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CRUSTAL AND UPPER MANTLE ELECTRICAL CONDUCTIVITY STRUCTURES IN WEST AFRICA: GEODYNAMIC IMPLICATIONS

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ABSTRACT

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Measurements of the electrical and magnetic fields at the surface of the earth have been carried out in West Africa in the period range 10–10,000 s. In this area, the method of magnetotelluric (MT) sounding finds its application in a variety of geological problems such as the deep shape of sedimentary basins, the geometry of orogenic belts and craton deep structures. The present article is an attempt to correlate the conductivity model with large scale tectonics. MT surveys have revealed the presence of several areas where electrical resistivity is abnormally low at crustal and upper mantle depths and the existence of lateral electrical conductivity inhomogeneities within the lithosphere. Subsurface electrical conductivity distribution is in good relation with the geological features, and its variation associated with lithological and structural changes. A major discontinuity found at a depth of several hundred kilometers in the lithosphere separates two structural blocks, the eastern one, with higher resistivities, being the West African craton. The lithosphere derived from this work has a maximum thickness of 300 km under the Senegalo-Mauritanian basin and more than 400 km beneath the craton. The electrical asthenosphere is certainly not "well-developed" under the craton. A sketch of electric structures across West Africa is presented and a geodynamic interpretation is proposed to explain the present structural pattern of the southern segment of the Mauritanides belt.

INTRODUCTION

During the last years, electromagnetic surveys (geomagnetic induction and magnetotelluric studies) have first led to the discovery and delineation of several conductive structures in the crust and upper mantle below many regions of the earth with different geological environments, and have shown secondly that lateral electrical conductivity inhomogeneities extend deep in the lithosphere between Phanerozoic and stable Precambrian regions (Drury and Niblett, 1980; Greenhouse and Bailey, 1981; Lilley et al., 1981; Adam et al., 1983). In Africa, the method of magnetotelluric (MT) sounding, in the period range 10–10,000 s, finds the applica-

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tion in a variety of geological environments such as sedimentary basins, orogenic belts and craton. This paper is the result of an integrated review of the geological and geophysical information available on the major tectonic provinces to sort out their main characteristics. Reviews of MT results are given by Ritz (1983, 1984a). The paper is divided into two main sections. The first one includes a study of the electrical conductivity distribution and its relation to the known geology and structure of the major provinces. In the second part of the paper, major differences in the lithospheric electrical structures are connected to main tectonic events that have taken place in West Africa to provide a geodynamic interpretation of the Mauritanides orogenic belt.

The prospected area is commonly divided into three main geological domains (Fig. 1):

(1) The West African craton is an old metamorphic and granitic basement, with structures inherited from the Eburnean orogeny (2400–1800 Ma). A good part of its surface is covered by slightly or not deformed Upper Proterozoic to Paleozoic sedimentary layers (Bessoles, 1977).

(2) The Mobile Belts, bounding the craton, consist of sedimentary and igneous formations of the basement and its cover which have been folded and more or less metamorphosed. The western belt, the Rockelides and Mauritanides, originated during the Pan-African event (Villeneuve, 1984; Culver and Williams, 1979), but the northern part was reworked by the Hercynian orogeny (Dia et al., 1979). The eastern belt arose during the Pan-African orogeny, between 620 and 550 Ma B.P. (Bertrand and Caby, 1978; Liégeois et al., 1983).

(3) The post-Paleozoic sedimentary cover includes the Senegalo-Mauritanian coastal basin and the intracratonic Iullemmeden basin in Niger.

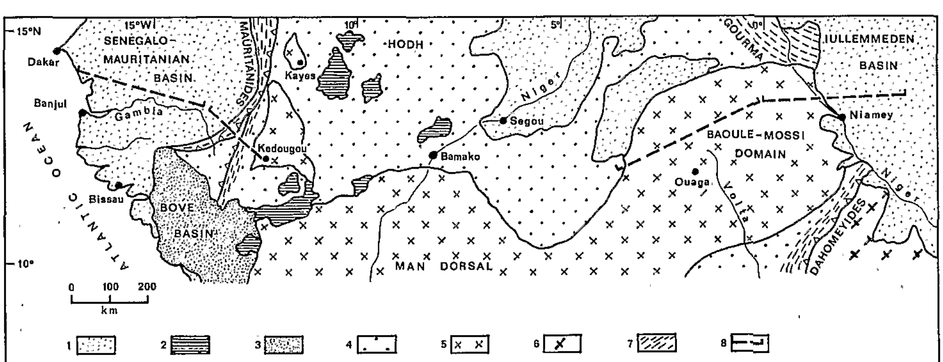

Fig. 1. West African geological units (after the international tectonic map of Africa 1968, modified). *1* = Mesozoic–Tertiary sediments; *2* = Permo-Liassic dolerite; *3* = Siluro-Devonian deposits; *4* = Upper Proterozoic and Cambo-Ordovician deposits; *5* = Eburnean (2200–1800 Ma) basement; *6* = Liberian (> 2400 Ma) basement; *7* = Pan-African belt; *8* = electromagnetic profile.

ELECTRICAL CONDUCTIVITY DISTRIBUTION AND REGIONAL GEOLOGY RELATIONSHIPS

Owing to the fact that measurement sites are widely spaced, geoelectric models are too schematic to be compared accurately with geological data. In addition, the prospected area involves various and complex geological structures. Meanwhile, some good connections can be seen. The electromagnetic profiles cut across the craton in two places: the Baoulé-Mossi Domain (northern part of the Man or Leo Dorsal) and the Kedougou Inlier in eastern Senegal. Both display Birrimian formations tectonized by the Eburnean Orogeny, but Liberian relics (> 2400 Ma) outcrop within the western part of the Baoulé-Mossi Domain. Orogenic belts, Mauritanides and the eastern belt are found on each side of the craton and they are partly covered by the sediments of the Senegalo-Mauritanian and Iullemmeden basins.

