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DEEP-REACHING FRACTURE ZONES IN THE CRYSTALLINE BASEMENT SURROUNDING THE WEST CONGO SYSTEM AND THEIR CONTROL OF MINERALIZATION IN ANGOLA AND GABON

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ABSTRACT

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A framework of major, deep-reaching fracture zones in western Central Africa is inferred from airborne magnetometric and surface geological observations in Central Angola and Gabon.

A correlation is proposed between these observations and the continental negative Bouguer anomaly.

The minimum age of the inferred tectonic framework is probably Kibaran. Considerable portions are thought to have been reactivated, and others may have only originated at later stages. Its control of major structural units and the distribution of carbonatite complexes and kimberlite occurrence and of diamond and lead-zinc deposits is discussed.

INTRODUCTION

In 1969 and 1970 a project of airborne geophysical and photogeological investigations was carried out by Hunting Geology and Geophysics Limited over an area of approximately 117,000 km^2 in Central Angola as part of the mineral exploration programme of the Companhia de Diamantes de Angola. In 1971 and 1972 a similar survey was conducted in Gabon for the United Nations Development Programme and the Government of the Republic of Gabon over an area of approximately 68,000 km^2. The results of these surveys appear indicative of an extensive structural framework of deep reaching fractures. In view of its function in the emplacement of mineral deposits, in particular those of diamond and lead-zinc mineralization, it could be of interest for mineral exploration in a considerable part of western Central Africa.

THE ANGOLA REGION

In Central Angola a number of long and therefore probably deep reaching fault zones are known in the Precambrian Crystalline Basement (Reis, 1971).

Three strike directions predominate: NE—SW, E—W and NW—SE. In addition, long NNE—SSW striking faults have been observed. Although the latter were not specifically indicated by the results of the airborne magnetometer investigations referred to by Reis (op.cit.), they were on several occasions encountered on the aerial photographs (Hunting Geology and Geophysics, 1970). The most salient "magnetic" fractures are shown in Fig. 1.

Fractures with a NE—SW strike constitute a belt of at least 400 km long and approximately 90 km wide across the outcrop of the Crystalline Basement between Quilengues and Andulo. The major fractures show symmetrical disposition towards the axis of the belt. Alkaline complexes occur along its entire length (De Sousa Machado, 1958; De Vries-Lapido Loureiro, 1967) and the four northeasternmost complexes are situated on the axis proper. This belt is in line with the Lucapa graben in northeastern Angola.

Around latitude 11° 30′ S a 65-km wide E—W fracture belt occurs and intersects with the major NE—SW belt in the Andulo area. At latitude 9° 10′ S another E—W fracture belt constitutes the boundaries of the Malange block in which granulite of the Crystalline Basement appears to predominate (UNESCO International Tectonic Map of Africa, 1969).

West of the River Cuanza a number of NW—SE striking major faults also tend to occur in belts. The most obvious one is between Mutumbo in the southeast and Cela in the northwest, with a width of approximately 25 km. The Mutumba—Cela faults transect the zone of alkaline complexes and the associated NE—SW fault belt in the area of the Capuía Complex. The slight curvature, mainly expressed by the fault line between Silva Porto and the Capula Complex, and an apparent offset of the fault lines around Matumbo in relation to the fault lines southwest and northeast of Cela (Fig. 1) would suggest a sinistral displacement at some time along the Quilengues—Andulo belt. A single fracture line runs from the Vila General Machado area to the northwest, close to the boundary of the Crystalline Basement and the Xisto-gresóso Series of the West Congo System and is apparently part of the tectonic control of the configuration of the present basement outcrop.

In Central Angola a number of outcrops of predominantly quartzite and conglomerate of the Precambrian Oendolongo System have been mapped (Hunting Geology and Geophysics, 1970). On aerial photographs they generally appear as long narrow ridges. The outcrops often represent tight synclines and clearly express strike and dip of bedding. The most prominent ones are shown in Fig. 1. Several outcrops are aligned along major faults described above. The alignment and the often sharp deflection of the fold-axes along intersecting faults would suggest that the faults were already in existence at the time of Oendolongo folding, probably during Kibaran orogenic events, initiating narrow tight synclines between broader anticlines.

