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EVIDENCE FOR UPPER PROTEROZOIC CONJUGATE STRIKE-SLIP BASINS CONTROLLED BY BASEMENT STRUCTURES IN NW TANZANIA AND BURUNDI

by

K. THEUNISSEN *

RESUME - L'examen des cartes géologiques et des images satellitaires, couvrant la région étudiée, montre des figures géométriques en losanges. Celles-ci, bien mises en évidence par l'allure des linéaments, apparaît clairement comme une caractéristique des séquences sédimentaires du Protérozoïque supérieur dans une vaste région du NW de la Tanzanie et dans le SE du Burundi.

Ces formes en losanges se développent selon une direction NW, lorsque les sédiments du Protérozoïque supérieur surmontent un socle Ubendien (Protérozoïque inférieur) et selon une direction NE lorsqu'ils surmontent un socle Kibarien (Protérozoïque moyen).
Des données récentes (sédimentologiques, structurales et magmatiques) relatives au Protérozoïque inférieur, moyen et supérieur, sont évoquées dans la mesure où elles peuvent contribuer à une meilleure compréhension du mécanisme majeur de la déformation, qui est à la base de la mise en place de ces bassins du Protérozoïque supérieur.

Sur les images Landsat il apparaît nettement que les deux directions, responsables des figures losangiques dans le Protérozoïque supérieur, se prolongent par des linéaments dans leurs socles respectifs. On peut donc supposer que ces bassins se sont mis en place en fonction de la réponse structurale propre de chacun de ces deux socles aux champs de contraintes, existant dans la région à cette époque.

Il est montré que le socle Ubendien s'est adapté selon un mécanisme de déformation par "décrochement latéral sénestre" (left lateral strike-slip) en direction NNW, conduisant à la mise en place des bassins losangiques ("pull-apart"), orientés NW dans la région d'Itiaso (Tanzanie).

Le comportement structural du socle Kibarien est plus complexe, bien que, sous plusieurs aspects, il s'insère particulièrement bien dans le phénomène tectono-magmatique tardif de l'orogenèse Kibarienne. A cette phase sont attribuées les structures appartenant à un système cisaillant et conjugé, selon une direction majeure NW au Burundi occidental et NE au Burundi oriental. Il est proposé ici que le système cisaillant NW est en relation étroite avec le "left lateral strike-slip", identifié dans la chaîne Ubendienne, située en dehors de la chaîne Kibarienne, mais se prolongeant en dessous de cette dernière comme la chaîne Rusizienne.

Le système NE, quant à lui, résulterait du comportement du socle Kibarien (lui-même sur son socle Archéen) selon le développement d'un réseau de fractures de style décrochant oblique et dextre suivant les directions NNE et ENE, conduisant ainsi à la mise en place des bassins losangiques des domaines de Bukoba et de la Malagarazi (Protérozoïque supérieur).

La position préférentielle de ces deux domaines en bordure de la chaîne Kibarienne est interprétée comme résultant de la mise en place (par fracturation en décrochements obliques) d'une zone de faiblesse structurale majeure, se situant dans la région de contact entre la chaîne Kibarienne et son socle Archéen.

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MOTS CLES : Protérozoïque inférieur, chaîne Ubendienne, Rusizien, Karema, Itiaso.
Protérozoïque moyen, chaîne Kibarienne, Burundien, cisaillement conjugé, magmatisme basique.
Protérozoïque supérieur, Malagarasien, Bukoba.
Mise en place de bassins, géométrie en losange, pull-apart, décrochement, linéaments, Landsat, Tanzanie, Burundi.

ABSTRACT The investigation of the compiled geological maps and Landsat imageries of the investigated region clearly shows a rhomb shaped geometrical pattern. This is best evidenced by the lineaments and geology of the Upper Proterozoic sedimentary sequences, covering a large region in NW Tanzania and in SE Burundi.

NW trending rhomb basins overly a Lower Proterozoic Ubende basement, whereas NE trending rhomb basins overly a Middle Proterozoic Kibaran basement.

Recent data (sedimentological, structural and magmatic) concerning the three different, Lower- Middle- and Upper-Proterozoic terrains will be dealt with here, as far as they contribute to a better understanding of the leading deformational mechanism, according to which these Upper Proterozoic basins have been emplaced.

On Landsat imageries it is obvious that the two different trends outlining the basin rhombic geometry, extend as lineaments concordantly into their respective basement. It is therefore assumed that the basins have been emplaced according to the particular structural adaptation of their different basements to the regional stress field in that period.

It will be shown that the Ubende basement adapted by NNW oriented left lateral strike-slip deformation, which lead to the emplacement of the NW oriented Itiaso rhombic basins (Pull-aparts).
The structural behaviour of the Kibaran basement is much more complex : however, in many aspects is fits surprisingly well in the late Kibaran orogenic event. Structurally this event is known for its "conjugate shearing" deformation, occurring along roughly NW and NE trends in western and eastern Burundi respectively. It is postulated here that this NW trending shear set is directly related to the strike-slip mechanism occurring in the Ubende belt, whereas the NE trending set is an adaptation of Kibaran basement (overlying Archaean) by ENE-NNE oriented shearing fracturation (right lateral-oblique slip), according to which in the NE oriented Malagarazi- and Bukoba-domains, the Upper Proterozoic sedimentary basins have been emplaced.
The preferential occurrence of both latter domains along the margin of the Kibara belt, is interpreted as resulting from the emplacement (by oblique slip fracturation) of a "principal Displacement Zone", sited near the contact between the Kibara belt and its Tanzanian Archaean cratonic foreland.

KEY-WORDS : Lower Proterozoic, Ubendian belt, Rusizian, Karema, Itiaso, Middle Proterozoic, Kibaran belt, Burundian, conjugate shear, basic magmatism.
Upper Proterozoic, Malagarasian, Bukoban.
Basin emplacement, rhombic geometry, pull-apart, strike-slip, Landsat lineaments, Tanzania, Burundi.

1. GEOLOGICAL OUTLINE (fig. 1)

As shown on figure 1A the Upper Proterozoic sequences appear as if they have been trapped between an Archaean cratonic terrain (Tanzanian craton), a NW trending Lower Proterozoic Ubendian linear belt and a roughly NE trending Middle Proterozoic Kibaran linear belt.

The investigation of the mutual structural relationship between these different precambrian terrains in NW Tanzania is highly obliterated by the occurrence of the wide region covered by recent sediments (fig. 1A), that accumulated in large part of the Moyowozi river drainage system.

Because of its particular position (fig. 1B) relative to the recent Eastern African Rift (western Branch), any structural interpretation of Precambrian geology, via remote sensing images, is confronted with the problem of distinguishing younger and older structures (rejuvenation or reactivation of older structural features by younger deformational events).

Particular attention is drawn on the assumption that cratonic Archaean Basement, structurally should

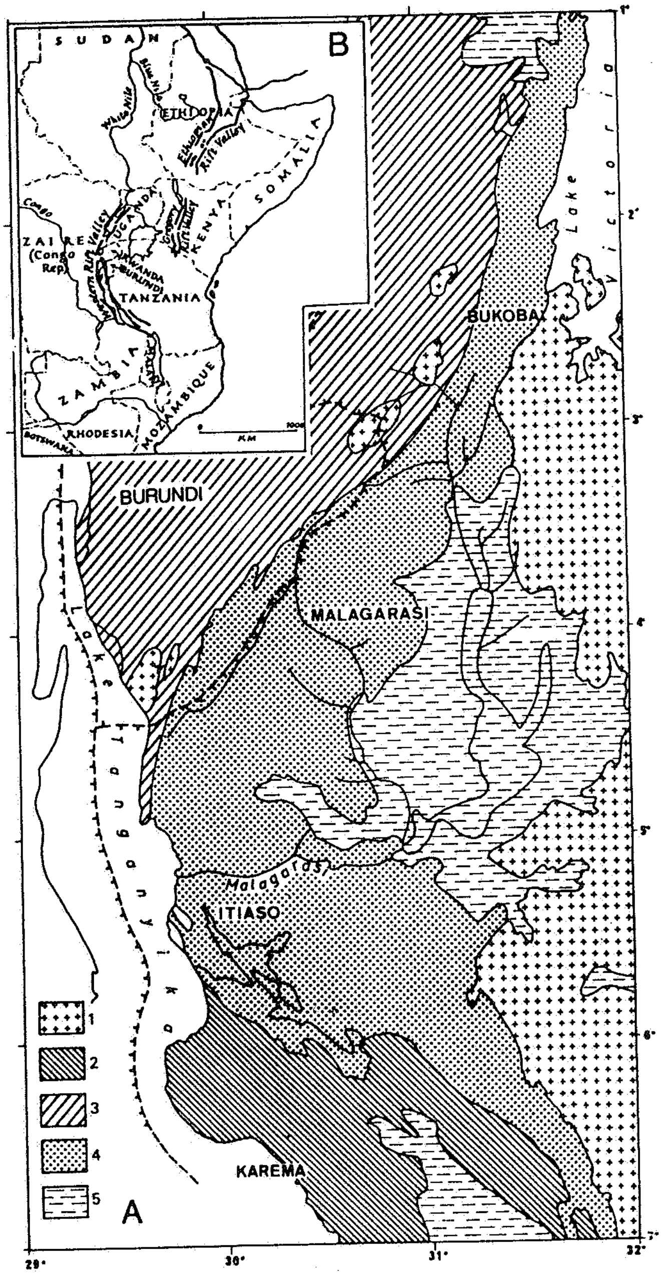


Fig. 1. A. GEOLOGICAL OUTLINE.
Legend : 1. Archaean craton, 2. Lower Proterozoic Ubendian belt, 3. Middle Proterozoic Kibaran belt, 4. Bukoba-, Malagarasi- and Itiaso Upper Proterozoic domains, 5. Recent cover.