Baoulé Mossi Domain

The basement is composed mainly of folded volcano-sedimentary formations (graywackes and slates) and syn- to post-kinematic granites emplaced during the Eburnean orogenesis (Machens, 1973). In the study area (Fig. 2) the Birrimian appears as large slaty belts trending NNE–SSW (Yako, Kaya, Dori and Tera Gassa units) separated by elongated granitic bodies.

The geoelectric cross-sections (Figs. 3 and 4) show a close relationship between the moderate resistivities (100–300 or 100–1000 ohm-m) extending downward from

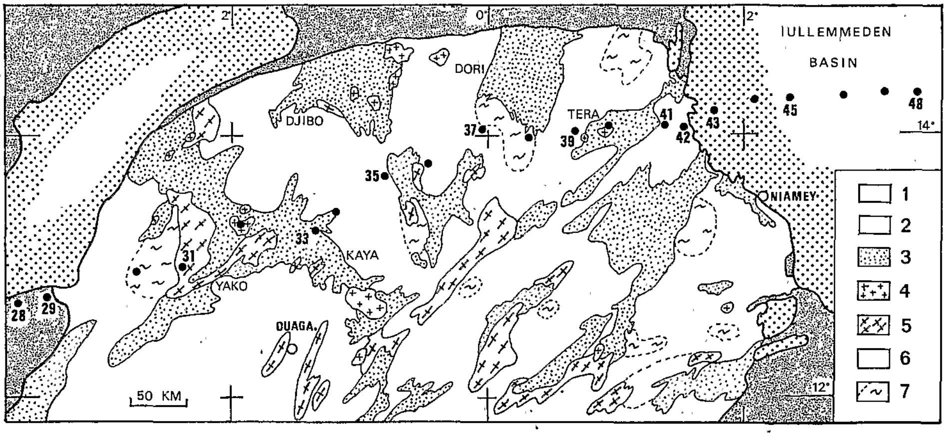

Fig. 2. Geology of the Baoulé-Mossi Domain (northern Burkina Fasso and western Niger) with MT sounding sites (after Bessoles, 1977). *1* = Mesozoic–Cainozoic sediments; *2* = Upper Proterozoic–Lower Cambrian sediments; *3* = Birrimian volcano-sedimentary formations; *4* = post-kinematic Eburnean granodiorite; *5* = syn-kinematic Eburnean granite; *6* = undifferentiated basement; *7* = Liberian relics (gneiss and migmatite).

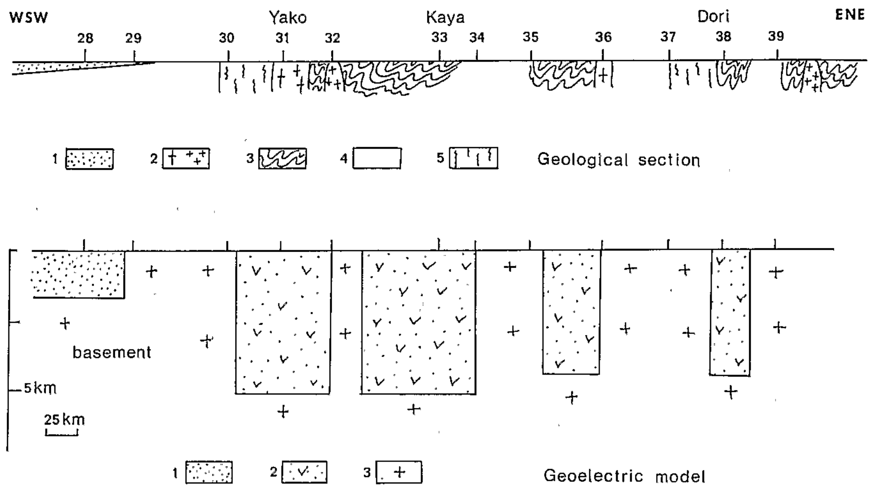

Fig. 3. Geological section and geoelectric model across the western Baoulé-Mossi Domain. Geology: *1* = Upper Proterozoic cover; *2* = syn-kinematic Eburnean granites and granodiorites; *3* = Birrimian volcanic and volcano-sedimentary rocks; *4* = undifferentiated basement; *5* = Liberian relics (migmatites and gneisses). Electric resistivity distribution: *1* = Upper Proterozoic sediments (30 ohm-m); *2* = Birrimian volcano-sedimentary formations (100–300 ohm-m); *3* = Liberian and Eburnean granitic rocks (3000–10,000 ohm-m).

the surface to a depth of about 5 km and sedimentary Birrimian formations. In contrast, the highly resistive zone with values varying between 3000 and 10,000 ohm-m are associated with vast amounts of granitic material. The volcano-sedimentary formations appear as "roof pendants" in granites and migmatites (Ritz, 1983). The model (Fig. 3) reveals the presence of conducting material (approximately 30 ohm-m) on the western part of the profile, which reflects the Upper Proterozoic cover of the craton (Ducellier, 1963).

Kedougou Inlier (Fig. 5)

In eastern Senegal, the West African craton appears through the Upper Proterozoic cover. It displays several sedimentary formations of Birrimian age, trending NE–SW, more or less metamorphosed and folded, in which Bassot (1966) distinguishes:

(1) The Mako group, a submarine eruptive complex interbedded with sediments (graywackes, slates and conglomerates);

(2) The Diale and Dalema groups, characterized by the predominence of flysch facies with intrafomational conglomerates, cipolins and volcanics.

Syn- and post-kinematic granites (2000–2100 Ma) intruded these formations during the Eburnean orogenesis.