In Angola the West Congo System shows predominantly NW—SE fold trends changing to NNE—SSW at latitude 7° S; the edges of the system have the same directions. At the latitude of the River Congo the structural grain grades from NEE—SSW again to NW—SE in Congo-Brazzaville and in

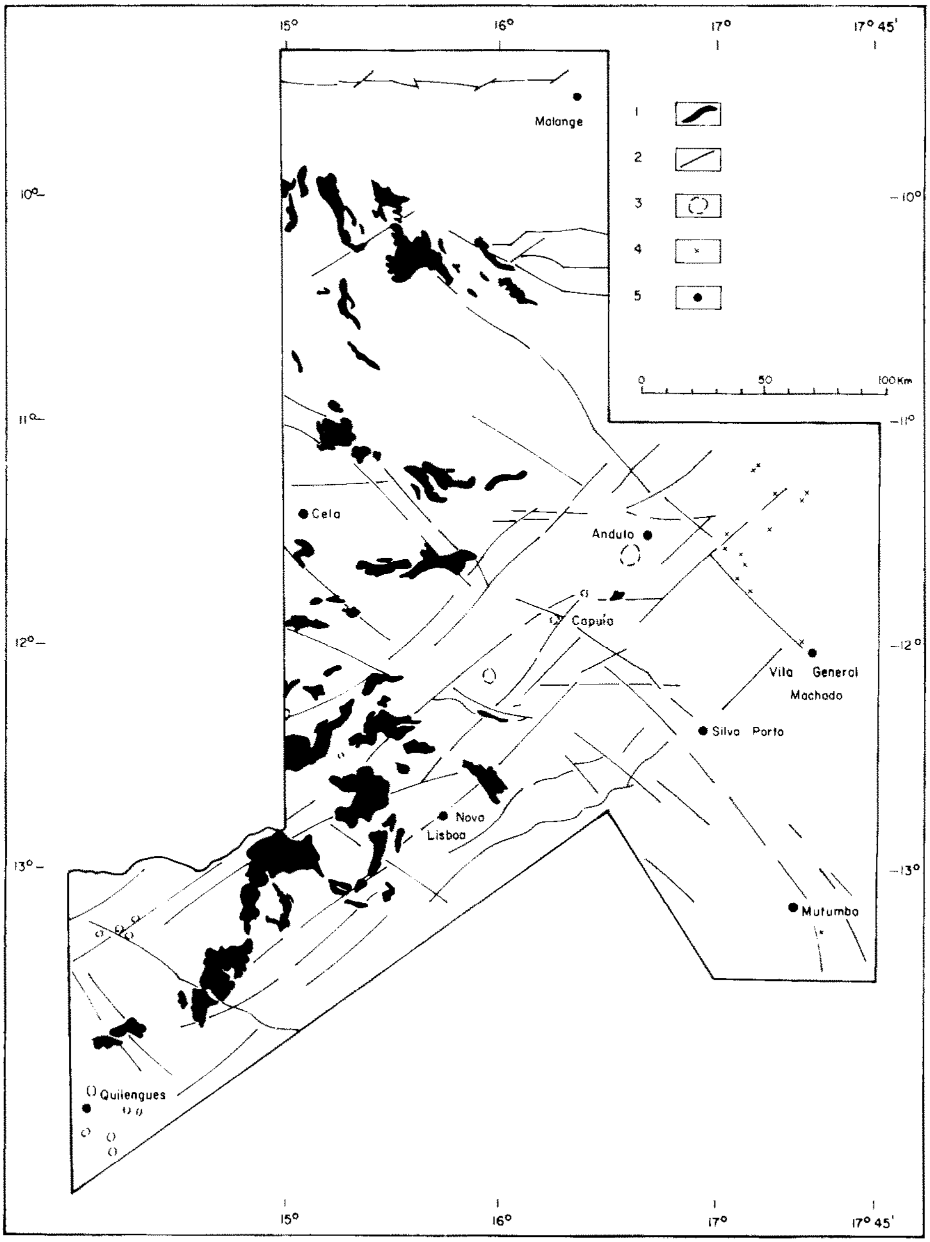

Fig. 1. Structural map of part of Central Angola, in part after Reis (1971): 1 = major outcrop of predominantly quartzite and meta-conglomerate of the Oendolongo System; 2 = major fault interpreted from magnetic contour maps; 3 = Alkaline Complex; 4 = occurrence of kimberlite; 5 = principal town.