B. LOCALISATION OF THE INVESTIGATED AREA RELATIVE TO THE EAST AFRICAN RIFT (from McConnell).

behave rather isotropically in contrast to both Lower- and Middle Proterozoic linear belts, bounding this cratonic area on its respectively W- and NW-limit. It is also worth to mention that the contact between the Kibara belt and its cratonic foreland is nowhere observed and that the southern limit of the belt (as shown on fig. 1A) is in fact its southernmost outcrop limit: the contact between the craton and Kibara belt is everywhere overlain by Upper Proterozoic strata or recent cover.

Obviously both Lower- and Middle Proterozoic differently structured belts seem to contribute largely to the general geometrical outline of the Upper Proterozoic strata.

The data concerning the leading characteristics of the Middle Proterozoic Kibara belt are largely dealt with by KLERKX *et al.*, 1987).

The Ubende belt is mainly dealt with by McCONNELL (1950), SUTTON *et al.* (1954, 1959, 1974) and a large part of its geology has been recently published. All data clearly show the Ubende belt as a leading structural feature in successive evolutionary stages of this part of the Precambrian- (and even recent) terrains of Western Tanzania.

At Karema (fig. 1, 2) part of the Ubende belt has been recently investigated (THEUNISSEN, 1988).

Along its NW trend and to the NW, the Ubende belt is known in Zaire, Rwanda and Burundi as the "Rusizian" (CAHEN, 1954).
Very few is known on Archaean craton in the investigated area.

2. UPPER PROTEROZOIC GEOLOGY (fig. 2).

Most of the region occupied by Upper Proterozoic sediments is sited in Tanzania. The present contribution will mainly deal with data available from geological maps and compilation work, performed by HALLIGAN (1963) for the Tanzanian part. The Upper Proterozoic sequences of Burundi have been studied by WALEFFE (1965) and have been recently mapped and published (WALEFFE, 1979).
Still more recent data are used here : some of them resulted from isolated studies (DE PAEPE *et al.*, in press), whereas others have been put forward during discussions with L. TACK (personal communications).

Definitely most field data dealt with here come from Burundi. WALEFFE (1965), suggests the stratigraphic correlation between Tanzanian- and Burundian Upper Proterozoic sequences as shown on figure 2A.

Dealing with the Upper Proterozoic sediments of Tanzania, these sequences are commonly mentioned in the literature as "Bukoban".

As a particular feature in the western region, we have to mention that the oldest metasedimentary sequences (Itiaso Group) have not been until to date attributed to Upper- or Middle Proterozoic. This western region is shown by HALLIGAN (1963) to be characterized by distinct structural evolution as far as the strata do outcrop north or south of the Malagarazi river : this statement will be fully exploited here.

In Burundi the Upper Proterozoic is commonly known as "Malagarasien".
Recent findings (DE PAEPE *et al.*, in press) have stratigraphical consequences. Some structural anomalies stated by WALEFFE (1965) will be interpreted here as related to the particular emplacement mechanism of Upper Proterozoic basins.

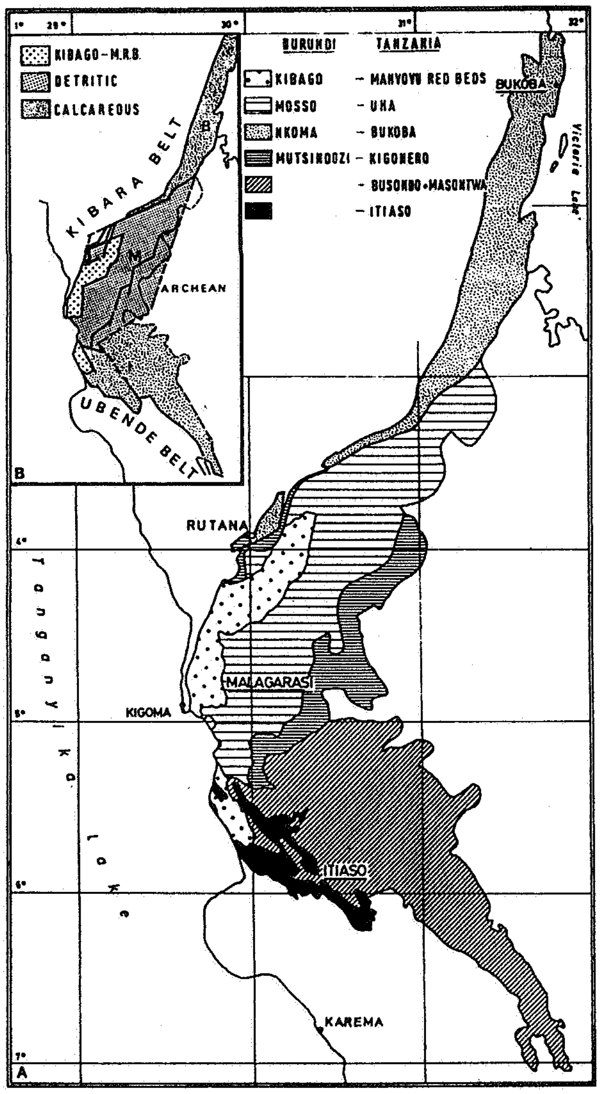


Fig. 2. A. COMPILED GEOLOGICAL MAP OF THE UPPER PROTEROZOIC SEQUENCES IN W. TANZANIA AND IN SE BURUNDI (after Waleffe, 1965).

B. IDEALIZED RHOMB PATTERN AND DOMINANT LITHOLOGY.

The compiled geological map (fig. 2A) clearly shows some very particular features, appearing in the Upper Proterozoic sequences, if we draw attention on the very contrasting lithology between the extended "Mosso-Musindozi" largely calcareous sequences and interlayered basaltic flows on one hand, and all other detritic arenopelitic sequences on the other hand. Furthermore it is repeatedly mentioned in the literature that all these sediments, wether they are calcareous (stromatolithic) or detritic, have been deposited under "shallow water" conditions.

Obviously the sediments preferentially extend along a roughly NE trend, when they occur along the Kibara belt and along a NW trend when they overly the Ubende belt.

In a very schematical way the lithologically distinct Upper Proterozoic sediments of the considered region appear in a "lineament bounded" geometrical pattern as shown on figure 2B.

3. MAIN LANDSAT LINEAMENT GEOMETRICAL FEATURES (fig. 3)

The region build up by Upper Proterozoic sequences has been investigated on Landsat (MSS) imageries.

The interpretation of the lineament pattern in this particular region is subtile since there is no doubt that part of the lineaments are intimately related to the recent rift emplacement (fig. 1B). However, all geologists, and particularly McCONNELL (1950, 1972) and more recently DALY *et al.*, (1985), which have been working in the Lake Tanganyika surroundings, drew attention on the particular behaviour of the Ubende belt, whose structural pattern is repeatedly invoked in most of the subsequent structural evolution of this part of Eastern Africa.

During our investigation of the Landsat imageries, we were aware of the seismically active zone of the Malagarazi region (WOHLENBERG, 1969).

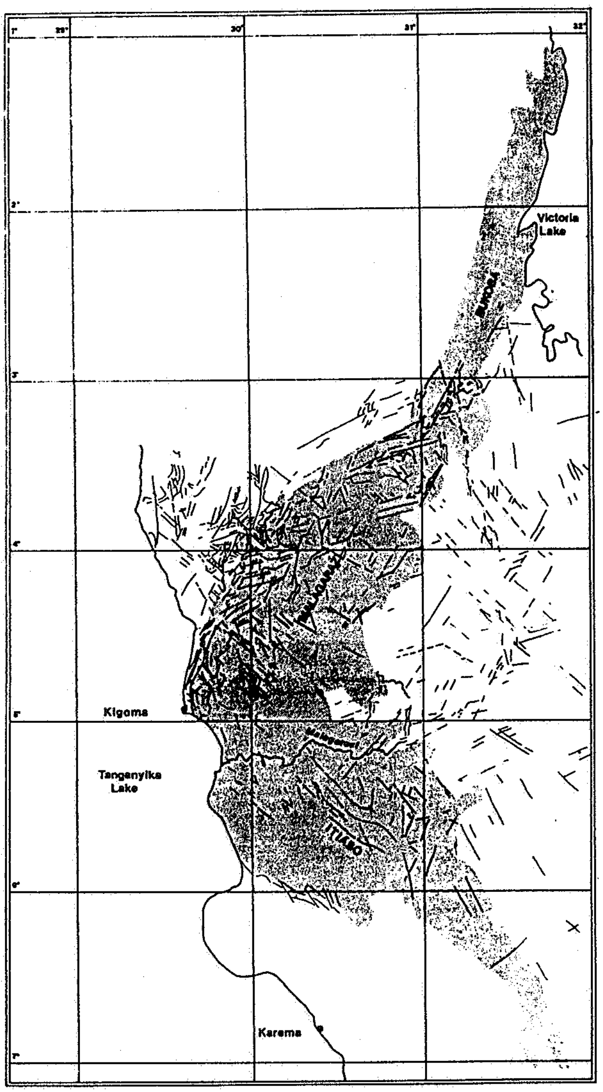


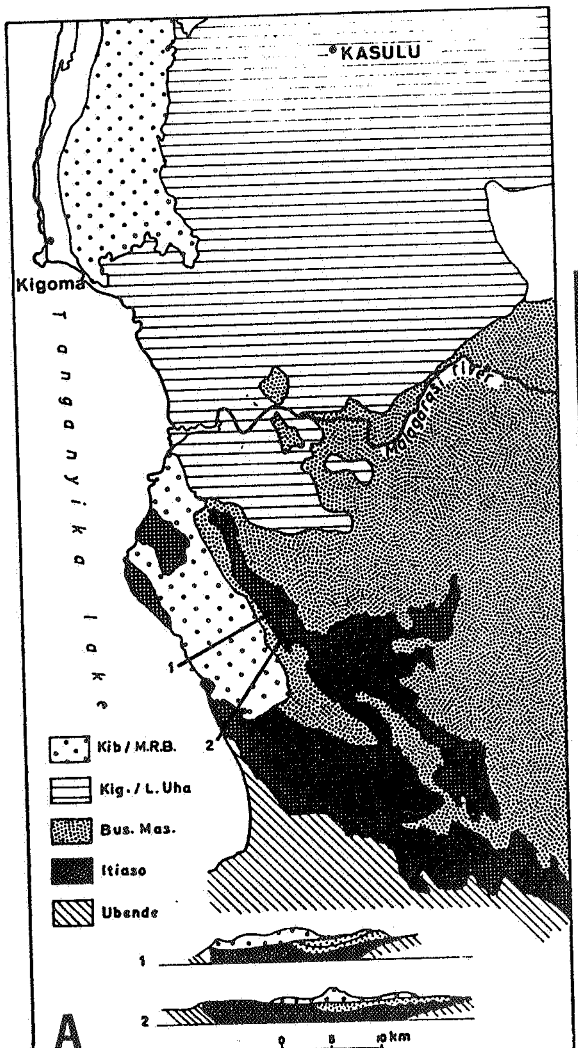
Fig. 3. DOMINANT LINEAMENT PATTERN AS SHOWN BY COMPILED LANDSAT IMAGERIES AND OUTLINE OF UPPER PROTEROZOIC SEDIMENTS.

