeastern extremity of the depression, the two half-grabens are separated by the uplifted Mbozi block. The eastern branch (Songe Valley) is connected to the northern extremity of the Malawi rift and to the transversal Usangu depression, in the Rungwe volcanic province. The western branch (Msangano trough) dies out gradually (Fig. 1B).

The Lupa fault, which separates the Rukwa rift zone from the Lupa block, part of the Tanzanian craton, appears relatively rectilinear, with a well expressed morphological scarp up to 200 m high, showing faceted spurs and oversteepening at its base. To the south, the scarp fades out progressively and the fault trace itself is lost near Mbeya.

The Ufipa escarpment, up to 1000–1200 m high, bounds the western side of the Rukwa rift, with a marked morphological scarp at least comparable to the Lupa fault, although less continuous (deep valleys cut through the range front) and rectilinear. Based on seismic reflection profiles (Morley *et al.*, 1992; Kilembe and Rosendahl, 1992), the total vertical offset of the Ufipa fault (2–4 km) is much less than that of the Lupa fault (4–11 km). Both border faults do not show clear indications of significant late Quaternary activity, which appears better expressed in smaller faults within the valley floor.

In the context of the Quaternary stress field in the area, in the Middle Pleistocene, after a period of semi-radial extensional stress, there was a stress inversion leading to a N–S horizontal principal compression. Normal faulting along the major fault zones was strongly reduced, and only some of them were reactivated by strike–slip faulting (dextral movements along NW-trending faults and sinistral displacements along NE-trending faults) (Delvaux *et al.*, 1992; Ring *et al.*, 1992). The present-day stress field for the study region can be inferred from a limited number of focal mechanisms. A compilation from various sources (CMT, Shudofsky, 1985, and NEIS) for the East Africa rift system is given in Giardini and Beranzoli (1992). They show predominant normal faulting with only minor strike–slip components in the Ruykwa rift. Tension axes trend WNW–ESE and ENE–WSW, following the orientations of the main structures.

KANDA FAULT

The NW-trending Kanda fault system can be followed for at least 180 km from north of Tunduma to Sumbawanga (Fig. 1B). It is a striking feature in the field and on available aerial photographs (scale 1:40,000) (Figs 2–4). However, it is poorly expressed on Landsat images, probably because of its very thin trace and the lithologic similarity between the footwall and the hangingwall, often comprising the same African 1 peneplain of Middle Miocene age (King, 1963), locally covered by a veneer of piedmont and alluvial deposits. The Kanda fault had a