MT results have not provided information on the Birrimian formations and the interpretation (Fig. 6) shows only a high resistivity layer (3000 ohm-m) which may

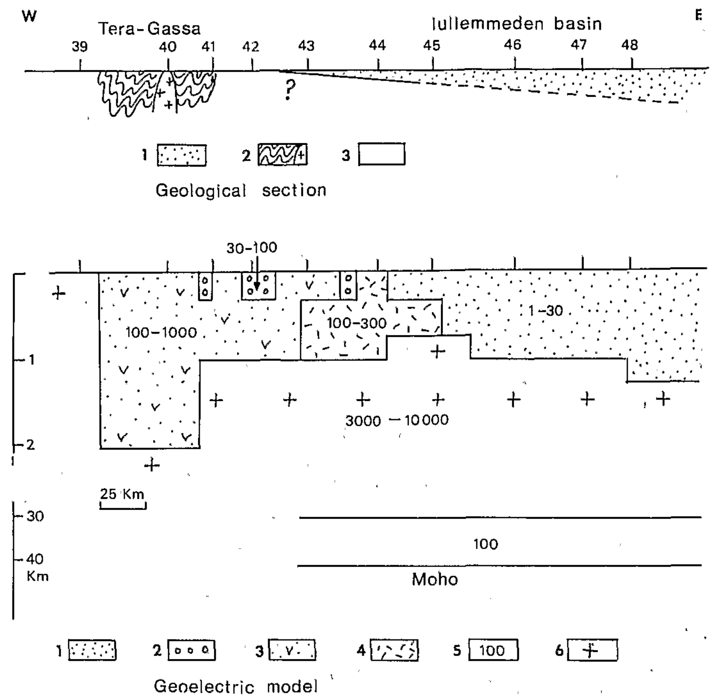

Fig. 4. Geological section and geoelectric model across the eastern Baoulé-Mossi Domain and part of the Iullemmeden Basin. Geology: *1* = Cainozoic sediments; *2* = Birrimian volcano-sedimentary rocks; *3* = granitic rocks. Geoelectric model: *1* = Iullemmeden sediments (1–30 ohm-m); *2* = Birrimian sediments (30–100 ohm-m); *3* = volcano-sedimentary formations? (100–1000 ohm-m); *4* = Proterozoic sandstones of the Volta Basin (100–300 ohm-m); *5* = transition zone crust–upper mantle (100 ohm-m); *6* = granitic rocks (3000–10,000 ohm-m).

represent the Archaean basement. Contrary to the Birrimian units of the Baoulé-Mossi domain, it can indicate the pellicular feature of the Birrimian series in the Kedougou Inlier. Tagential tectonics may be involved because of the outer position relative to the Eburnean belt; the Kedougou Birrimian formations displaying the western most prints of the Eburnean orogeny in Africa.

Mauritanides belt

In the southeastern part of Senegal, Bassot (1966) describes the following groups (Fig. 5):

(1) The Faleme Group consists of a large pelitic synclinorium which shows lateral changes of lithofacies. Eastward, the undeformed Late Precambrian tillite directly overlies the Kedougou basement and the Upper Paleozoic formations are missing. Westward, the tillite is found inside a basic volcano-sedimentary complex and the deformation increases gradually, but metamorphism remains low.

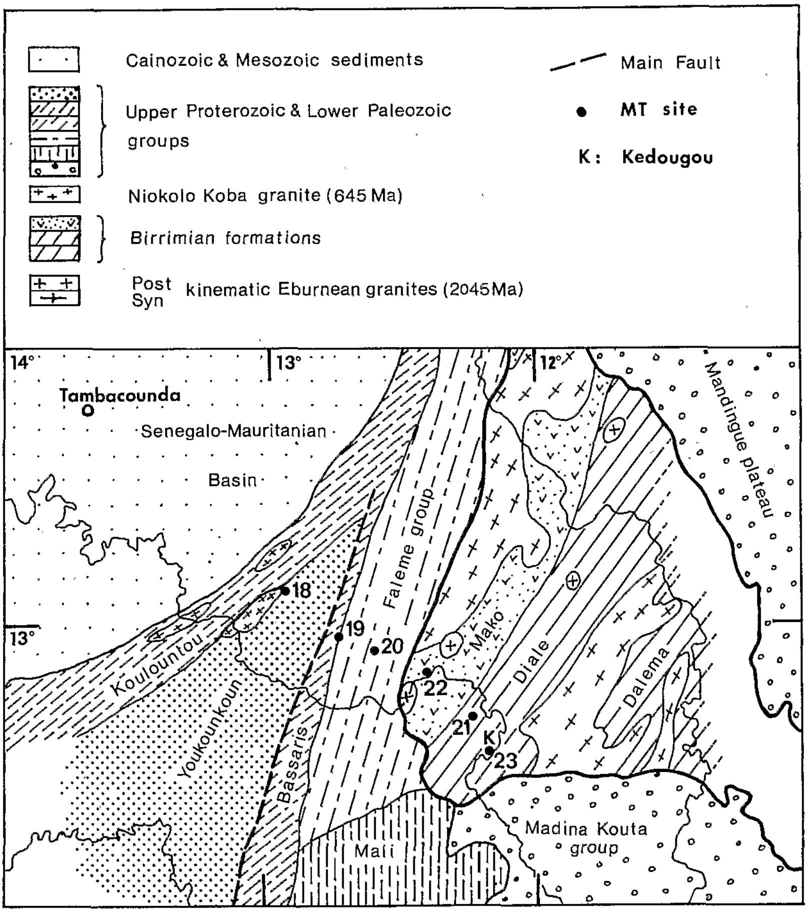

Fig. 5. Geological units of the Kedougou Inlier and the Mauritanides Belt in Eastern Senegal (after Bassot, 1966).

(2) The Bassaris group contains volcanic, volcano-detrital and detrital layers tightly folded and metamorphosed in the greenschist facies. Westward, a prominent vertical fault bounds this group, laterally equivalent to the lower Faleme (Bassot, 1966) or older as suggested by Villeneuve (1984).

(3) The Youkounkoun group consists of thick, non-metamorphic formations that Bassot (1966) interprets as Faleme equivalent. Its lower part is characterized by an acidic volcanic complex (calc-alkaline and alkaline rhyolites) and granitic intrusions.