The lineament pattern, as roughly outlined on figure 3 clearly shows that its geometry is not confined to the Upper Proterozoic region. Although rather complex, the NNE-ENE set of Bukoba- and Malagarazi regions on one hand, and the NNW-WNW set of the Itiaso region on the other hand, are obviously present in respectively the Kibara basement and in the Ubende basement area.

Clouded parts of the Bukoba Landsat imagery are not adequately investigable: only the southern part will be dealt with here. Mainly based on the configuration of the rhomb shape appearing in the Upper Proterozoic domains and on the fact that their lineaments extend along trend into their respective basement areas, the present contribution will deal with three different Upper Proterozoic domains:

- Itiaso domain (Tanzania) in the south,
- Bukoba domain (Tanzania) in the north,
- Malagarazi domain (Burundi and Tanzania).

This rhomb shaped geometry outlined by lineaments of Upper Proterozoic geology and its extent into the Kibara- and Ubende-basement areas is indeed the leading feature in the interpretation of structural behaviour of Precambrian terrains, allowing the emplacement of basins in which Upper Proterozoic sediments have been deposited.



4. ITIASO DOMAIN MAJOR CHARACTERISTICS (fig. 4)

One of the most obvious features, outlined by the compiled geological map (fig. 2A) as well as by the Landsat lineament map, is the NW trending rhomb shape, bounded, but also internally structured by roughly NNW and WNW oriented features, including the boundaries between successive lithological sequences (fig. 4A,B). According the statement of HALLIGAN (1963, p. 23) that "It is interesting to notice the diminishing intensity of all these folds, as they approach the area of the Malagarazi river", it is inferred here that the "Itiaso-domain" is sited south of this river.

The geological map, as well as two cross sections of the Upper Proterozoic near Lake Tanganyika are shown on figure 4A (modified after HALLIGAN, 1963).

If we do not consider the very limited extent of "Kigonero", equivalent of Mosso-Musindozi in the Malagarazi domain, all of these successive lithological sequences are characterized by their areno-pelitic composition.

Attention is drawn on the limited extent of "Manyovu Red Beds" (M.R.B.) in an isolated region near the Malagarazi river (fig. 4A).HALLIGAN (1963, p. 13) mentioned that these M.R.B. "are well developped in two areas. The succession is slightly different in the two areas, but both are characterized by a great thickness of fine grained red sandstones. "These two different areas may be distinguished as separate regions on figure 2A: the northern area (named Kasulu, by

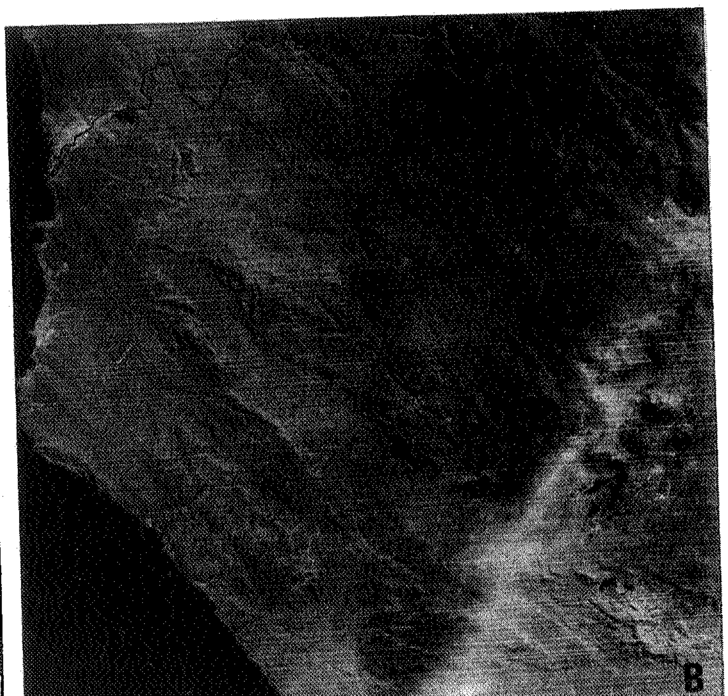


Fig. 4. ITIASO DOMAIN.
A. GEOLOGICAL MAP AND CROSS SECTIONS IN THE ITIASO DOMAIN (modified after Halligan, 1963).

B. PART OF LANDSAT IMAGERY OF THE ITIASO DOMAIN.

HALLIGAN and location shown on figure 4A) in fact belongs in the present hypothesis to the Malagarazi domain (which is part of the Kibago according WALEFFE, 1965), whereas the southern area still shows geometrical similarity with the Itiaso domain, sited along Lake Tanganyika.

As mentioned by HALLIGAN (1963), all geologists which have been working in the Itiaso region draw attention on "the repeated tectonic activity during Upper Proterozoic sedimentation in this part of Tanzania".

The Upper Proterozoic sedimentary units of the region are subdivided by HALLIGAN in three main "Group if we join his Busondo and Masontwa Groups in one single major B-M Group (fig. 4A). These three main groups become than respectively Itiaso-, B-M- and M.R.B.-Groups, all confined to the area sited south of the Malagarazi river.

Obviously these "Groups" show a younging of the stratigraphic succession from south to north.

The situation is very schematically interpreted on figure 5.

5. ITIASO BASIN EMPLACEMENT RESULTED AS A NW-ORIENTED PULL-APART BASIN IN LEFT LATERAL STRIKE-SLIP REGIME, AFFECTING ITS LOWER PROTEROZOIC (UBENDE BELT) BASEMENT INTERPRETATION (fig. 5).

The WNW-NNW lineament set of the Itiaso region also develops in the southern Ubende belt : near the contact between Upper- and Lower Proterozoic terrains the Ubende WNW structure as it appears on Landsat imagery, may be interpreted as the leading lithological boundary direction, clearly crosscut and off set by mainly NNW oriented tectonic structures.

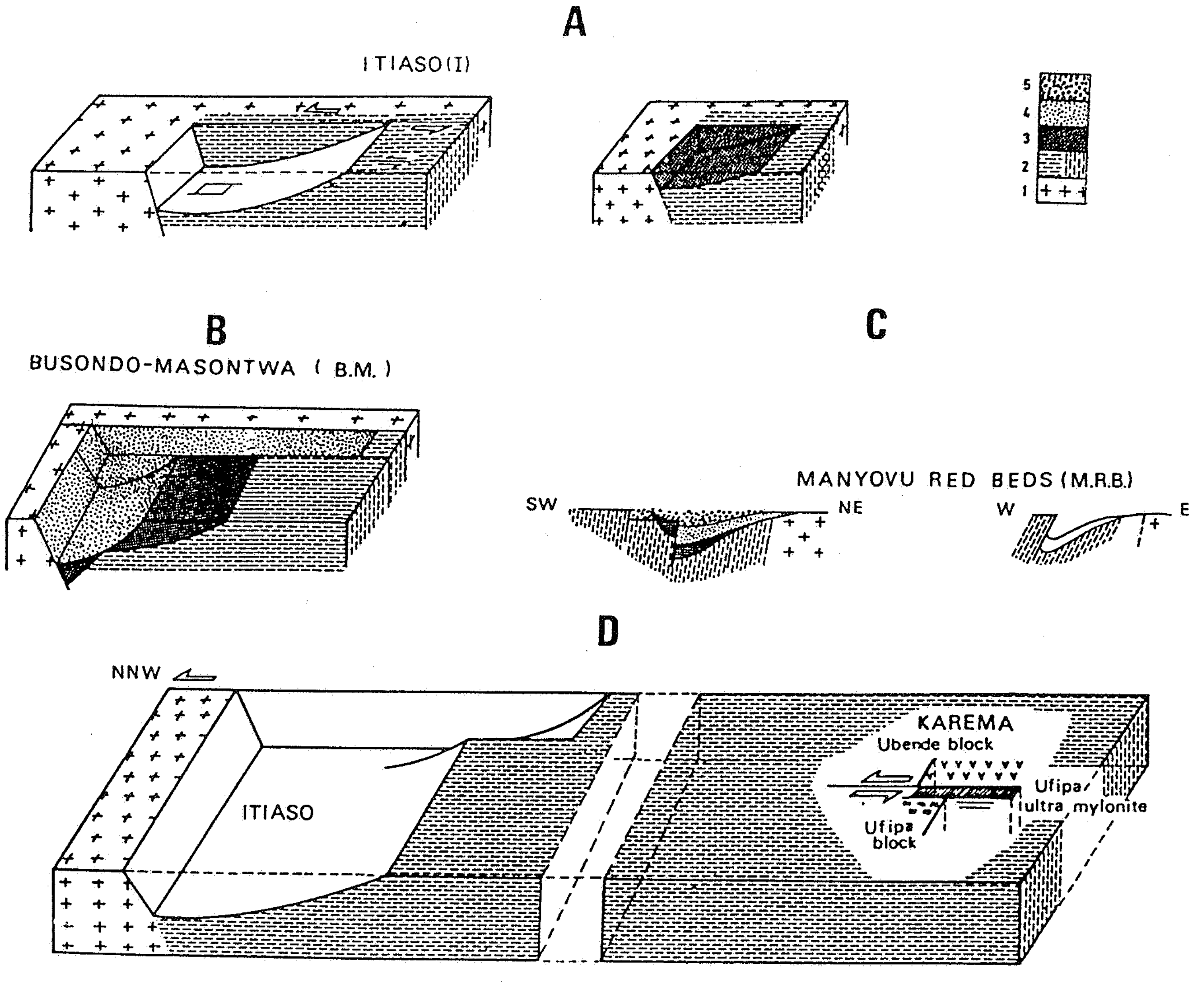


Fig. 5. ITIASO BASIN EMPLACEMENT MECHANISM IN NNW ORIENTED LEFT LATERAL STRIKE-SLIP.