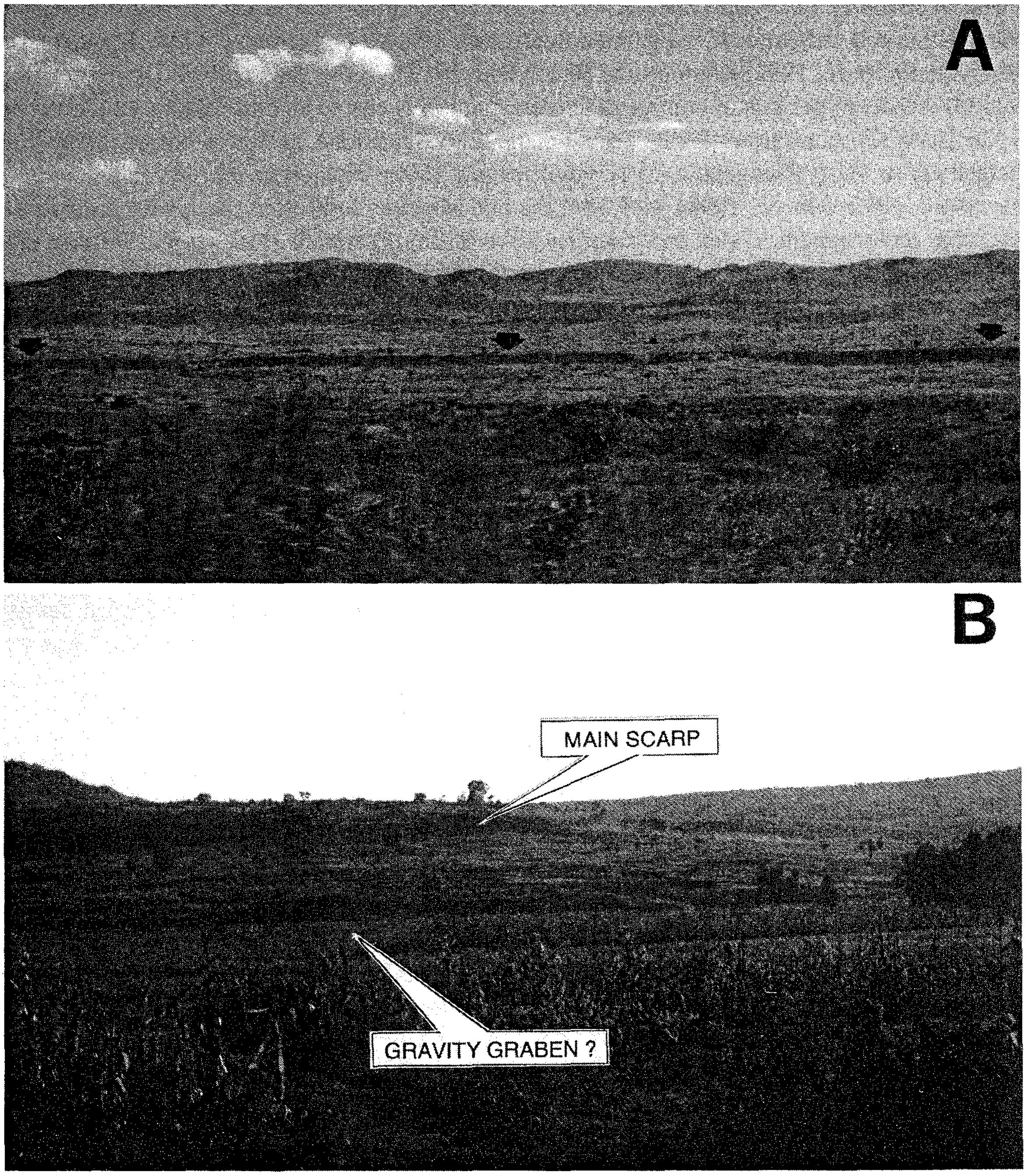


Fig. 2. A—View of the Kanda fault near Kaengesa. Arrows point to the upper rim of fault scarp. More subdued fault traces are at the base of the foothills in the background. B—View of the Kanda fault on the northern outskirts of Sumbawanga. Note the probable gravity graben, hosting a small pond, in front of the main scarp, which is here about ten metres high.

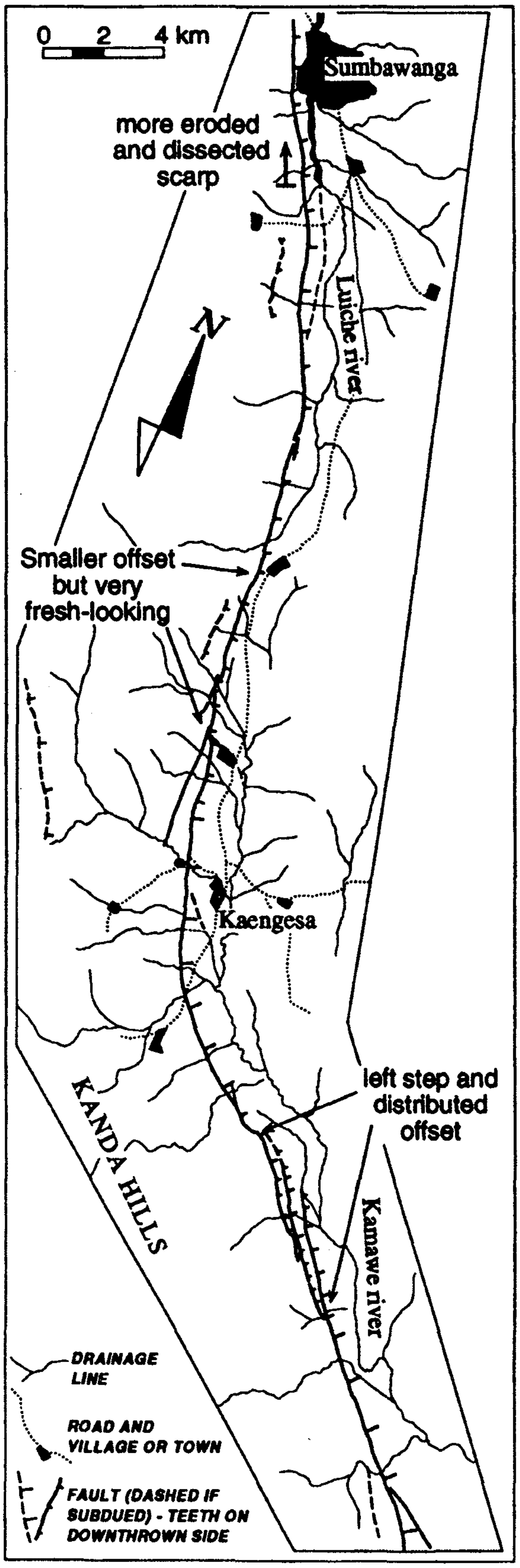
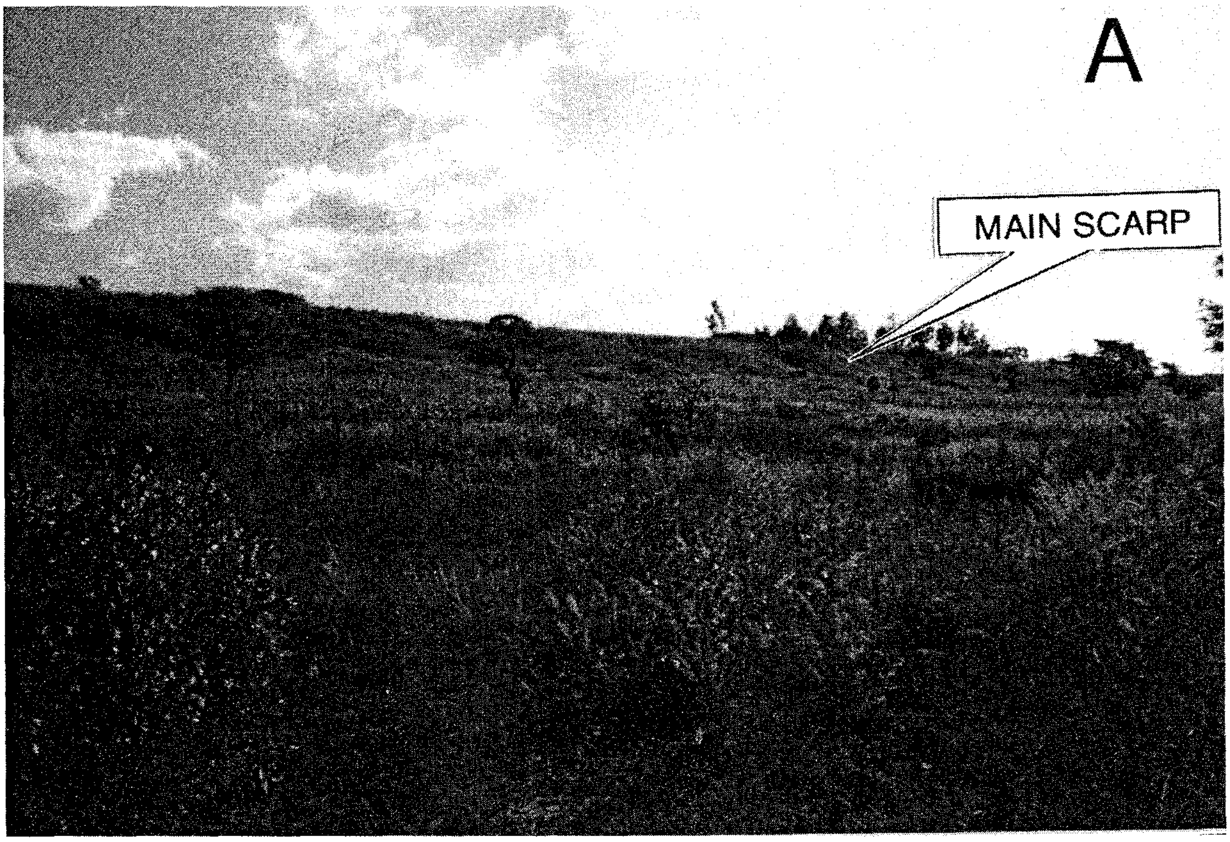