(4) The Koulountou branch includes reworked gneisses of the basement strongly intruded by calc-alkaline granitic and volcanic material. It is supposed to be a lateral equivalent of the lower Youkounkoun.

In the southern Mauritanides, Villeneuve (1984) proposes to separate the belt into two zones. The central zone, including the Faleme and Bassaris groups, is marked

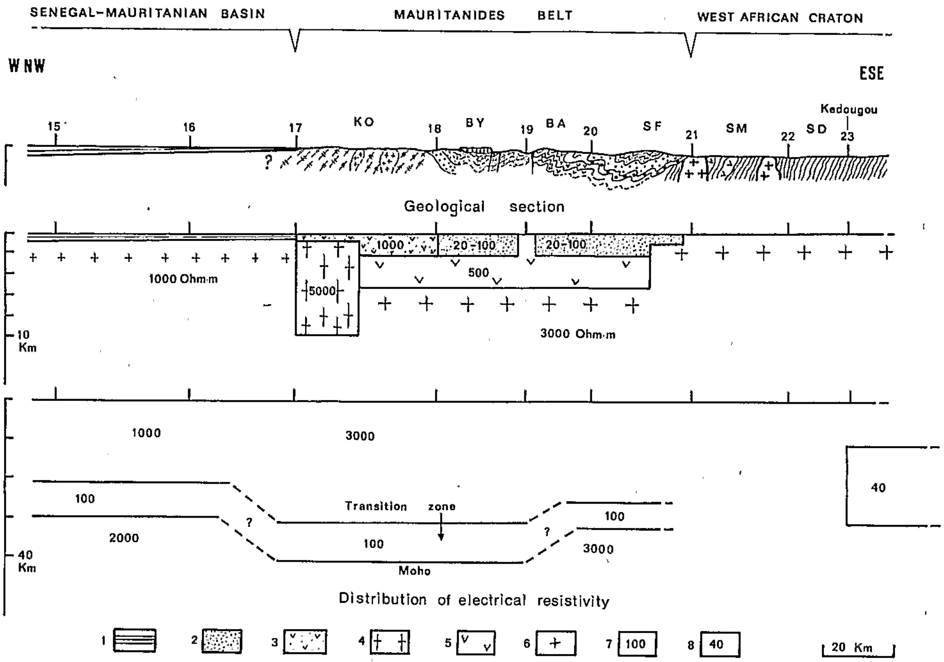

Fig. 6. Geological section (after Bassot, 1966 and Villeneuve, 1984) and geoelectric model across the southern Mauritanides belt. *1* = Mesozoic Tertiary cover (10 ohm-m); *2* = flysch deposits (20–100 ohm-m); *3* = volcanic and granitic material (1000 ohm-m); *4* = basic intrusions or granodiorite (5000 ohm-m); *5* = volcanic and volcano-detrital rocks (500 ohm-m); *6* = basement (1000–3000 ohm-m); *7* = electric resistivity value in the transition zone; *8* = conductive body in the craton. *KO*—Kouloutou branch; *BY*—Youkounkoun group; *BA*—Bassaris group; *SF*—Falème group; *SM*—Mako group; *SD*—Dialé group. *15–23*—MT sites.

out by a tholeitic volcanism interbedded with volcano-detrital sediments. It could correspond to the passive margin of the West African craton. The western zone, (Koulountou branch and Youkounkoun group) displaying calc-alkaline material is interpreted as the active margin of another continent, a Pan-African suture separating the two zones.

One of the possible 2-D geoelectric models constructed (Fig. 6) shows that the basement (3000 ohm-m), outcropping in the craton, sinks under the Mauritanides belt between depths of 6–10 km and reappears under the thin sedimentary formations (< 1000 m) of the Senegalo-Mauritanian basin; however a lower resistivity (1000 ohm-m) is found under the coastal basin. In the 2-D model, the resistivity increases in depth, except below the western part of the Koulountou ridge (*KO*).

Correlation of the relevant electrical zones with the results of geological investigations indicates certain relationships. The model shows trough structures filled with low resistivity material of about 20–100 ohm-m. As much as 3000 m of conductive flysch deposits are correlated with the Youkounkoun (*BY*) and Faleme (*SF*) synclinoriums (Bassot, 1966). The second lower layer seems to have a resistivity of 500 ohm-m and a thickness of about 4000 m and it is assigned to the basal volcanic complex. This complex seems to disappear under the western part of the Koulountou ridge (*KO*) and the eastern part of the Faleme group (*SF*). This resistive structure outcrops at site 19 in the Bassaris ridge (*BA*). Underlying these two layers is a third layer with a much higher resistivity (3000 ohm-m), interpreted as being the basement.

The western part of the Koulountou ridge (*KO*) is characterized by a highly resistive body (more than 5000 ohm-m), which has a minimum thickness of 10 km. Two tentative interpretations can be proposed to explain how this body originated in the upper crust and what kind of material gives rise to high resistivity:

Intrusive basic and/or ultrabasic rocks intruded along a major crustal discontinuity, marked by a positive Bouguer anomaly (Guétat, 1981).

Granodiorite associated with a calc-alkaline magmatism intruded into the basement during the Early Pan-African, in a tectonic setting similar to active continental margins (Villeneuve, 1984).

Eastern belt

In Fig. 1, the Mobile zone is represented to the north by the Gourma belt and to the south by the Dahomeyides belt. Their continuity is masked by the Cretaceous and Tertiary deposits of the Iullemmeden basin. In the study area, Iullemmeden formations overlie unconformably the Proterozoic sediments of the Volta basin and the Birrimian basement (Machens, 1973; Affaton et al., 1980).