Gabon where it abuts against the NNE—SSW striking eastern margin of the Libreville—Port Gentil Basin.

More detailed data on the structure of the West Congo System and the surrounding Crystalline Basement (Basement Complex) is contained in three sheets of the 1:250,000 scale geological map of northern Angola (Direcção de Serviços de Geologı́a e Minas). On two sheets (Naqui—Tomboco and Bembe) the western boundary of the system appears. On the sheet Noçui-Tomboco (Korpershoek, 1964) from west to east three major units occur: the Luanda Basin with Mesozoic—Cenozoic sediments, the Crystalline Basement with predominantly gneisses and migmatites, and the West Congo System with its orthogneisses, granites and low grade metamorphic platform sediments, respectively. The contacts between these units strike approximately NNE—SSW. The zone of Crystalline Basement is about 75 km wide. Outliers of the West Congo System occur on top of the Crystalline Basement as far west as the eastern edge of the Luanda Basin. The contacts between the Basement and the West Congo System are generally defined as thrust faults.

The traces of axial planes of the folds in the gneisses and migmatites often have approximately E—W strike. Refolding of these structures along N—S strike occurs in relation with the main NNE—SSW thrust fault contacts of the West Congo System and Crystalline Basement within a zone of approximately 10 km wide and is particularly intense along the western boundary of the Crystalline Basement strip. The structure underlying the latter zone of refolding is covered by the sediments of the Luanda Basin, however,

Within the Basement zone major faults and "dykes" of siliceous breccia and silicified mylonite are shown with predominantly NNE—SSW to N—S strike, parallel with the trend of the West Congo System. Dykes of intermediate type and lamprophyre occur as well, together with a number of small bodies of ultramafic composition.

The direction and length of the older major fractures in the Crystalline Basement, the configuration of the West Congo System and its structural trends and the coincidence of the northwestern projection of the Machado fault zone with the western boundary of the southern part of the System would suggest that the older features, in particular the NW—SE and the NNE—SSW fractures, may have been conductive towards the initiation of the West Congo Geosyncline. They are thought to have continued to influence its later development. The dykes and fractures in the Crystalline Basement of the Noqui—Tomboco region are here conceived as exponents of the earlier tectonic framework that controlled the configuration of the West Congo System.

The same framework of major fractures appears as a possible control of the configuration of the Luanda, Benguela and Moçamedes Basins. The outline of the coast between Luanda and Benguela would suggest yet another controlling fault belt of comparable magnitude, possibly coinciding with a proved fault zone SW of Nova Lisboa (see Fig. 3).

To the east of the present outcrop of the West Congo System, at a distance of approximately 100 km, the River Cuango flows parallel to the edge of the system over a distance of about 400 km, suggesting that its course is tectonically controlled by a fault zone of a magnitude similar to that of the fault zones described and inferred above.

THE GABON—NIGER REGION

The NW—SE trend of the West Congo System in southern Gabon is taken up to the northwest by numerous NW—SE faults along the northeastern margin of the Libreville Basin (Fig. 2). The geological map of Gabon (Hudeley, 1966) does not indicate specific boundary faults along the West Congo System, although immediately east of the belt a major fault is shown with a NNW—SSE to N—S strike. The eastern and northeastern margins of the Libreville—Port Gentil Basin, like the margins of the coastal basins in Angola, are of a fault-controlled monoclinal type.

Toward the east, in Central Gabon, a NNE—SSW striking fault-controlled zone of approximately 30 km wide is known on the western margin of the Booué—Lastoursville Basin with its gently folded, hardly metamorphic Precambrian platform sediments. To the east the sediments of this basin are separated from those of the Franceville Basin by the Lastoursville threshold with its outcrops of granitic rocks and gneisses. To the south this threshold is continuous with the boundary zone between the Franceville sediments and the Crystalline Basement of the Chaillu Massif. The latter zone is known to be in part controlled by NW—SE striking normal faults. Projection of this zone toward the northwest leads to a belt of NW—SE faults in the Crystalline Basement in the area west of Mitzic (Bardet, 1970).