Legend : 1. Archaean, 2. Ubendian belt, 3. Itiaso Group, 4. Busondo-Masontwa Groups, 5. Manyovu Reds Beds.

A. CREATION OF A PULL-APART BASIN (Aydin et al. , 1982) ON LOWER PROTEROZOIC UBENDE BELT. INFILL WITH ITIASO GROUP SEDIMENTS. SCHEMATICAL BLOCK DIAGRAM.

B. BUSONDO-MASONTWA DEPOSITS IN A COMPOSITE PULL-APART BASIN.

C. MANYOVU RED BEDS, TRANSGRESSIVE UPON FORMER DEPOSITS (simplified cross section). Eastern margin evolves into a half-graben situation.

D. THE ITIASO PULL-APART BASIN HAS BEEN EMPLACED UPON THE UBENDIAN BASEMENT IN WHICH LEFT LATERAL STRIKE-SLIP, AS THE LEADING DEFORMATIONAL EVENT, IS OBSERVED AT KAREMA.

Near Karema(localized on fig. 2), south of the Itiaso region, the Ubende belt has been structurally investigated recently (THEUNISSEN, 1988) : it has been stated here that in the Ubende belt, two blocks (Ubende- and Ufipa- as shown on figure 5D), that in many aspect show striking different evolutionary characteristics, are in tectonic contact along a narrow but consistent strip of roughly NNW trending ultramylonites, exhibiting all scale structural features in favor fortheir belonging to a left lateral strike-slip deformational event. These ultramylonites furthermore have been emplaced in very shallow conditions, sharply contrasting with the high grade metamorphic conditions appearing in both blocks outside their contact area.

Considering this deformational feature occurring in the Lower Proterozoic basement on one hand, and the NNW-WNW outlined rhomb-shape in the Upper Proterozoic basins of Itiaso (fig. 4B) on the other hand, it is here postulated that both events reflect the same geodynamic environment (fig.5D).

The WNW-NNW linear pattern is shown internally in the general outline of the different "Groups" and also appears as the main boundary of the "Itiaso-through" as a pull-apart basin (AYDIN *et al.*, 1982). The emplacement mechanism of the Upper Proterozoic sediments in this Itiaso domain clearly calls for a left lateral strike-slip regime along NNW oriented structurally reactivated basement.

Figure 5 shows the generalized these schema of the successive stages as,may be proposed for the Itiaso evolution, by that deformational mechanism, based mainly on the "rhomb-graben and rhomb-horst" geometrical relationships as demonstrated by AYDIN *et al.* (1982). The postulate farther infers that the Itiaso Group are the oldest sediments, laid down in the pull-apart.

The northern boundary of the Itiaso domain is assumed to be sited near the Malagarazi river.

6. BUKOBA DOMAIN MAJOR CHARACTERISTICS (fig. 6)

Geology of the Bukoba region (schematically outlined on fig. 6A), sited west of Lake Victoria, is much less studied in detail than is the case for Itiaso.

Probably the fairly monotonuous lithology of these Upper Proterozoic sediments did not necessitate a similar detailed geological mapping as was necessary for Itiaso.

Because of the lack of any detailed data on structural features geometry is not fully exploited here

For the present contribution we will mainly stress attention on the next significant features which characterize this domain and which are schematically outlined on figure 6 :

- broadly NNE oriented "basin",
- concordant with the general structural trend of the Kibara belt sited on the west; the contact is mapped as a normal fault,
- the bassin is build up by a thick pile of detritic sediments, which are mainly pelitic in the lower half and mainly arenitic in the upper part of the sequence,
- all these sediments are stated by HALLIGAN (1963) as representing shallow water deposits over the entire sequence, implying a continuously subsiding basin. Conglomeratic interbeds are rare and generally the sandstones are well sorted,
- basic intrusions are mainly described as "sheet like" or sills which seem to occur preferentially near the arenitic upper part. These sills seem to occur more to the south of the domain and also appear in Kavumwe (Malagarazi domain). It is therefore postulated that their feeding dykes may appear nearby the ENE trending Musongati lineament (see Malagarazi domain), separating the Bukoban and Malagarazi domains.separating the Bukoban and Malagarazi domains.
- probably along a roughly NW trend there is a break in the general trend of the basin near Nyamagojo (locality shown on figure 6A). Very weakly WNW trending lineaments appear in this part of the Bukoba Landsat imagery,
- the neighbouring Kibara belt appears as a major anticlinal structure in the core of which Archaean basement is locally outcropping and assumed here to extend over most of the anticlinal core (fig. 6B),
- to the west of this anticlinal structure the Kibara belt is more complexely structured and intruded by granites,
- east of the Upper Proterozoic sediments,the Archaean cratonic block of Tanzania is sited,
- the Upper Proterozoic strata overly the never observed contact between the Tanzanian craton and the Kibara belt,
- the dominant lineament pattern (fig. 3), in the southern part of this Bukoba region definitely is a NNE-ENE set : the NNE direction is structurally concordant with lithological boundaries in the basin and also with the dominant NNE trending Kibara belt structure, whereas ENE clearly defines the southern boundary of the domain (Kavumwe on figure 6B),
- Bukoba Sandstone, are correlated by WALEFFE (1965) with the Nkoma in Burundi.

The Bukoba domain is a rather weak link in the present investigation because of lack of information,compared with both other domains.

7. MALAGARAZI DOMAIN MAJOR CHARACTERISTICS (fig. 7)

Its major characteristics, dealt with here, may be deduced from the geological map or the "Malagarasien" in Burundi, shown on figure 7A (simplified and slightly modified after WALEFFE (1965), from its major Landsat lineament pattern (fig. 3) and from particular features appearing in its Kibara basement and schematically outlined on figure 7B.

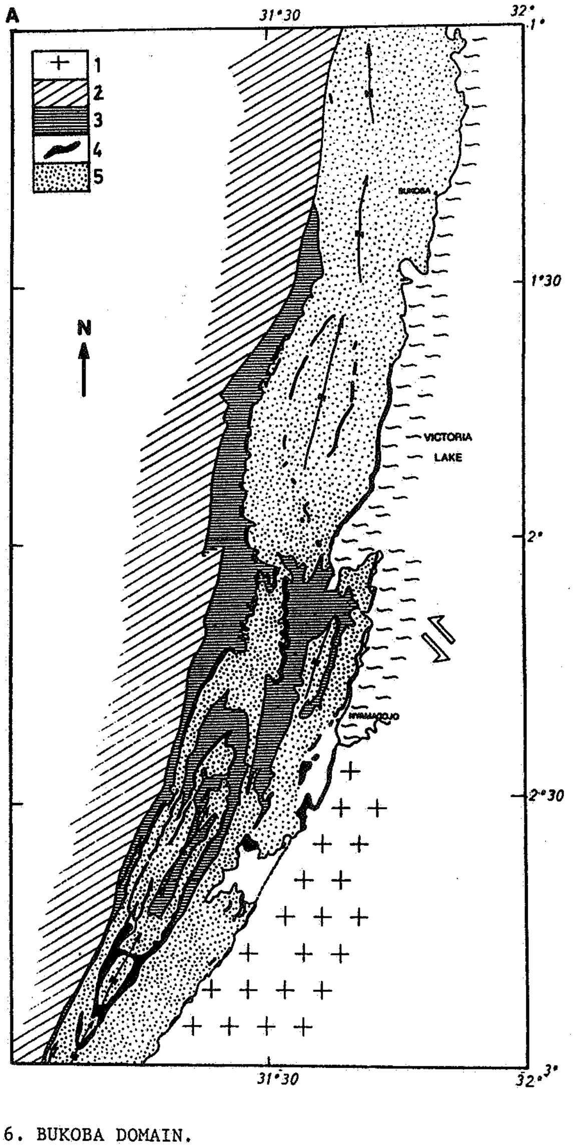
Large part of the domain extends in Tanzania, where geological mapping is however hindered by the occurrence of recent cover (fig. 1) over a wide region.

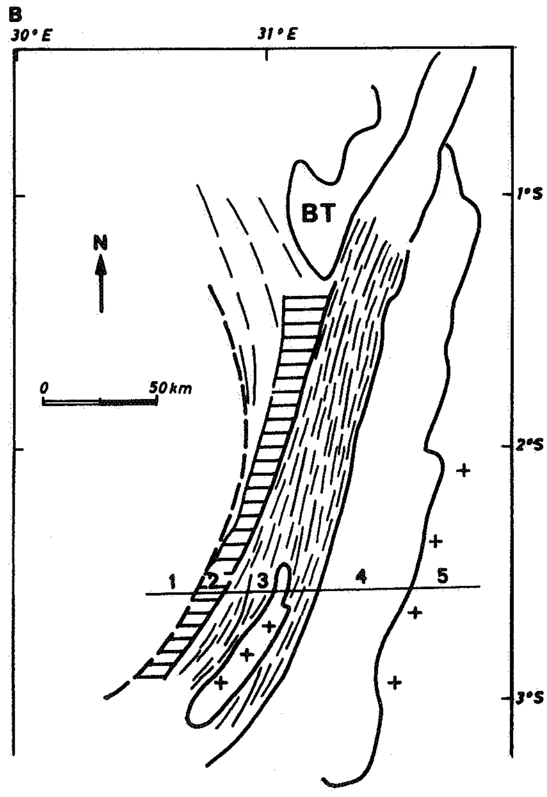
The emplacement mechanism of the Upper Proterozoic basins is largely based on data obtained on Burundi's Malagarasien. The lithostratigraphy of the Malagarasien in Burundi is summarized in table 1 (from WALEFFE, 1979).