The 2-D resistivity model (Fig. 4) on the east end of the profile indicates the existence of a low resistivity (1–30 ohm-m) zone extending from the surface to a depth of about 1000 m depending on the locality. This low-resistivity layer coincides with the sediments of the Iullemmeden basin. Westerly, a 100–300 ohm-m layer occurs beneath the sedimentary rocks and probably corresponds to the Proterozoic formations of the Volta basin. It is underlain by a zone with a resistivity ranging from 3000 to 10,000 ohm-m. This zone of high resistivity, which is observed all along the profile, is interpreted as corresponding to the Archaean basement in the eastern part of the model, the 100–300 ohm-m layer tends to disappear and the Cretaceous–Tertiary sediments lie unconformably on the old basement. No structure can be observed below the Iullemmeden basin which could correspond to the Gourma–Dahomeyides Pan-African belt.

Senegalo-Mauritanian basin

In 1982, magnetotelluric and differential geomagnetic soundings were carried out in the onshore Mesozoic–Tertiary Senegal basin. The survey and its results are described in recent papers (Ritz, 1984b, c). The main result is that a conducting body (less than 30 ohm-m), nearly 90 km large, centered on a zone of N–S flexures and faults along longitude 15°W (Podor–Kolda line), appears at only some kilometers from the surface to a depth of 5 to 10 km depending on the locality. This crustal conductive layer is assumed to mark the existence of a deep, sediment-filled, Jurassic or Paleozoic graben in the Precambrian basement.

SIGNIFICANCE OF ELECTRICAL RESISTIVITY VARIATIONS IN THE LITHOSPHERE

Kedougou crustal anomaly (Fig. 6)

The model indicates the existence, within the craton, of a low resistivity (≈ 40 ohm-m) zone at depths between 10 and 30 km beneath the Kedougou site (Ritz, 1984a). No exact information can be obtained on the lateral extension of this layer at the present stage. However, using the differential geomagnetic sounding, Albouy et al. (1982) show a large conductive anomaly inside the craton trending N30E at Kedougou, which could extend northward over a distance of about 250 km (Mali) and southward up to Guinea. Two interpretations can be proposed to explain low resistivities in the lower crust of a craton: (1) the existence of conductive graphites associated with extensive shear zones in the Precambrian basement (Gough, 1983); (2) the incorporation of hydrated conductive oceanic materials in the present continental crust (Drury and Niblett, 1980). Law and Riddihough (1971) have suggested that conductivity anomalies in stable areas should be associated with geological features marking former plates boundaries. Given the lack of evidence of widespread graphitic zones, the latter mechanism can be envisaged and the conductive structure would represent a Birrimian paleo-suture linked to the ophiolitic complex of the Mako group (Debat et al., 1984).

Low resistivities in the lower crust (Fig. 7)

Conductive structures (transition zones) appear at a depth of 20 to 30 km beneath the eastern part of the Senegalo-Mauritanian basin, the Mauritanides belt and the Iullemmeden basin. On the contrary, the crust–upper mantle transition does not appear to be associated with a pronounced conductivity change beneath the craton and the western part of the coastal basin.

The presence of small quantities of water is a reasonable way to explain the origin of conductive layers in the depth range 20–40 km, as proposed by Hyndman and Hyndman (1968). The water would be supplied by any later thermal reactivation (Greenhouse and Bailey, 1981). Hydration alone is sufficient to explain the observed data (Wyllie, 1971; Van Zijl, 1977). In contrast, the whole of the crust in the craton (except for the Kedougou site) has been fully dehydrated by metamorphic processes.

Upper mantle (Fig. 7)

The low mantle electrical resistivities (50–100 ohm-m) are typically found 130–150 km beneath the craton, and 80–100 km beneath the Mauritanides fold belt and the Iullemmeden basin. Some degree of partial melting (Duba, 1976; Shankland and Waff, 1977) has been the most frequent interpretation for conducting layers in the upper mantle. Another possible explanation is the presence of water produced by amphibole dislocation (Wyllie, 1981) under pressure and temperature conditions found around 90 km.

In the West African craton the resistivity falls to approximately 10 ohm-m at a depth of 460 km. Beneath the whole of the Senegalo-Mauritanian basin a resistivity of 10 ohm-m is reached sooner, around 300 km, indicating the likelihood of a partial melting zone (Ritz, 1984a). The decrease in resistivity found at a depth of 460 km appears to be the same effect noted in global studies and may correspond to the olivine–spinel phase transition (Garland, 1981; Lilley et al., 1981).

Thickness of the lithosphere (Fig. 7)

The lithosphere has a rheologic definition in plate tectonics (Le Pichon, 1972). The notion of lithosphere is not defined by electromagnetic induction studies. However MT soundings in continental areas frequently show a general reduction in mantle resistivity between a depth of 80 and 190 km (Schmucker and Jankowski, 1972; Drury, 1978). At these depths there would be a transition from 1000 ohm-m (or more) down to about 10 ohm-m which might correspond to the lithosphere–asthenosphere transition zone (Jones, 1982).

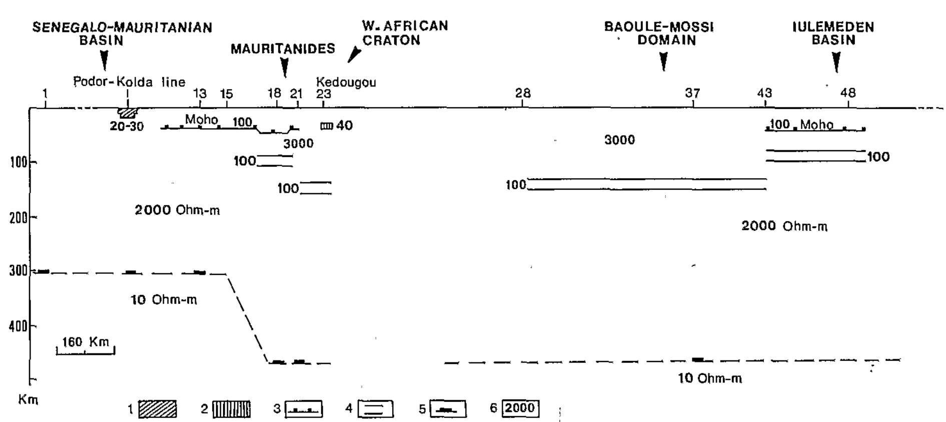

Fig. 7. Sketch model for the conductive structures in the West African lithosphere. *1* = conductive body in the upper crust beneath the Senegalese basin (20–30 ohm-m); *2* = conductive body in the lower crust of the West African craton (40 ohm-m); *3* = crust-upper mantle interface (Moho); *4* = conductive layer in the upper mantle (100 ohm-m); *5* = determined depth of the lowest conductive layer; *6* = electric resistivity value in the upper mantle (2000 ohm-m).