Fig. 3. Main features of the northwestern segment of the Kanda fault from Sumbawanga to 20 km south of Kaengesa village (approximate location in Fig. 1), interpreted from black and white aerial photographs at the scale of 1:40,000. Length of teeth in hangingwalls of fault is proportional to the vertical height of the scarp.

period of earlier activity probably during the Mesozoic, when strike–slip movements displaced the Karroo sediments of the Namwele coal field (Late Carboniferous–Permian), but did not affect the laterite crust of the Ufipa plateau, believed to correspond to the African 1 peneplain.



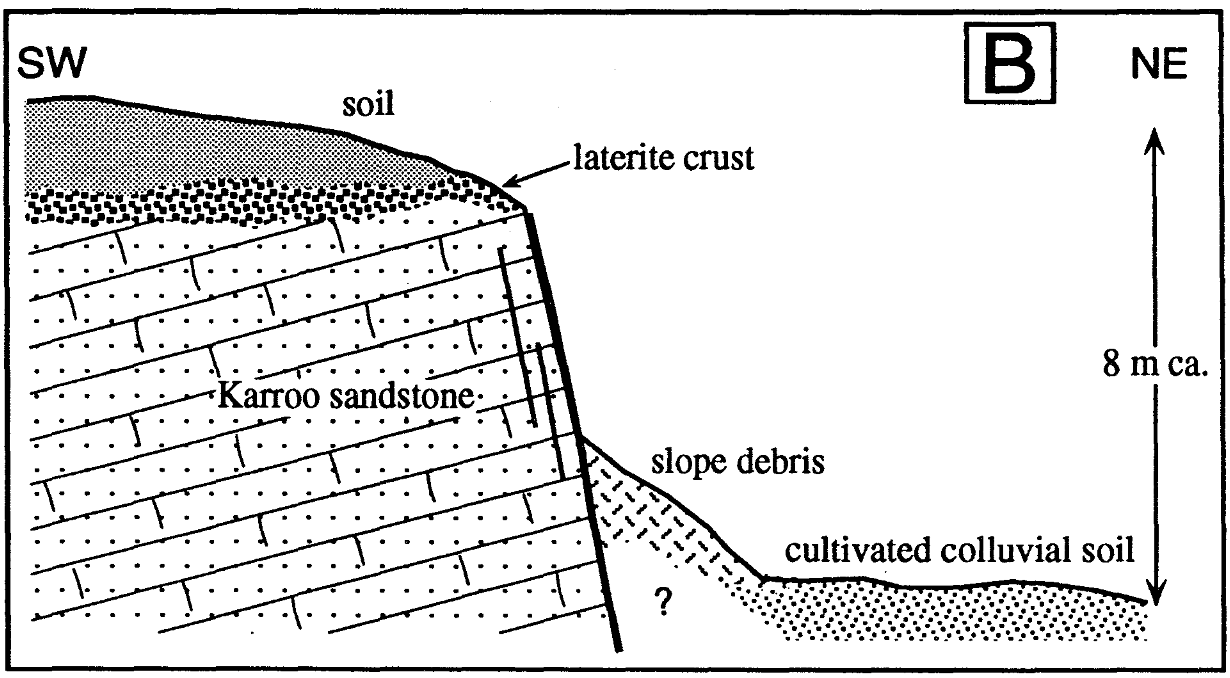


Fig. 4. View of the Kanda fault a few kilometres northwest of Sumbawanga (A) and a schematic cross-section of the fault scarp (B).

This surface lies at 1800–1900 m above sea level at Sumbawanga, near the Ufipa scarp, and decreases westwards to 1500 m near Lake Tanganyika (Delvaux *et al.*, 1995). West of the Kanda fault, in its northern sector, a fault line runs at the base of the slope along the range front (Kanda Hills), affecting some Quaternary alluvial fans. This fault, much more subdued than the Kanda fault, is probably now inactive.