As a very contrasting characteristic with both Itiaso- and Bukoba-domains, the present Malagarasi domain is mainly build up by calcareous sediments (fig. 7A, B); the areno-pelitic lithology is confined to small areas (Nkoma- and Kavumwe-formations of WALEFFE (1965).

The Kibago formation is identified in Burundi and on equivalents in Tanzania, as typically transgressive deposits upon older sequences of Upper Proterozoic as well as upon Kibara- and Ubende basements.

As we already mentioned for the Itiaso domain, this Kibago (of Burundi) extends in Tanzania, where it is shown by HALLIGAN (1963) that the deposits are different in the Kasulu region (located on fig. 4A), which is interpreted here as part of the Burundian Kibago sequences on one hand, and in the region south of the Malagarasi river, for which the "Manyovu Red Beds" appellation of HALLIGAN is here maintained.





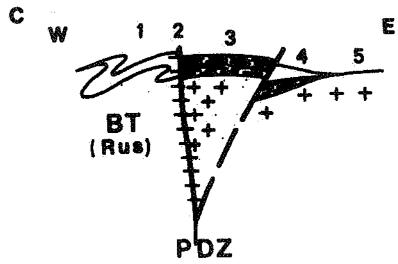


Fig. 6. BUKOBA DOMAIN.

A. COMPILED GEOLOGICAL MAP OF UPPER PROTEROZOIC SEQUENCES.

Legend : 1. Archaean, 2. Kibaran, 3. Upper Proterozoic sills of mafic intrusions, 4. Lower pelitic sequence of Upper Proterozoic, 5. Upper arenitic sequence of Upper Proterozoic.

B. MAJOR CHARACTERISTICS (schematical map view).

Legend : 1. Intruded and highly deformed Kibaran, 2. Mafic- and ultramafic belt (from van Straaten, 1984), 3. Weakly deformed Kibaran, 4. Buganda-Toro, 5. Archaean.

C. INTERPRETATIVE SCHEMATIC CROSS SECTION, CONSIDERING THAT MAFIC INTRUSIONS AND UPPER PROTEROZOIC BASINS APPEAR IN THE SAME DEFORMATIONAL ENVIRONMENT (PRINCIPAL DISPLACEMENT ZONE, PDZ of fig. 8B).

Legend : Idem of B

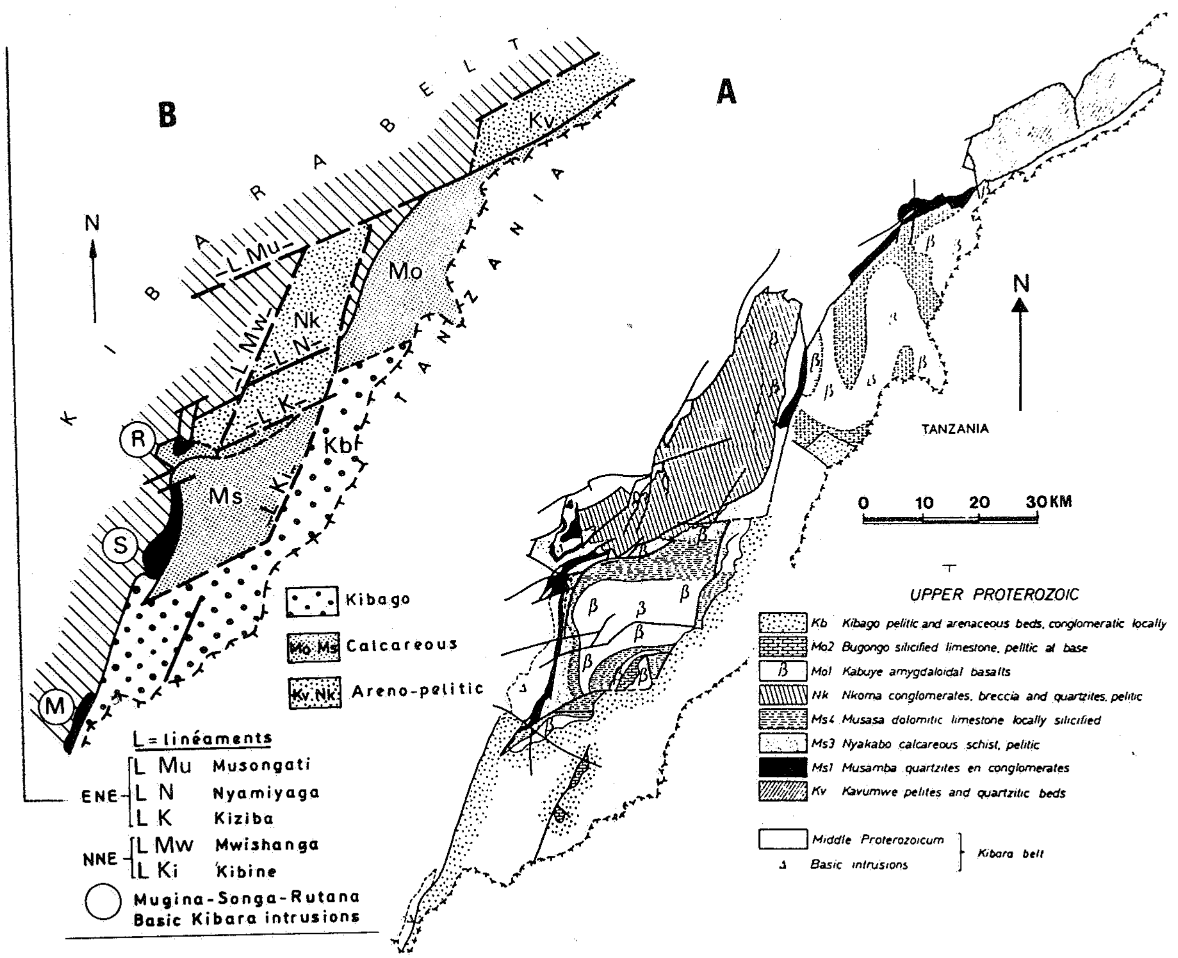


Fig. 7. THE "MALAGARASIEN" IN BURUNDI.

A. GEOLOGICAL OUTLINE (slightly modified after Waleffe, 1965, 1979).

B. IDEALIZED RHOMB SHAPED LITHOLOGICAL BOUNDARIES OUTLINED BY ENE-NNE LINEAMENT GEOMETRY

Taking into consideration these characteristic and different lithologies and accentuating the dominant linear features, subscribing internal lithological differences in the domain, the idealized schema of figure 7B is obtained.

The Kabuye basalts extend into Tanzania as the Gagwe basalts,where they have been mentioned (HALLIGAN, 1963) as "subaerial lava-flows";whatever this later qualification may represent, it fits in the shallow-water depositional environment of the interbedded stromatolitic limestones.

The detritic Kavumwe- and Nkoma formations (WALEFFE, 1979) may be mutually correlated. The bases of both formations are unknown. The Nkoma is partly overlain by Kabuye basalts and is also outlined by NNE and ENE directed linear features (fig. 7B). No intrusions have been stated until to date in the Nkoma. The Kavumwe is mainly pelitic (WALEFFE, 1979) and is intruded by basic sills. The Kavumwe is therefore stratigraphically correlated with the lower part of the Bukoban lithology, which is dominantly pelitic (fig. 6).

Nkoma- and Kavumwe- formations appear in contact with the Kibara basement (fig. 7B) of the Malagarazi domain; both are nearly enterely fault-bounded.

The linear pattern of the NE trending rhombs of Upper Proterozoic terrains in the Malagarazi domain clearly extends into its Kibaran basement (fig. 3).

As was the case for the Bukoba domain, there is also an Archaean inlier near the southeastern boundary of the Kibara belt in the region of Nyanza-Lac (southern Burundi). West of this nucleus the Kibara belt is complexely structured and highly metamorphic (Vyanda area, localized on figure 13). The Archaean basement itself is part of a rather weakly deformed external part of the Kibara belt, where local complex structures are typically shear-related (THEUNISSEN, 1988).

This "external" part of the belt bears many basic- and even ultra-basic intrusions, which are in shapr contrast with the western dominantly granitic intruded terrains.

Three mafic intrusions occur along the contact between the belt and its Upper Proterozoic cover : Mugina, Songa and around Rutana. Other similar intrusions (TACK *et al.*, 1987) occur inside the belt and a large ultramafic intrusion is known at Musongati. This latter intrusion is bounded in its southern limit by an ENE trending lineament, which we name the "Musongati-lineament" (fig. 7B). Along trend and to ENE the Kavumwe Upper Proterozoic "basin" is bounded by this lineament set.

This ENE oriented "Musongati-lineament" also occurs on the sharply outlined transition between the Bukoba domain in the north and the present Malagarazi domain in the south.

The Mugina-Songo-Rutana basic intrusions are lined up along a NNE oriented "M-S-R- lineament", which is parallel with some major linear structures in side the Kibara belt, but also with the boundaries between Upper- and Middle Proterozoic terrains (fig. 7B).

The Nkoma is over a large part NNE oriented and only in its southern extremity (Rutana) it appears ENE oriented : it is completely fault-bounded, except where WALEFFE showed the Nkoma unconformably overlying the Mosso. This feature will be dealt with later.

As was the case for the Bukoba, domain the present domain is also lying in the area, where the contact between the Middle Proterozoic Kibaran belt and its Archaean foreland is assumed to occur.