In Senegal, the upper mantle is characterized by a major discontinuity dipping eastward for a depth range of about 300–460 km (Ritz, 1984a). This discontinuity appears also as a vertical boundary in the crust and cuts the surface between sites 15 and 16 (Fig. 6). It separates a moderate resistivity zone of 1000 ohm-m to the west, under the Senegalo-Mauritanian basin, from a higher resistivity (3000 ohm-m) zone to the east under the Mauritanides belt and the craton. This discontinuity coincides near the surface with significant geophysical and structural changes. Two major deep structures can be postulated to explain the nature of the revealed inhomogeneity of the lithosphere in the region under study:

(1) Dorbath et al. (1983) relate a prominent seismic discontinuity, striking N–S, which extends downward from the surface to a depth of 150–200 km, with the trace of a Precambrian east dipping suture.

(2) In his study, Ponsard (1984) evokes the Bissau–Kidira lineament, a major SW–NE Pan-African shear zone.

At the present stage, and because of our linear approach, it is impossible to determine the trend of the large inhomogeneity in electrical conductivity structure observed between the Senegalo-Mauritanian basin and the West African craton. Additional MT studies on another profile have been started to locate precisely the deep anomaly strike.

In continental areas, seismological studies have shown that structural differences may exist down to the upper mantle between Phanerozoic and stable Precambrian regions (Anderson, 1979; Finlayson, 1982). Lilley et al. (1981) see a major conductivity increase at about 200 km depth under the Phanerozoic Australia but not until about 500 km under the Precambrian Australia. In this continental region lateral heterogeneities extend to depths as great as 500 km.

Chapman and Pollack (1974) think, from surface heat flow measurements, that the lithosphere is very thick beneath West Africa, probably more than 400 km, and that the asthenosphere is absent or at least not "well-developed". In old basement and platform areas (East European and Siberian platforms, Canadian shield) characterized by low heat flow, the asthenosphere would be very thin or absent (Chapman and Pollack, 1977; Vanyan et al., 1977). In contrast, "well-developed" asthenosphere is found in tectonically perturbed environments (Adam, 1980).

Beneath the Senegalo-Mauritanian basin, a rapid increase in electrical conductivity is found at a depth of 300 km (Fig. 7) and the transition to a highly conducting layer of the order of 10 ohm-m could be correlated with the top of the asthenosphere. The fact that two conducting zones are detected in the upper mantle under the Mauritanides belt and the craton (Fig. 7), makes the assignment to lithosphere or asthenosphere difficult. However, Vanyan et al. (1977) propose that the electrical nature of the asthenosphere be divided into three categories on the basis of the conductance (conductivity-thickness product). A "well-developed" asthenosphere is defined by Vanyan et al. (1977) as exhibiting a conductance of greater than 1000 Siemens. In the West African craton, the conductance of asthenosphere does not exceed 1000 Siemens (assumed to extend from 130 to 460 km). The West African craton and the Mauritanides belt are characterized by a "poor" asthenosphere.

Thus the MT study in West Africa shows the existence of a major discontinuity in upper mantle conductivity structure, which separates two structural blocks; the east one, with a larger thickness (about 460 km), being the West African craton. The eastern block, which is better anchored, could then exert a restraining action leading to differential stress on the western block. The thickening of lithosphere according to the age (Piper, 1983) would imply that the western block is younger than the eastern one.

GEODYNAMIC SIGNIFICANCE OF THE GEOELECTRIC MODEL FOR THE MAURITANIDES BELT

The study of electric resistivity variations allows us to identify crustal and upper mantle structures and to give some geotectonic markers. The new geophysical informations are here confronted with the geodynamic models already proposed to explain the structures of the belt.

In the lower part of the crust, between 20 and 40 km, an abrupt change in the electric resistivity value is observed. It corresponds to the transition zone (100 ohm-m) between the crust (2000 ohm-m) and the upper mantle (3000 ohm-m) (Fig. 6). From west to east, significant changes of the Moho-discontinuity depth are noticed. The crust, 30 km thick below the sedimentary basin, becomes suddenly thicker (40 km) below the Koulountou branch (*KO*). This paleoroot found under the Mauritanides disappears eastward from the vertical to site 20. It underlines the importance of compressive processes during the formation of the belt. Such processes can occur after the closing of a continental rift (Guétat, 1981; Lecorché et al., 1983) by shortening of crustal blocks of a single continent. Or it is produced by the collision of two continents after resorption of an oceanic domain (Dorbath et al., 1983; Roussel et al., 1984; Villeneuve, 1984). In the geoelectric cross section, the presence of two crustal blocks with different resistivities separated by a deep electrical discontinuity argues for a collision model. However, as pointed out by Villeneuve (1984), some typical characteristics of collision belts are missing in this area, such as HP/LT metamorphism and ophiolitic sequence.