Preliminary aerial photograph interpretations and field observations allow us to identify the main features of the Kanda Fault (Figs 3–6). At some localities patches of basement rocks crop out near and along the fault scarp, generally in the footwall, showing a system of megafractures, enhanced by deep erosion, that often parallel the trend of the fault scarp. However, at several locations the fault cuts across this old fracture set, which controls the drainage and shape of the mountain and hill areas (e.g. the Kanda Hills). Similar tectonic features also characterize the basement near the main faults bordering the Rukwa rift.

The scarps defining the present-day trace of the fault are always very fresh-looking, very steep and laterally continuous. The slope angle can exceed 40°, when the Archaean basement makes the scarp a free-face. The scarp crests appear very well preserved, locally partially incised by stream channels. Only the main drainage channels can cut down significantly through the scarp, generally showing steps across the fault zone (often corresponding to minor faults) and denuding the metamorphic basement. The fluvial network in the footwall is clearly perched above the present valley, as it was rapidly displaced by faulting. Only in the Sumbawanga area (Fig. 3) does the scarp appear significantly eroded and dissected. Here, its height decreases down to 10–15 m from a maximum of about 50–60 m measured in the southeast. To the north of Sumbawanga, the height of the Kanda scarp reduces to a few metres before disappearing. It probably resumes or connects to other faults in the northwest, which are aligned with it, but there are not studies of its northern as well as southern terminations.

In the footwall behind the present scarp, several more subdued fault traces can be recognized, which determine a step-like profile in the fault zone. Possibly these faults are now inactive as was originally suggested by Hancock & Barka (1987) for comparable faults in the Aegean region. In contrast, no clear faulting is generally visible in the valley floor (hangingwall), but only minor, although sometimes up to several kilometres long, lineaments lacking significant displacements, which splay from the main scarp. At the base of the main scarp there are frequent ponds and wet areas, indicating that the water table intercepts the ground surface at this point. Some wet areas coincide with small depressions, which suggests development of secondary faulting (gravity grabens), and backtilting of hanging-walls.

The recent offset along the Kanda Fault is generally concentrated on a single plane. Only in a few places it appears split in two or even three closely spaced fault traces, apparently all active. One example is to the south of Kaengesa (Fig. 3), where the fault distributes its vertical offset in an en échelon left-stepping system of three scarps of comparable height. A similar situation, but at a smaller scale, occurs just north of Sumbawanga. Several sub-parallel fault scarps are visible in the Mpui area (location in Fig. 1).

The most evident slip component is vertical or just normal; morphological features typical of strike–slip faulting (e.g. lateral offset of drainage lines or other markers, pull-apart basins, push-up ridges) being absent. However, the left-stepping en échelon system quoted above implies some amount of right-lateral slip on the fault zone. It occurs where the fault rotates its strike from NW–SE to N–S, suggesting that the NW–SE trend is slightly oblique to the present-day stress regime. No significant variations have been observed along the fault that might be suggestive of different behaviour; that is, fault segmentation, but this should be confirmed by a more comprehensive study. The African 1 surface in the footwall can be matched at a similar elevation on the valley side facing the Kanda Fault (northeast). No antithetic faults are evident on this side of the valley. Topographic studies, including precision leveling, would be useful to determine the long-term offset and the amount of back-tilting of the hangingwall.