The lineament pattern outlined on the Landsat imageries in the Tanzanian part of the present domain still shows similar geometry with the Burundian "Malagarasien". Although Kibara is expected underneath the Tanzanian part, linear features appear far to the East, where the Archaean craton is outcropping: the contribution of this cratonic structural pattern to the emplacement of the Malagarazi domain is not dealt with here.

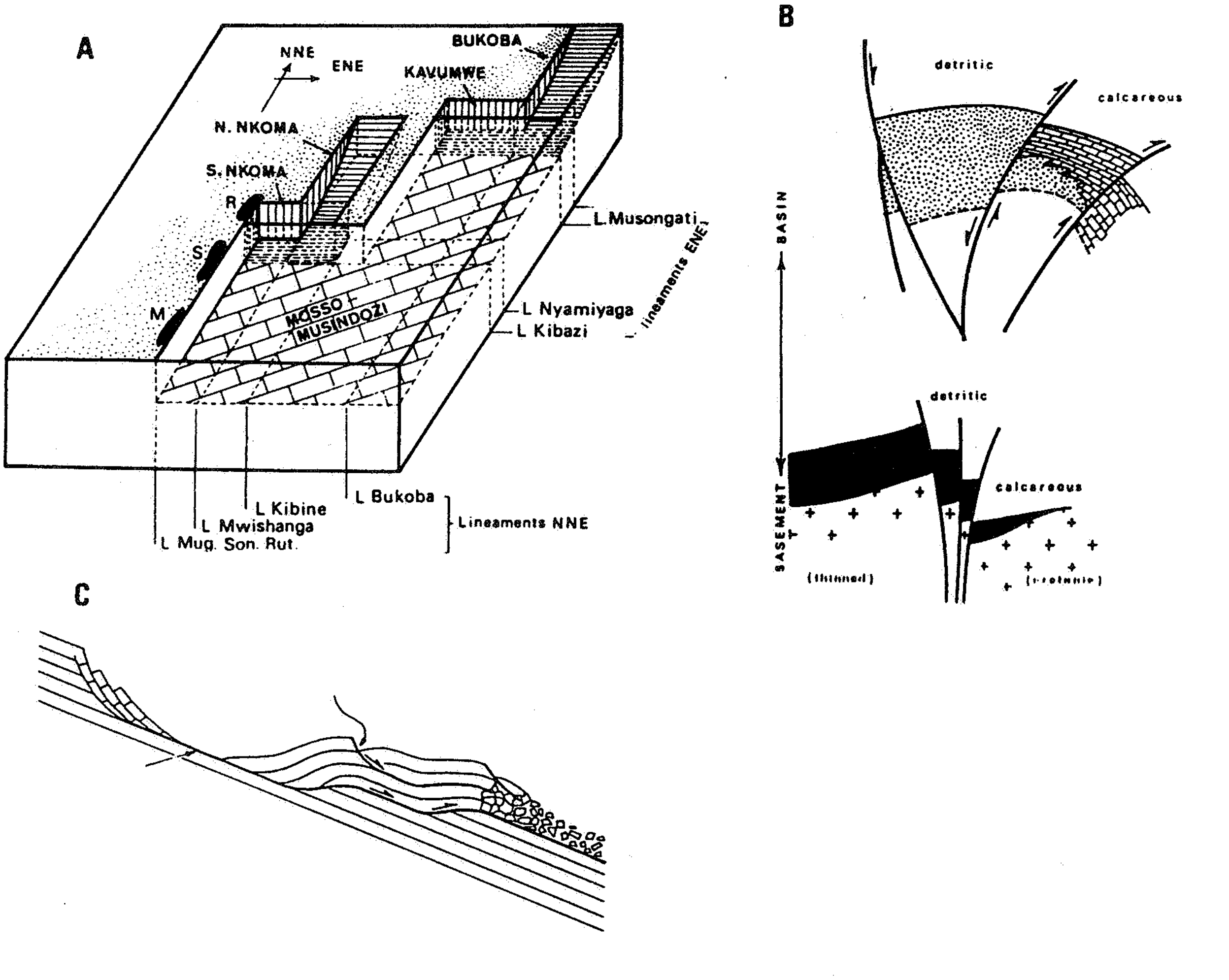


Fig. 8. MALAGARAZI- AND BUKOBA BASIN EMPLACEMENT. INTERPRETATION.

A. LINEAMENTS, BASINS, LITHOLOGY, KIBARA BASIC INTRUSIONS.

B. RHOMBS PREFERENTIALLY APPEAR IN DETRITIC BASINS OVERLYING THE ASSUMED "P.D.Z.", CALCAREOUS BASIN IS SITED SE.

C. LAND-SLIDES (from Gawthorpe et al., 1985) AS AN ALTERNATIVE FOR NKOMA LITHOLOGICAL AND STRUCTURAL FEATURES.

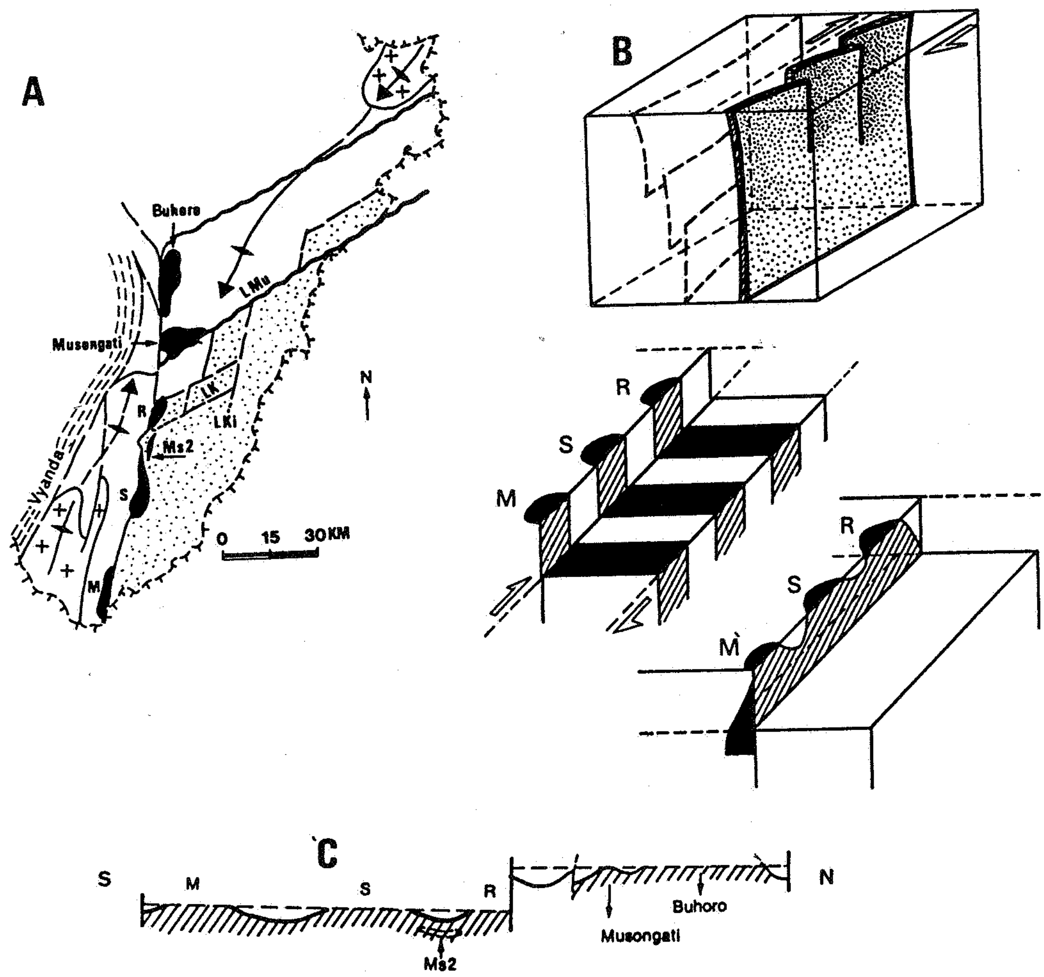


Fig. 9. KIBARA BASIC AND ULTRABASIC INTRUSIONS.

A. SIMPLIFIED MAP VIEW

B. INTERPRETATION OF GEOMETRICAL ARRANGEMENT RELATIVE TO THE UPPER PROTEROZOIC "STRIKE-SLIP" BASINS. M.S.R. basic intrusions related to "P.D.Z." (after Aydin et al., 1985) as one single intrusion (// to the lineament) or as separate dykes.

C. BUHORO- AND MUSONGATI BASIC INTRUSIONS, LINED UP ALONG THE MUGINA-SONGA-RUTANA LINEAMENT, BUT TOPOGRAPHICALLY SITED ON HIGHER LEVEL (roughly N-S schematic section along M.S.R.).

8. BUKOBA- AND MALAGARAZI- BASINS EMPLACED ACCORDING RIGHT LATERAL AND NNE ORIENTED STRIKE-SLIP, AFFECTING THEIR KIBARAN BASEMENT. INTERPRETATION (fig. 8 and 9).

As far as available information is concerned, which is mainly confined to the Burundian region, the present Upper Proterozoic basins may be satisfactorily explained as strike-slip related.

Unambiguous evidence is however not demonstrated here and adequate investigation should be performed essentially on structural and sedimentological features.

The following points are therefore merely indications rather than proves of the mechanism; they have been put together in kind of a "model" emplacement as schematically drawn on figures 8 and 9.

1. Ms2 is an intrusion (DE PAEPE *et al.*, in press) : figures 8 and 9.
   - It is therefore no longer of stratigraphical use.
   - The basaltic flows (Kabuye and Gagwe), thus occur only in the Mosso- and Musindozi stromatolitic limestones, which are the uppermost deposits in this calcareous basin. These basalts also occur on top of the detritic Nkoma formation. At time of extrusions, the uppermost strata of the detritic Nkoma and the the calcareous Mosso-Musindozi, occupied suitable paleoreliefs for "subaerial" basaltic flows to accumulate.