Gravimetry studies show large variations of Bouguer anomaly across the Mauritanides, −40 to +40 mGal from east to west (Crenn and Rechenman, 1965; Guétat, 1981; Roussel et al., 1984). For Guétat (1981) the negative Bouguer anomaly observed on the external part of the belt is partly due to a thickening of the crust. It is also suggested by seismic studies (Dorbath et al., 1983). In a recent gravimetric interpretation, Ponsard (1984) individualizes two crustal blocks separated by a west-dipping suture plane, resulting from the Pan-African collision of the West African craton with a western continent. The overlapping western block is characterized by a higher density and a larger thickness. The suture is underlined by a dense body between 2 and 20 km below the Koulountou branch. This body can be related to the very high resistivity zone observed on the geoelectric model (Fig. 6), where the thickness reaches 10 km. However, the electric model cannot fit with the other gravimetric interpretations. Two crustal blocks are also individualized but the western block is characterized by a lower resistivity and a smaller thickness. The collision model with a west-dipping subduction, deduced from structural, geochemical and gravimetric data, shows some analogies with the geoelectrical model but they differ from one another in the Moho depth below the western and eastern part of the belt.

In their interpretation of a seismic profile Dorbath et al. (1983) propose a subduction model for the Mauritanides belt. A western continent was subducted along an east-dipping plane below the craton after the opening of a back-arc basin ("Faleme trough") and the creation of an island arc (Koulountou branch and Youkounkoun group) during Late Precambrian time. But Villeneuve (1984) contests this model with geological arguments, for instance the 820 and 683 Ma radiogenic ages given by the calc-alkaline material related to the subduction. Furthermore, petrological characteristics of an active margin type of magmatism are found in the western part of the belt. The pelitic formation of the Faleme group, associated with intraplate type of magmatism, were surely deposited in a subsident environment, but most probably in a narrow oceanic basin or maybe in a rift (Hawkins et al., 1984; Villeneuve, 1984).

The geological, geochemical and geophysical characteristics discussed above argue for a Pan-African continental collision to explain the tectonics of the southern Mauritanides belt. Villeneuve's (1984) and Ponsard's (1984) model with a west-dipping suture plane seems, at the present time, the most suitable one to explain the arrangement of the structural units of the belt. But some important elements are missing.

CONCLUSIONS ON THE PAN-AFRICAN MAURITANIDES BELT

When two continents start to drift toward each other, the subduction of the oceanic lithosphere is mechanically more difficult beneath the margin of the thicker continental plate. Subduction occurs on the margin of the thinner and younger continental plate (Poupinet, 1977). This assumption, correlated with MT results in West Africa (Fig. 7), suggests a subduction plane dipping westerly beneath the western continent, if a subduction zone was involved in the Mauritanides belt formation. Consequently, the deep electrical discontinuity observed between 300 and 460 km, with a steep east-dipping, should rather be related to the Bissau–Kidira tectonic lineament, a major Pan-African and Hercynian structure. At a crustal level, this discontinuity is marked by a resistivity contrast between the western (1000 ohm-m) and the eastern block (3000 ohm-m).

In Senegal, Villeneuve (1984) distinguishes 2 zones along the West African craton

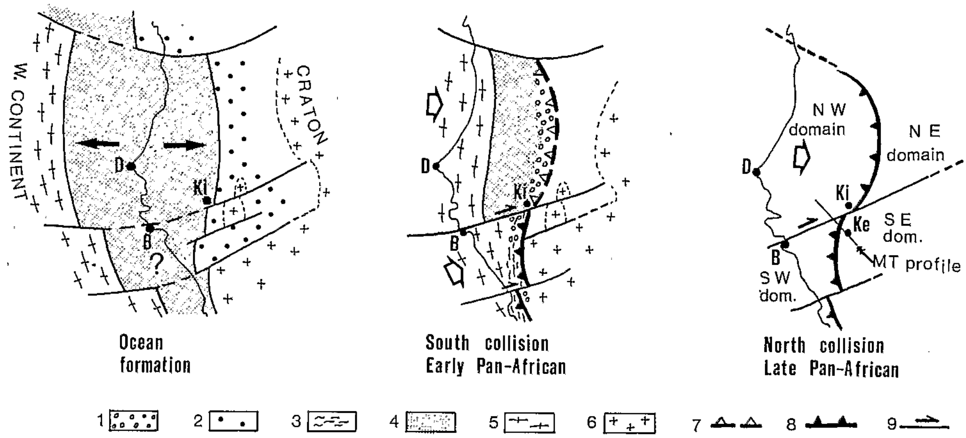

Fig. 8. Geodynamic evolution of the Pan-African Mauritanides Belt (after Villeneuve, 1984). The ocean South of Bissau is questionable; an intracontinental basin on a stretched crust is an alternative model. *1* = Pan-African flysch and molasse; *2* = Proterozoic cover; *3* = Pan-African folding; *4* = oceanic crust; *5* = western continental margin; *6* = eastern continental margin; *7* = subduction; *8* = collision; *9* = fracture zone. *D*—Dakar; *Ki*—Kidira; *Ke*—Kedougou; *B*—Bissau.

margin before the Pan-African event (Fig. 8). Northerly, an ocean was present, as confirmed by Dia's (1984) interpretation of ophiolitic complexes in the Middle Mauritanides, when in the south the oceanic domain was much narrower. The Bissau–Kidira fracture zone separates the two zones. Continental blocks located on each side of this ocean would later collide first in the south, then in the north. Such differential movements were assumed by the Bissau–Kidira transform fault. However, the Mauritanides virgation along this fault zone proves its synchroneous activity with the formation of the belt. Fig. 8 presents the geodynamic evolution of the Pan-African Mauritanides belt (Villeneuve, 1984) with a west-dipping subduction before the collision. The suture zone and the Bissau–Kidira fault divide the area into four domains:

(1) The northwest domain with the Mesozoic–Cainozoic basin covering the Senegalo-Mauritanian microplate.

(2) The southwest domain with the Paleozoic Bové basin covering part of the southern continental block. This block collided with the craton during the Early Pan-African (620 Ma).

(3) The northeast domain related to the West African craton. Its border (passive margin) was reworked by the Late Pan-African event (600–550 Ma).

(4) The southeast domain also related to the craton, but its margin was affected by the Early Pan-African event.