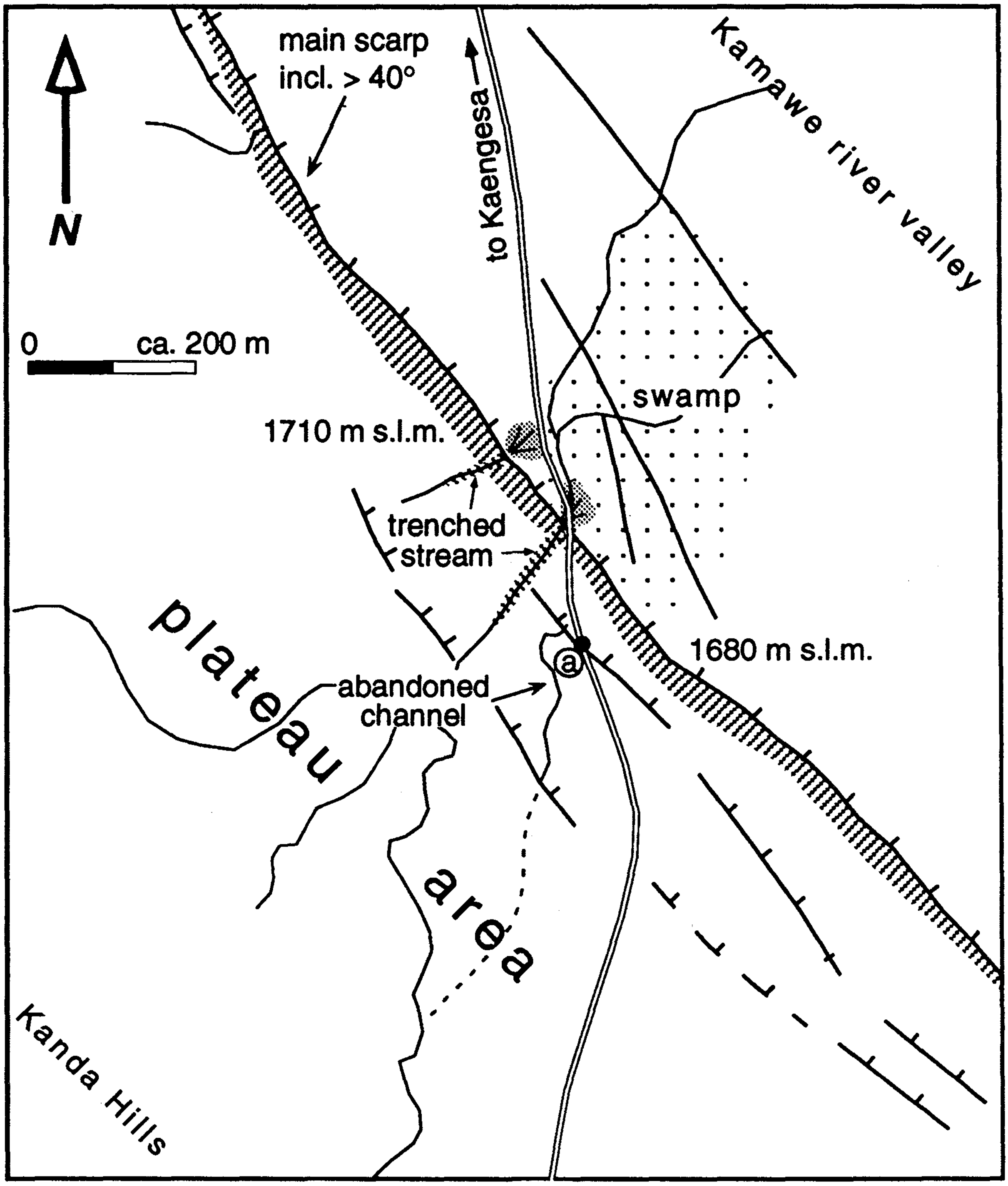


Fig. 5. Main features of the Kanda fault near Kaengesa (from aerial photograph interpretation and land survey). There is only limited evidence for faults in the footwall (southwest part of map) on available photographs. Lineaments inside the wet area in front of the main scarp might be faults, but, so far, there is not any additional field evidence to support this idea. Teeth are drawn on the downthrown side of the fault trace. "a" is the site of the section described in the text (see also Fig. 6).

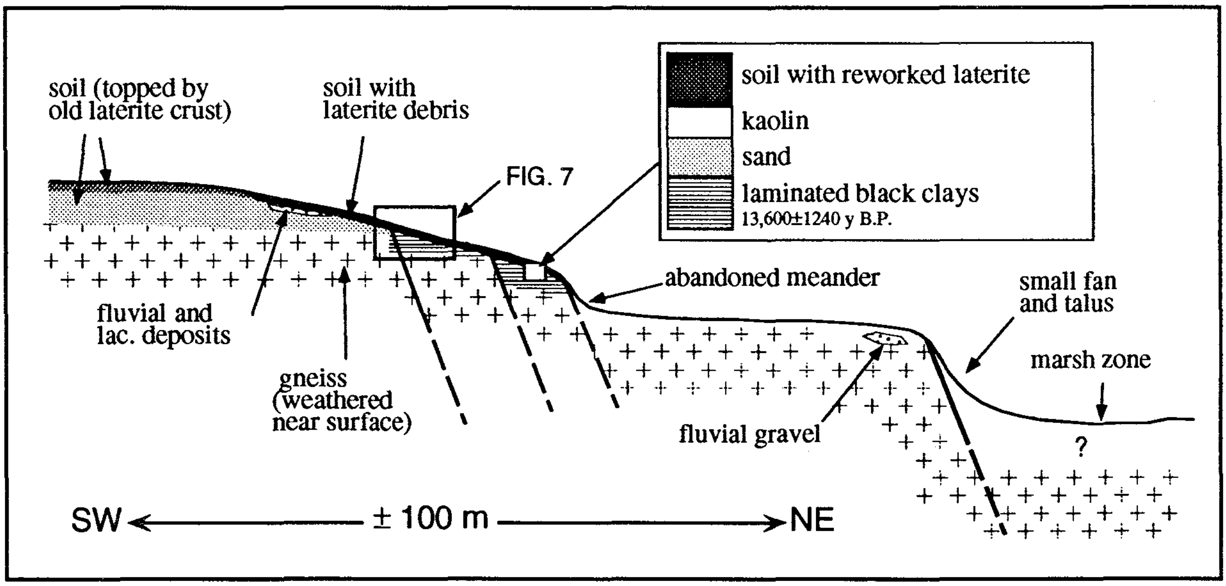


Fig. 6. Schematic profile of the Kanda scarp near Kaengesa (not to scale); box locates the section shown in Fig. 7 (site labelled "a" in Fig. 5).

FIELD SURVEY

The nature of our investigation, aimed at a preliminary evaluation of activity along the Kanda fault and its potential for paleoseismic analysis, allowed a field study of the fault scarp at only two sites: Sumbawanga town and Kaengesa village (Figs 1B and 3), both of which proved sufficient for a first assessment of the seismic potential of the fault.

Sumbawanga

This site is located a few kilometres northwest of Sumbawanga, just out of the area shown in Fig. 3 (end of aerial photograph coverage). The scarp here is about 10 m high and exposes a well-preserved sub-vertical free face trending N294°, cut in Karroo sandstone beds (Fig. 4). The sandstone is covered by a few tens of centimetres of thick lateritic crust, topped by a dark soil. Well-preserved slickenside lineations, very likely related to older periods of activity, show striations made of iron oxides and calcite, pitching 102° and about 15° (very thin traces). The lack of any significant degradation of this scarp, although partly due to the hard cementation of the sandstone, is suggestive of recent reactivation. The presence of thick vegetation hindered more detailed observations in the hangingwall at the foot of the scarp.