Further to the north the coast of Rio Muni is controlled by a major NNE—SSW fault zone, probably also of monoclinal character, with a considerable downthrow of the Basement towards the Atlantic (A. Mourot, pers. comm.).

It is noted that the northwestern projection of the inferred Cuango fault zone in Angola coincides with the eastern boundary of the West Congo System in the Kinshasa—Brazzaville area, the western boundary of the Franceville Basin (Lastoursville threshold) and the Mitzic fractures in northwestern Gabon. Further northwestward extrapolation leads to the eastern edge of the delta of the River Niger, with Mt. Etinde and its potassium-rich lavas where it intersects with the Fernando Poo volcanic zone, the lower course of the river and its associated fractures (Furon, 1963; Reyment, 1965) and dolerite dykes to the northwest of Niamey (Machens, 1967), and the Gao trench in Mali (Radier, 1959; Reichelt, 1967; McConnell, 1974).

Along the Cuango—Niger zone several airborne geophysical surveys have been flown at low altitude (150—250 m above ground level). In addition to the surveys mentioned before, aeromagnetic maps have been published for portions of Cameroon and Niger (Canadian International Development Agency, 1972). The aeromagnetic maps of relevant and adjacent areas in Gabon, Cameroon and Niger show only limited evidence on the NW—SE striking major structures inferred above, however. In Fig. 2 the presumed position of the Cuango—Niger