Consequently, the MT sites are located in three domains (Fig. 8), which have a different geodynamic evolution. To the southeast, the MT profile starts within the West African craton, then crosscuts its margin reworked by the Early Pan-African

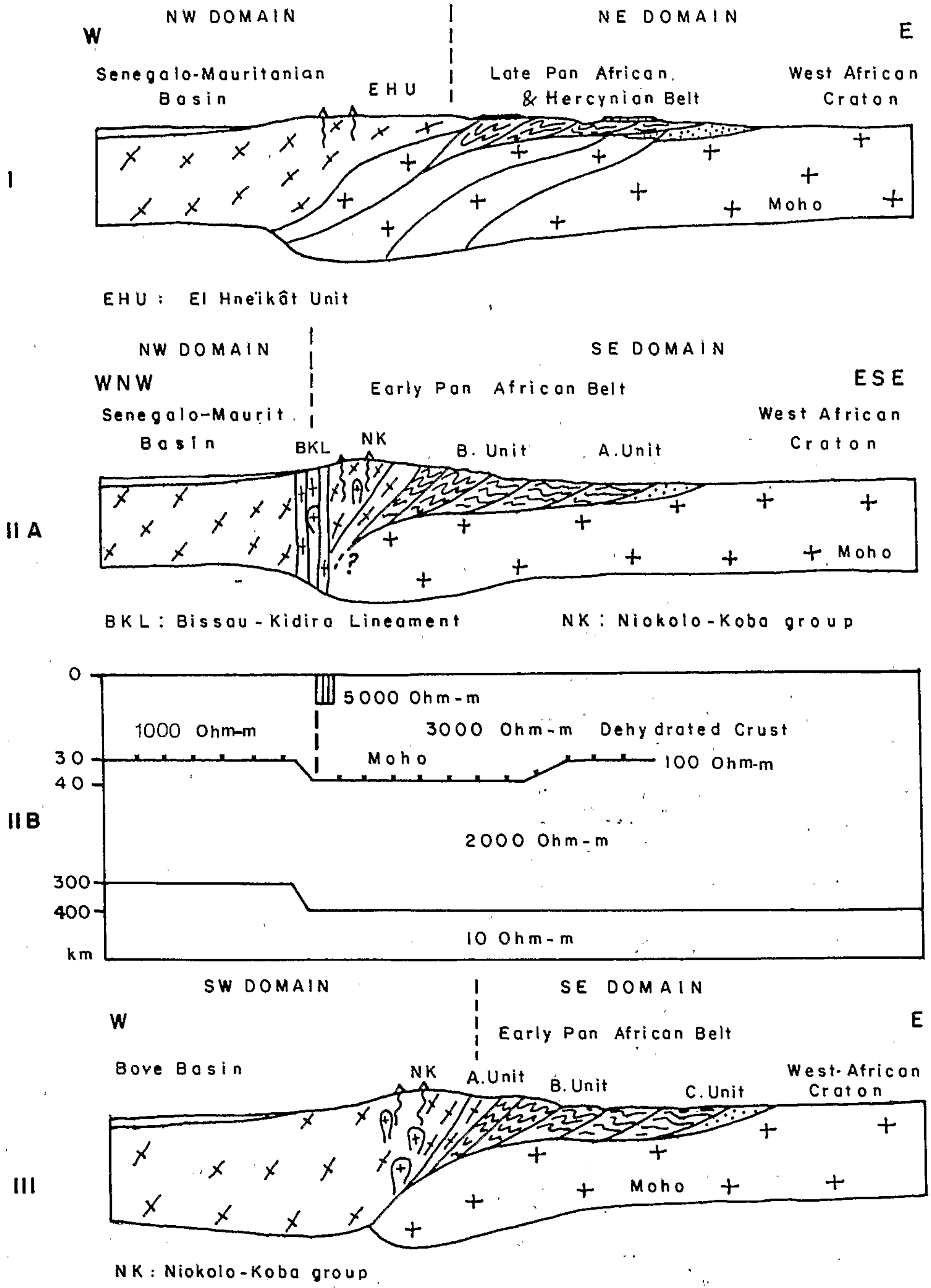

Fig. 9. Geodynamic interpretation of the Mauritanides Belt. I. Middle Mauritanides (after Guétat, 1981 and Dia, 1984). IIA. Eastern Senegal Mauritanides (this study). IIB. Corresponding geoelectric structures III. Southern Mauritanides (after Villeneuve, 1984 and Ponsard, 1984).

event. To the northwest, after crossing the Bissau–Kidira lineament, it enters within the Senegalo-Mauritanian microcontinent which collided with the craton during the Late Pan-African. These three domains, accidentally regrouped through the action of a transform fault, belong to two distinct segments of the belt with a different tectonic history. It is therefore difficult to show an entire cross-section of the belt and to try to locate the trace of a collision. The Bissau–Kidira Pan-African and Hercynian strike-slip fault modified in a determining way the morphology and structure of the belt in the study area, and probably obliterated the structures which are observed to the south. The geoelectric model seems to underline this shear zone by a subvertical high-resistive body beneath the Koulountou ridge (*KO*) and a thickening of the crust beneath the western Mauritanides belt (Fig. 6). The major inhomogeneity in the upper mantle is then attributed to be the Bissau–Kidira deep trace (Fig. 7).

A second profile, to the south, would allow to differentiate the N–S Pan-African suture from the SW–NE Bissau–Kidira lineament and to state precisely the deep conductivity anomaly strike. Presently, observations on the major Bissau–Kidira discontinuity allow us on the one hand to explain why the results obtained cannot fit with a Pan-African suture model (east- or west-dipping), and on the other hand to interpret these results in a simple way, compatible with the established models in the north or the south. We show (Fig. 9) a geodynamic interpretation of the belt along the MT profile, in comparison with geodynamic models proposed for the middle Mauritanides (Guétat, 1981; Dia, 1984) and southern Mauritanides (Williams and Culver, 1982; Ponsard, 1984; Villeneuve, 1984).

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