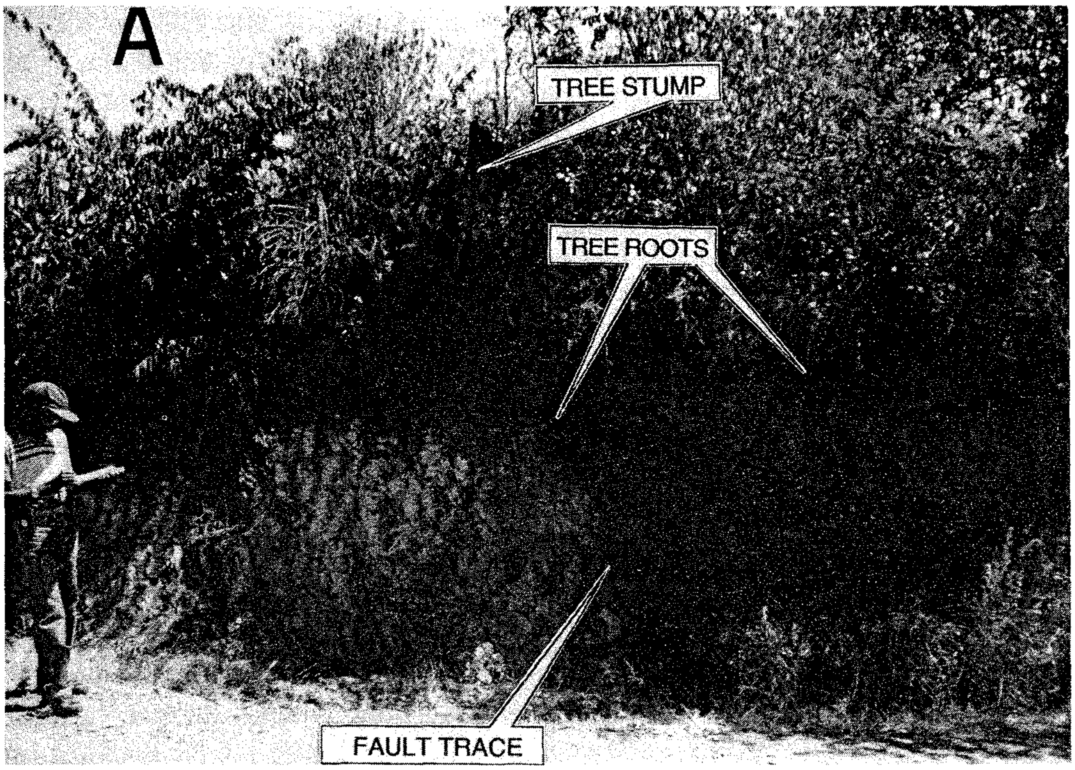
Just south of this site, on the outskirts of Sumbawanga, a small graben (a few hundred metres long), hosting a wet zone in the river valley, is located in front of the main scarp, at a distance of a few tens of metres. It is bounded by very fresh-looking fault edges with 1–2 m of vertical separation (Fig. 2b). This feature might be interpreted as a gravity graben affecting the hangingwall of a normal fault. Near this area, an en échelon set of fractures in the main scarp possibly suggests a right-lateral component of slip.

Kaengesa

The second site is very near Kaengesa village (Figs 3 and 5), where a road climbs across the fault scarp exposing along its flanks an interesting section (Figs. 6 and 7). The surface topping the footwall is at an approximate elevation of 1710 m above sea level, whereas the ponding area in front of the fault (hangingwall) is at about 1680 m. The difference in elevation is about 30 m (measured with a field altimeter). Approximately half of this difference in elevation is along the main scarp, the remainder is distributed on a few minor fault scarps, which disrupt the upper surface, approaching the main escarpment in a belt 100–150 m wide. One of these faults, well exposed along the road cut (Figs 5, site a, 6 and 7), separates Archaean basement from slope and lacustrine deposits. The section shows the following units (Fig. 7B). The bedrock (*Br*), visible either in the footwall or at the base of the section in the hanging wall, is made of foliated mylonitic gneiss densely fractured with alteration increasing upward, grading into the C horizon of a soil directly developed on it (So_{br}). The sandy soil (*So*) above it in the footwall, rich in organic matter, does not contain the lateritic crust typical of the African 1 surface, but only sparse fragments of it, therefore it could have formed much more recently, its colluvial component coming from the erosion of the lateritic soil that crops out behind it (see Fig. 6). A colluvial wedge (*Cw*) rests against the fault surface; it is made of fragments of weathered bedrock in a sandy matrix; no clear internal structures (e.g. layering) being present. Unit *L1* is made of thinly stratified (1–2 cm) beach and lacustrine deposits, consisting of alternating layers of medium to coarse blackish sand (with whitish pebbles, 1–6 cm in diameter, of kaolinized basement) and greyish-brown fine sand to silt, more common near the fault surface. At its base, this unit contains disrupted layers of cemented grey clayey silt in small ball-like phenomena. This is typical of cemented silt all along the exposed section. A sample of charcoal was collected at the top of this unit for dating and yielded a radiocarbon age of 8340±700 years. Unit *L2* is a well-sorted medium to fine sand, weakly stratified, of lacustrine origin. Oxidation patches suggest some light pedogenesis. Unit *L3* is a finely stratified lacustrine deposit, made of alternating dark grey and whitish levels of well indurated sandy and clayey silt. A weak alteration affects this layer, that grades into soil (So_l) with an uncertain undulating boundary. Unit So_l is a brownish soil more than 1 m thick, developed on unit *L3* with a complete profile; it has a colluvial component, indicated by sparse laterite debris. Rootlets penetrate the soil and the detrital units, including a big tree root following the fault plane (Fig. 7). At this site, faulting has produced about 1.5 m of vertical offset (top of bedrock on both sides of fault). A first movement determined the deposition of the colluvial wedge *Cw* before sedimentation of the lacustrine sequence. It is not clear if the lake deposits were involved in the activity of this fault. Units *L1* and *L2* dip 15–20° NE, while unit *L3*, very similar to *L2*, is almost horizontal; this suggests limited tilting or dragging. A secondary plane splaying from the main fault bounds unit *L1* and probably displaces unit *L2* for 20–30 cm.