Obviously these flows occur preferentially south of the "Musongati" lineament (ENE), which separates Bukoba- and Malagarazi basins : the Malagarazi basin (detritic and calcareous) was thus suitable for lava-flows to accumulate, whereas these conditions do not exist far to north of the "Musongati" lineament (i.e. Bukoba basin).

   - The Ms2 extends (fig. 8A) concordantly to the Upper Proterozoic basin margin, itself concordant to the NNE uplined three basic intrusions of Mugina, Songa and Rutana sited on the M.S.R. lineament.

Wheter Ms2 is a sill or a dike, it may easely belong to the Kibara M.S.R.

intrusions (fig. 9A, C) as f.e. part of Songa or Rutana : margin-concordant faulting is indeed very frequent in the Malagarazi domain (fig. 7A).

- When Ms2 is indeed a Kibara intrusuion, this would imply that until to date no Upper Proterozoic basic intrusions have been observed in the Malagarazi domain, except in the Kavumwe, where the sills of the Bukoba domain appear.

Whatever this statement might represent, it looks that the Upper Proterozoic sills or "sheet like" basic intrusions occur preferentially around the Bukoba-Malagarazi basin boundary, which is best outlined by the ENE-trending lineament set of "Musongati".

2. The preferential site and rhombic shape of the detritic sequences, relative to the calcareous lithology

If we do not consider the uppermost and transgressive Kibago deposits, the areno-pelitic detritic lithology of Bukoba, Kavumwe and Nkoma occurs in narrow elongate regions, fault bounded on their contact with their basement, as well as on their contact with the calcareous lithology. Their geometrical pattern fits very well in the schematical lineament geometry, as shown on figure 8A.

Although rhombs also occur in the calcareous part (and particularly on the regional scale, shown on figures 2 and 7) they are less well evidenced.

The detritic lithology is therefore assumed to concentrate in conti nuously, rapidly subsiding and probalby deep "strike-slip" basins (see Nkoma features), on the margin of which the undeep calcareous basin is evolving (fig. 8A and B).

3. Nkoma features (fig. 8B and C)

- The bottom of the Nkoma basin is unknown.
- The unconformity between Nkoma and Ms3, as stated by WALEFFE (1965) is thus disputable : which sequence of the Nkoma thick arenitic pile is seen by WALEFFE overlying the Ms3 ?

  In terms of a strike-slip basin environment, similar "unconformities" may be expected as explained by CHRISTIE-BLICK *et al.* (1985) and shown on figure 8B.
- The Nkoma is known as a very thick arenitic pile : Nilsen *et al.* (1985) demonstrated that thicknesses of sedimentary rocks in strike-slip basins a comparable to or greater than their widths.
- Badly sorted "fan-glomeratic" lenses are frequently stated in the Nkoma, particularly south of Rutana. As far as we visited this area, our observations indicate that at least part of these badly sorted (frequently subangular pebbles) lenses may be very likely explained as landslides, in terms of GAWTHORPE *et al.* (1985). Furthermore this statement may be quoted also as partly responsible for local layer-concordant "schistose" fabric encountered in the Nkoma : any distinction between Kibara basement rocks of the region and these Nkoma sediments on ground of that "layer-concordant" local schistose fabric, becomes thus ambiguous.

  On figure 8C, the land-slide figure of GAWTHORPE *et al.*(1985) is shown: our observations measurements) are added as an example. Nearly synsedimentary tectonic (strike-slip) instability may produce bedding-slip until in the deepest part of the basin.

4. Basement features (fig. 9)

Although obviously complicated by other lineaments, the NNE and ENE oriented Bukoba- and Malagarazi domainal lineaments clearly appear inside the Kibara belt (fig. 3).

In southern Burundi (fig. 9A), the southeastern part of the belt, compared to the northwestern part, is generally weakly folded, except where local, and then intense shear is stated. Shearing deformation is obvious near the Nkoma basin at Mwishanga and south of Rutana, where highly sheared Kibara rocks occur side by side with nearly horizontal and unaffected Kibara equivalents.

Structurally (see layer-concordant schistose fabric above) as well as lithologically, a distinction between Kibara- and Nkoma rocks becomes inconclusive.

Although no detailed structural analysis on the Kibara belt has been performed until now, in order to identify Upper Proterozoic basin emplacement mechanism, it is assumed by us that these local shear is in good agreement with "strike-slip" environment.

Structural investigation should however take into account that this area of Nkoma is considerably affected by recent reactivation (rift emplacement).

5. Kibara basic- and ultra-basic intrusions (fig. 9).

- Because of their geometrical arrangement inside the Kibara belt may be tentatively related to the Upper Proterozoic basin shape, and because of their preferential occurrence in this eastern most part of the belt, these intrusions are here considered as fitting in the general geodynamic environment.
- Three basic intrusions, Mugina, Songa and in a less well extent Rutana, conspicuously occur along the NNE oriented boundary between the Kibara belt and the Malagarazi basin (fig. 7B, 8A and 9A).

The NNE oriented lineament also appears inside the basement. As already mentioned, the Ms2 might belong to this intrusives. They are assumed to have been emplaced during the late Kibara deformational event (KLERKX *et al.*, 1987; Tack *et al.*, 1987).

To the north (fig. 9A) basic and ultrabasic intrusions occur along roughly similar trend as the Buhoro- and Musongati-massives. The Musongati intrusion is largely sited in the ENE lineament set, which forms the southern limit of that massif. To the east the Upper Proterozoic Kavumwe formation is bounded by the ENE trending lineament set, which at the same time is roughly the boundary between Bukoba- and Malagarazi domains.

For some reason the ENE lineament of Musongati might be a very important feature in the basic magmatism.

Besides structurally significant the NNE and ENE oriented lineaments apparently have also "magmatic" signatures in the Kibara belt.

These lineaments dominate the Upper Proterozoic basins, which are likely strike-slip emplaced.
The basic intrusions may fit in such generalized strike-slip environment as we tentatively show in figure 9B (fig. from AYDIN *et al.*, 1985, applied to intrusions) : the M.S.R. intrusions may belong to one single intrusion, but they may also correspond to individual and, slightly oblique to NNE oriented, dykes extending underneath the Upper Proterozoic basin.

Because of the pronounced topographic difference between the Buhoro and the Musongati intrusions, sited north of the Musongati lineament, on one hand, and the NNE uplined M.S.R. intrusions, south of that lineament, the postulated relationship between all these intrusions is somewhat obliterated : as shown on figure 9C a cross section along the NNE oriented M.S.R. lineament, implies that geometrically the relationship may exist between both domains as well as with the evoked (fig. 9B) right lateral strike-slip emplacement mechanism (Principal Displacement Zone).

These different features, shown by Upper Proterozoic as well by the Kibara basement, may fit in a strike-slip emplacement model. Preferentially occurrence of basic magmatism and localized shear in an otherwise weakly deformed basement, the extension of lineament geometrical pattern from basement inot its sedimentary cover, where they do outline basinal shapes and boundaries as well as lithologically distinct sediments and last, synsedimentary deformation in these cover sequences all have been joined in a roughly NNE trending lateral strike-slip environment.

9. DISCUSSION AND CONCLUSIONS

The postulate is largely based upon structural observations performed on the Ubendian belt at Karema. The extrapolation of the leading deformational mechanism, affecting the basement to the north, in the basin environment of Itiaso, is based upon particular geometrical pattern, associated to such strike-slip regime.

Roughly the postulate so far may be realistic for the Itiaso domain. Even for this case however, we can not confirm that the structural behaviour of the Ubendian belt, as stated at Karema, is responsible for the emplacement of the Itiaso pull-apart basin; the Ubendian belt is known for its repeatedly intervening character during successive deformational events, occurring in that part of eastern Africa, as dealt with amongst others by KLERKX (1988), THEUNISSEN (1988) as far as the Kibaran belt is involved.

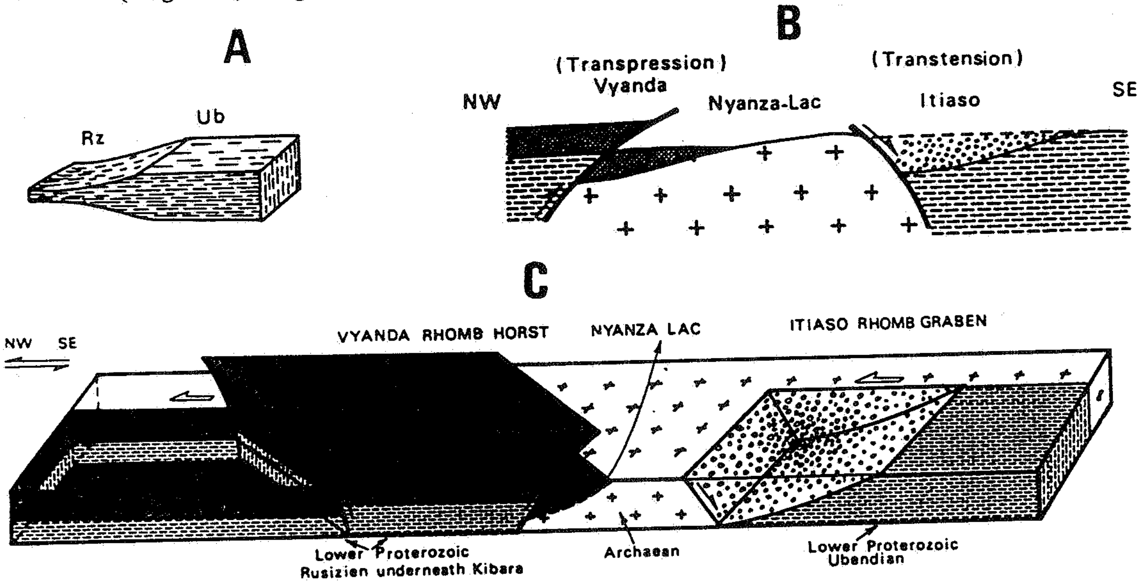


Fig. 10. NNW ORIENTED LEFT LATERAL STRIKE-SLIP IN LOWER PROTEROZOIC UBENDE- AND RUSIZI BELT.