About 25 m towards the northeast (Fig. 6), therefore a few metres lower than in the described section, 5–10 cm-thick horizontal layers of lacustrine blackish organic clay with thin sand interlayers crop out. The entire organic matter in this deposit yielded a radiocarbon age of 13,600±1240 yr. This deposit is probably faulted and incised by an abandoned meander channel of the stream now partly downcutting the scarp by a rectilinear channel (Fig. 5). Fluvial gravel and sand deposits crop out along the road near the main scarp.

It is noteworthy that these lacustine deposits, dated as end Pleistocene–Early Holocene, cannot be explained in their present geomorphological setting, characterized by a steep scarp about 15 m high only a few tens of metres away. Very likely they were deposited in an environment similar to that visible in the present-day hangingwall. This implies that the main



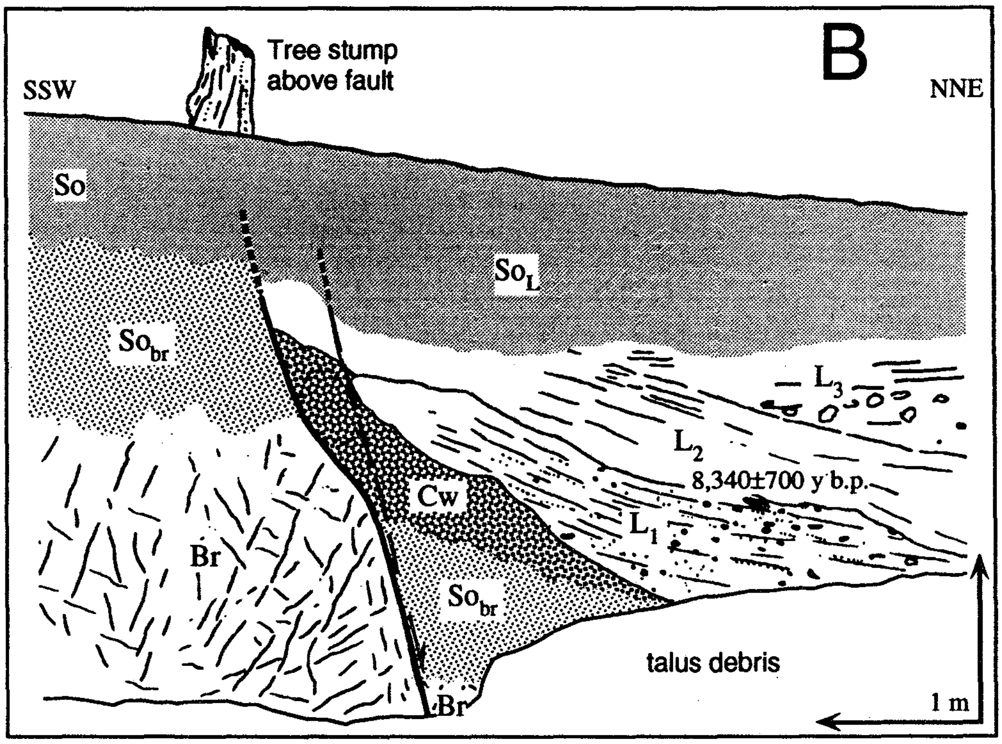


Fig. 7. A—Photograph taken along the road from Kaengesa that climbs the Kanda fault scarp (site labelled "a" in Fig. 5; see also Fig. 6). It shows a detail of one of the minor faults within the present footwall of the most active fault plane. B–Interpretive line drawing of the road cut showing the faulted contact between Archaean basement and a lacustrine sequence dated as Early Holocene. *Br*—gneiss; So_{br}—horizon C of a soil developed above *Br*; *So*—soil containing laterite debris; *Cw*—colluvial wedge; *L1*, L2 and L3—lacustrine units made of sand and silt with kaolin and black clay; So_l—soil developed on *L2* and *L3*. The lacustrine sequence is faulted and dragged along the fault plane. See text for a detailed description.

Kanda scarp, very fresh-looking as described above, formed less than 8000 yr B.P. Therefore, the mean vertical slip-rate in the Holocene was at least near 2 mm/yr; this allows us to classify the Kanda fault as a major normal fault, considering as secondary its horizontal component of motion, which it was not possible to evaluate in this study.

SEISMICITY

Although neither homogeneous nor complete, seismicity data from historical and instrumental (far field and local networks) databases confirm that the southern Tanganyika and Rukwa grabens are tectonically very active. The strongest known earthquake occurred on December 13, 1910, and had $M=7.4$. It released 80% of the total seismic moment of the Rukwa region for the last 100 yr (Ambraseys, 1991). The macroseismic epicentre falls approximately on the Kanda Fault a few tens of kilometres southeast of Sumbawanga, not far from Kaengesa, but this location is poorly constrained, due to the very sparse population at that time (Fig. 1B). Therefore, it could also have occurred on the Ufipa escarpment or, less likely, on another still undetected fault (Fig. 1B). The instrumental location, of quite low quality is more to the northwest, near Tanganyika lake, but still on the same alignment of the Kanda fault. Also, the main aftershocks were located by Ambraseys (1991) as occurring between the Kanda fault and the Ufipa escarpment. The magnitude of this event would require extensive surface faulting (which was not reported after the earthquake), but not necessarily the predominant strike–slip component of motion suggested by Ambraseys (1991). Wells and Coppersmith (1994), for example, list several normal faulting events with magnitudes above 7, all characterized by ample surface rupturing.

Several moderate-sized earthquakes (M near 6–6.8) occurred in this region, some of which were very near the Kanda fault (Fig. 1B): e.g. the Ufipa earthquake ($M=6.8$) and the Rungwe earthquake ($M=6.2$) in 1919, the Rukwa earthquake ($M=6.2$) in 1922 (Ambraseys and Adams, 1992), and the recent north Rukwa earthquake in 1994 ($M=5.9$), occurred along the Lupa escarpment. In general, most events fall along the margins or outside the rift.

The distribution of damage of the 1910 earthquake, as reconstructed by Ambraseys (1991), clearly indicates that the repetition of a similar event would now produce extensive destruction over a wide area, due to the rapid urban development of the region. The towns where the damage would be expected to be the highest, depending on the location of the ruptured fault segment, are Sumbawanga, which is crossed by the fault; Tunduma (main gateway to Zambia), at its southern termination; and towns in the valley floor, including part of Mbeya, because of probable local shock wave amplification.

A local network of five three-component stations has been operating in the Mbeya area since 1992 (Camelbeek and Iranga, 1996). These stations detected seismic events along the Lupa escarpment and beneath the plateau, to the east of it, along secondary faults splaying from the main scarp (Delvaux and Hanon, 1993; Camelbeeck and Iranga, 1996). This seismic network will be extended in order to better localize events coming from the Kanda fault area. Hypocentres reach down to depths of 28 km and more, suggesting an uncommon brittle behaviour of the deep crust in this area, as already noted by Shudofsky (1985). Jackson and Blenkinsop (1993) note that the larger and "deeper earthquakes in East Africa occur outside the most extended part of the late Cenozoic rift system", and that the width of the grabens is larger than commonly observed in continents. They interpret these observations as reflecting the cold and shieldlike thermal structure of the crust bounding the rift system.

Kennerly (1962) and Van Loenen and Kennerly (1962) mapped surficial faulting, which may have accompanied the moderate 1950 Ivuna earthquake, which we could not find during our preliminary 1994 survey (Delvaux *et al.*, 1995). No more reports of surficial faulting during historical earthquakes are known from the study area. This may be due either to the lack of local witnesses or, more likely, to the hypocentre depths often being greater than 20 km. Therefore, the threshold magnitude for surface rupturing should be higher than that for many upper crustal events, probably between 6.5 to near 7.

CONCLUSIONS

Many elements testify to active tectonism in the Rukwa rift: historical and instrumental seismicity; surface faulting in the valley floor; tilting of recent deposits; hydrothermal activity, and active volcanism (Delvaux and Hanon,1993). No major activity during the Late Quaternary has affected the main faults bordering the rift (the Lupa and Ufipa escarpments), which nevertheless display faceted spurs and oversteepening at the base of scarps, suggestive of some Middle–Late Quaternary activity.

It is interesting to note that, at present, the major evidence for activity comes from faults located in the uplands behind the main escarpments. These are the ones on the Lupa block, where most of the recent seismic activity recorded by a local network is concentrated, and the Kanda fault in the Ufipa block, which constitutes a high topographic ridge between Lakes Rukwa and Tanganyika. This fault presents a fresh-looking scarp 10–50 m high, which can be followed for more than 180 km from north of Tundama to Sumbawanga. This fault reactivates an old (Permian–Triassic?) strike–slip fault, but the recent mechanism appears mostly dip–slip, because of the lack of typical structural indicators of lateral offset. Radiocarbon dating of organic material associated with small secondary steps in the fault zone provided Late Holocene to end Pleistocene ages. These preliminary results confirm the freshness of the tectonic activity, already suggested by the geomorphological evidence. More studies will better constrain the Holocene slip rate and ages of past seismic events.

The lack of predominant strike–slip components along the investigated fault, and the comparison with available focal mechanisms (Giardini and Beranzoli, 1992) suggests that the Kanda fault moved under a horizontal tensile axis oriented approximately ENE–WSW.

Tens of metres of vertical offset during the Holocene strongly suggest that several seismic events of magnitude above 6, including the largest African earthquake of this century: the $M=7.4$ Rukwa earthquake of December 1910 (Ambraseys, 1991), probably occurred along this fault. Therefore, it is a likely candidate for future shocks of above $M=7$ and will probably cause significant surface displacement. The distribution of seismicity and geomorphological features indicates that other faults are active east of the Kanda fault and should be also considered for seismic hazard assessment, although their capability for large shocks and significant surface faulting is much less evident. In conclusion, seismic hazard deserves considerable attention, especially around the fast-growing urban areas of Sumbawanga, which is crossed by the fault, and Tunduma, and generally in the south-Tanganyika–north-Malawi region, because of the wide area over which the 1910 event was felt, and the concentration of the present-day urban development in flat areas of recent sedimentary fill. Hopefully, paleoseismic analyses in the near future will better constrain fault behaviour and recurrence intervals.

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