A. Rusizien as Lower Proterozoic belt and part of a "thinned" crust underneath the (D2) Kibara belt. The Ubende belt is sited south of the Kibara belt.

B. Schematic NW-SE cross section from Vyanda (N) to Itiaso (S).

C. Block diagram. Modelized emplacement of Itiaso rhomb-graben on the Ubende belt and the Vyanda rhomb-horst on the Rusizien belt, overlain by Kibara.

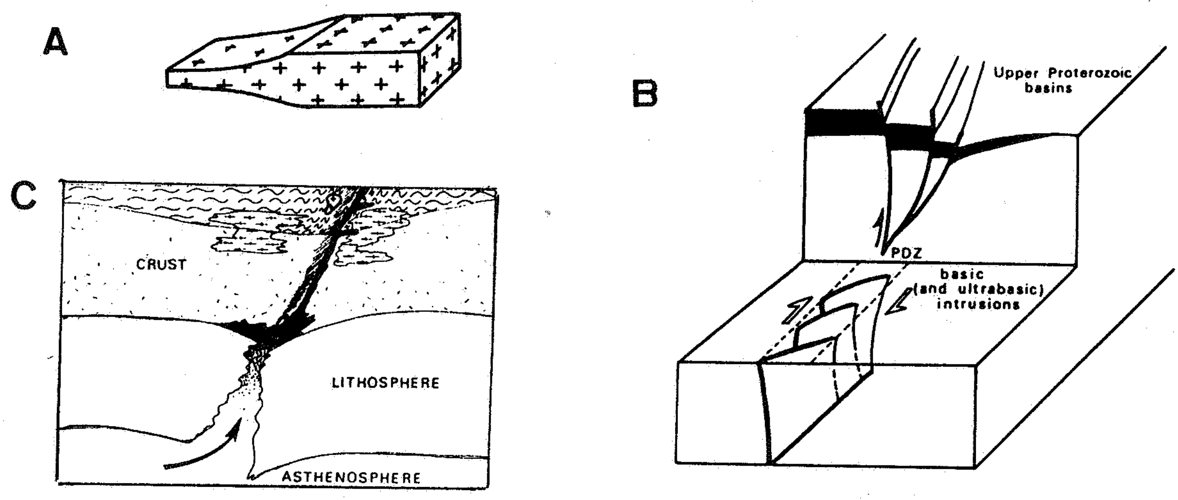


Fig. 11. NNE ORIENTED RIGHT LATERAL STRIKE-SLIP (OBLIQUE-SLIP) ACCORDING THE ASSUMED PRINCIPAL DISPLACEMENT ZONE (P.D.Z.) OCCURRING IN THE THINNED (WEAKENED) CRUST UNDERNEATH THE KIBARA BELT.

A. Thinned crust underneath the Burundian Kibara belt, contrasting with the unaffected Archaean craton of Tanzania.

B. Block diagram. Postulated (geometrical) relationship between the Upper-Proterozoic strike-slip basin emplacement and the (preferential ?) occurrence of Kibara basic intrusions.

C. The "P.D.Z." is tentatively correlated to the model of the Kibara belt evolution (fig. from Klerkx et al., 1987, lithospheric delamination).

Extrapolating the Ubendian structural behaviour into its northern Rusizian equivalent, is still more hypothetical. Not only is the real status of this Rusizian very poorly known, but this Rusizian may have suffered some Kibaran orogenic event (thinning in fig. 10A), which is lacking in the Ubendian.

However in this preliminar contribution, we may assume that the particular characteristic of the Ubendian belt, as a zone of fundamental structural weakness, may be reasonably extrapolated on scale of the entire Lower Proterozoic belt, including thus the Rusizian.

In that way we postulate that the strike-slip regime in the Lower Proterozoic Ubendian-Rusizian belt may result into the Itiaso rhomb graben emplacement (upon Ubendian) and into the emplacement of the Vyanda rhomb horst (upon Rusizian) as respectively appearing in a transtension zone and a transpression zone (fig. 10B), sited south and north of an Archaean block (Nyanza-Lac) as shown on figure 10C.

The Vyanda rhomb horst is bounded in its southern limit by the Nyengwe shear zone, attributed to the late Kibaran deformational event (KLERKX *et al.*, 1987; THEUNISSEN, 1988). In western Burundi this event is outlined by NNW oriented shear zones; in central Burundi the Cene zone is a major shear zone. The deep seated origin of the late Kibaran deformational event, is shown by alkali granite intrusions and even the basic and ultrabasic intrusions are temptatively attributed to the same deformation: crustal delamination is therefore invoked by KLERKX *et al.* (1987) as shown on figure 11C.

The basic and ultrabasic intrusions roughly extend along a NNE trend in the eastern part of the Kibaran belt.

In this contribution we assume that they may fit in a right lateral strike-slip regime along a NNE oriented Principal Displacement Zone (P.D.Z. on fig. 11B) occurring underneath the Kibaran belt, in a thinned or weakened crust (fig. 11A) environment, sited north of the Tanzanian craton.

This mechanism is inferred here to explain the appearance of the Upper Proterozoic Bukoban and Malagarazi domains, as strike-slip basins in front of the reactivated belt (fig. 12).

Temptatively the Kapalagulu basic intrusions, sited west of the Itiaso basin, are here assumed to may belong to the same dynamic environment : CAHEN *et al.* (1984), showed that a late Kibaran event (± 1200 Ma) is recorded by the Kapalagulu.

In the present contribution the Upper Proterozoic basins are thus postulated to have been emplaced in a major strike-slip regime.

However, as shown by READING (1980), there are considerable difficulties in recognizing ancient strike-slip environments because unambiguous evidence is seldom preserved : a major difficulty in the investigated area is the recent rift tectonic event.

We speculate that the leading strike-slip is occurring on the NNW oriented fundamental structural weakness, outlined by the Lower Proterozoic belt, and that NNE oriented

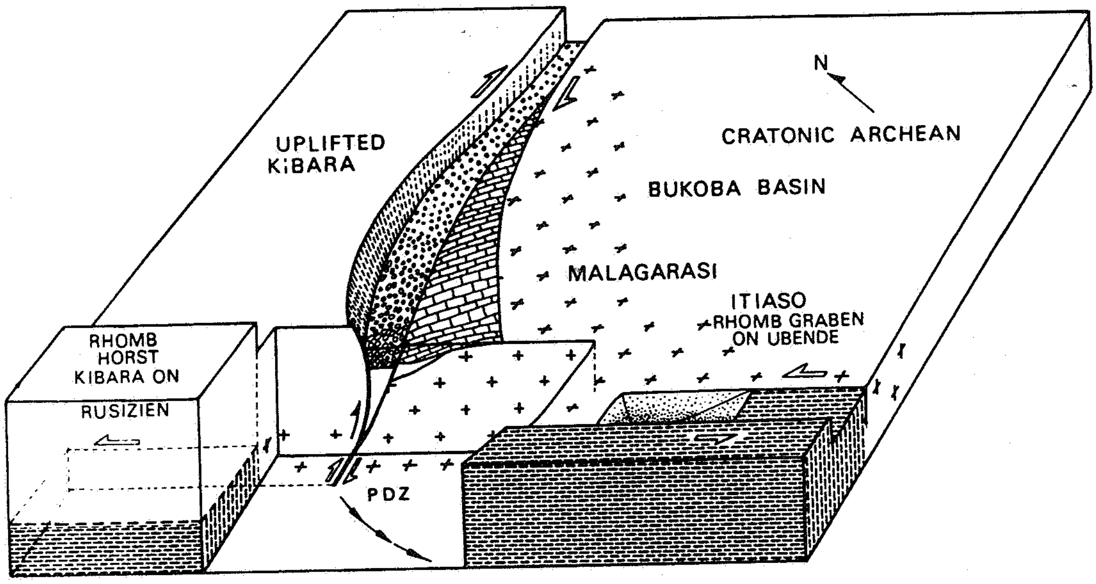


Fig. 12. IDEALIZED BLOCK DIAGRAM OF UPPER PROTEROZOIC BASIN EMPLACEMENT CONTROLLED BY ROUGHLY NNW ORIENTED LEFT LATERAL STRIKE-SLIP ON THE LOWER PROTEROZOIC UBENDE BELT (ITIASO) AND BY ROUGHLY NNE ORIENTED RIGHT LATERAL STRIKE (OBLIQUE)-SLIP ON MIDDLE PROTEROZOIC KIBARA BELT (BUKOBA AND MALAGARAZI).

TABEL 1. - Lithostratigraphy of the Malagarasien (according WALEFFE, 1979)

FORMATIONS		DOMINANT LITHOLOGY
Kibago	: Kb	Detritic, mainly arenites, conglomeratic
Mosso 2	: Mo2	Limestone (± stromatolitic)
Mosso 1	: Mo1	Basalt (Kabuye)
Nkoma	: Nk	Detritic, mainly arenitic (breccia, congl.)
Mutsindozi 4	: Ms4	Limestone (± stromatolitic)
Mutsindozi 3	: Ms3	Calc-pelites
Mutsindozi 2	: Ms2	Basalt (Nyaganza)
Mutsindozi 1	: Ms1	Detritic, only arenitic (breccia, congl.)
Kavumwe	: Kv	Detritic, essentially pelitic

strike-slip (or oblique-slip) in the Kibaran belt is rather an accomodation feature:the NE trending rhombs and their causal Principal Displacement Zone turn off, when reaching the Itiaso region (fig. 12).

The Itiaso-Group sediments, as far as they do not occur underneath the Bukoban- and Malagarazi basins, may represent the oldest sequences of the Upper Proterozoic sediments. This implies that this Itiaso basin has been emplaced prior to both other basins and that indirectly the NNW oriented left lateral strike-slip is indeed appearing first.

Assuming that the NE trending strike-slip set is a structural accomodation of the Kibara belt on the NW trending and leading strike-slip, we postulate that the NW trend is predominant.

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