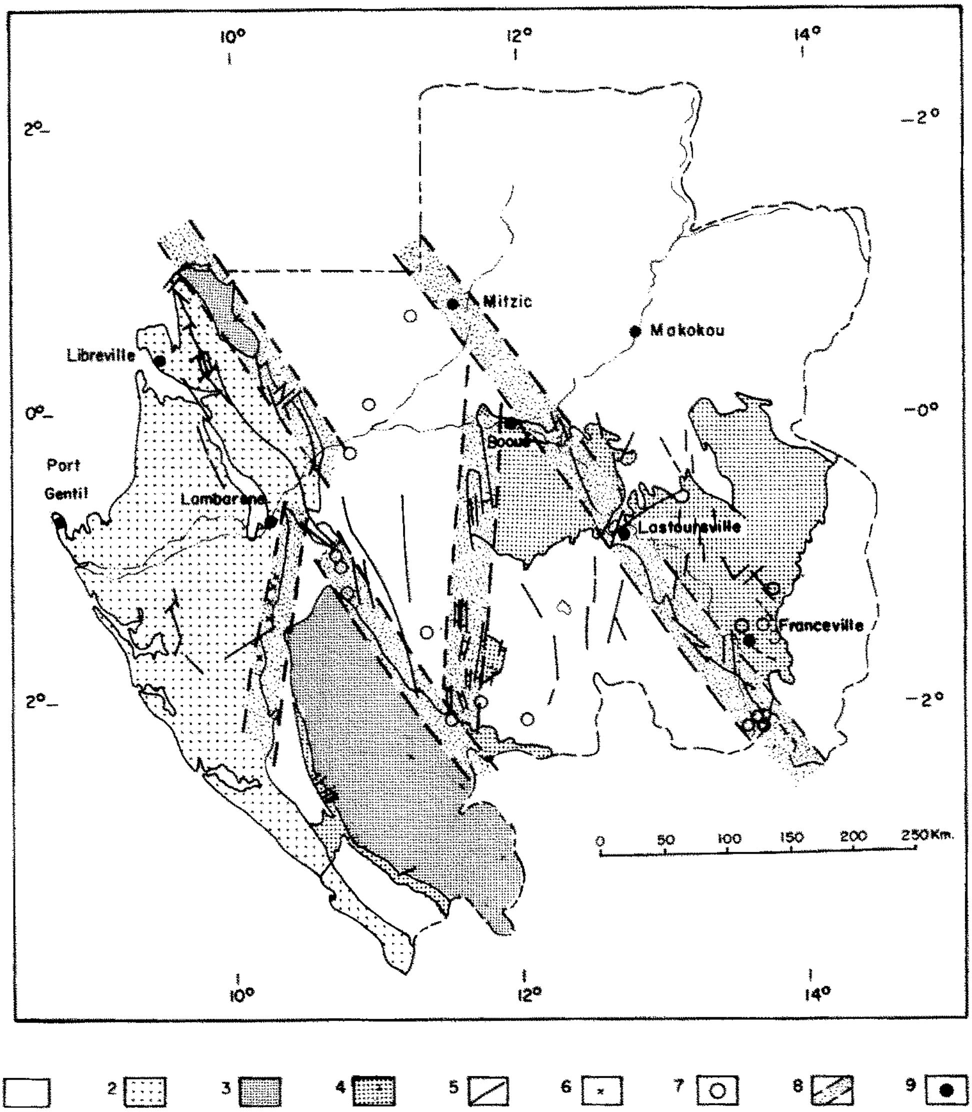

Fig. 2. Structural map of Gabon, in part after Hudeley (1966): 1 = Precambrian Crystalline Basement; 2 = Libreville—Port Gentil Basins; 3 = West Congo System; 4 = Booué and Franceville Basins; 5 = major fracture; 6 = lead-zinc mineralization; 7 = diamond indication; 8 = inferred deep-reaching fracture zone; 9 = principal town.

lineament in Central Gabon is shown, based mainly on the assumption that the contact zone of the Massif du Chaillu and the Franceville sediments would constitute an essential portion of the lineament, continuous with the Mitzic fractures reported by Bardet (1970).

On the aeromagnetic map of part of West Cameroon (Canadian International

Development Agency, 1972), along the border with Nigeria, a NW—SE striking discontinuity is obvious in the southern part of the survey area, situated approximately 50 km NE of Mt. Etinde. The survey does not extent to the coast, however,

In the southwestern part of the Republic of Niger approximately 50,000 km^2 were covered along the River Niger (Canadian International Development Agency, 1972). Major linears strike WNW—ESE and ENE—WSW but NW—SE striking elements are rare. Only in the northeastern part of the survey area, approximately 90 km to the northeast of the river a prominent NW—SE striking set of magnetic anomalies occurs. Its significance is not known. Other aeromagnetic surveys have been flown elsewhere along the inferred Cuango—Niger lineament, but results have apparently not yet been released.

ASPECTS OF MINERALIZATION WITHIN THE DEEP TECTONIC FRAMEWORK OF WESTERN CENTRAL AFRICA

The data presented and reviewed above suggest the existence of a systematic framework of deep reaching fracture zones, in particular with NW—SE and NNE—SSW strike, controlling the tectonic features of the West Congo System, the sedimentary basins along the Atlantic Coast and the coastline itself. Locally E—W fractures are of importance. Major fractures with a NE—SW strike appear to occur in abundance only in Central Angola. This framework may be of at least Kibaran age.

In the area between Andulo and the River Cuanza in Central Angola thirteen occurrences of kimberlite have been reported (Reis, 1971). They are found around the intersection of the NE—SW Quilengues—Andulo fracture belt and the NW—SE Machado fault (Fig. 1). They occur also within the limits of the E—W fracture belt around 11°30′ S. Near Vila General Machado another occurrence is known along the Machado fault. So far few diamonds have been found in this area. Around latitude 9° S alluvial diamond deposits occur along the River Cuango (Fig. 3) but kimberlite is unknown here. By analogy with the Andulo area the intersection of the eastward extension of the E—W faults along the Malange block around latitude 9° S with the inferred NW—SE Cuango lineament may represent a suitable site for kimberlite emplacement.

The geological map of Gabon and the "Plan minéral du Governement de la République Gabonaise" (1971) show a number of indications of alluvial diamond. In view of the distribution of several of these along the fault-controlled margins of the Libreville Basin Bardet (1970) infers the existence of kimberlite in the adjacent Crystalline Basement. Diamond indications further south, as far as Komono in Congo-Brazzaville, would point to a similar relationship along the eastern edge of the West Congo System.

According to Bardet (1970) the kimberlite of the Mitzic area occurs as dykes following the NW—SE fractures referred to above. The original rock is strongly altered and contains up to 80% of talc. Bardet would have preferred to classify the rock as mica peridotite. It was defined though as "metakimberlite" in view

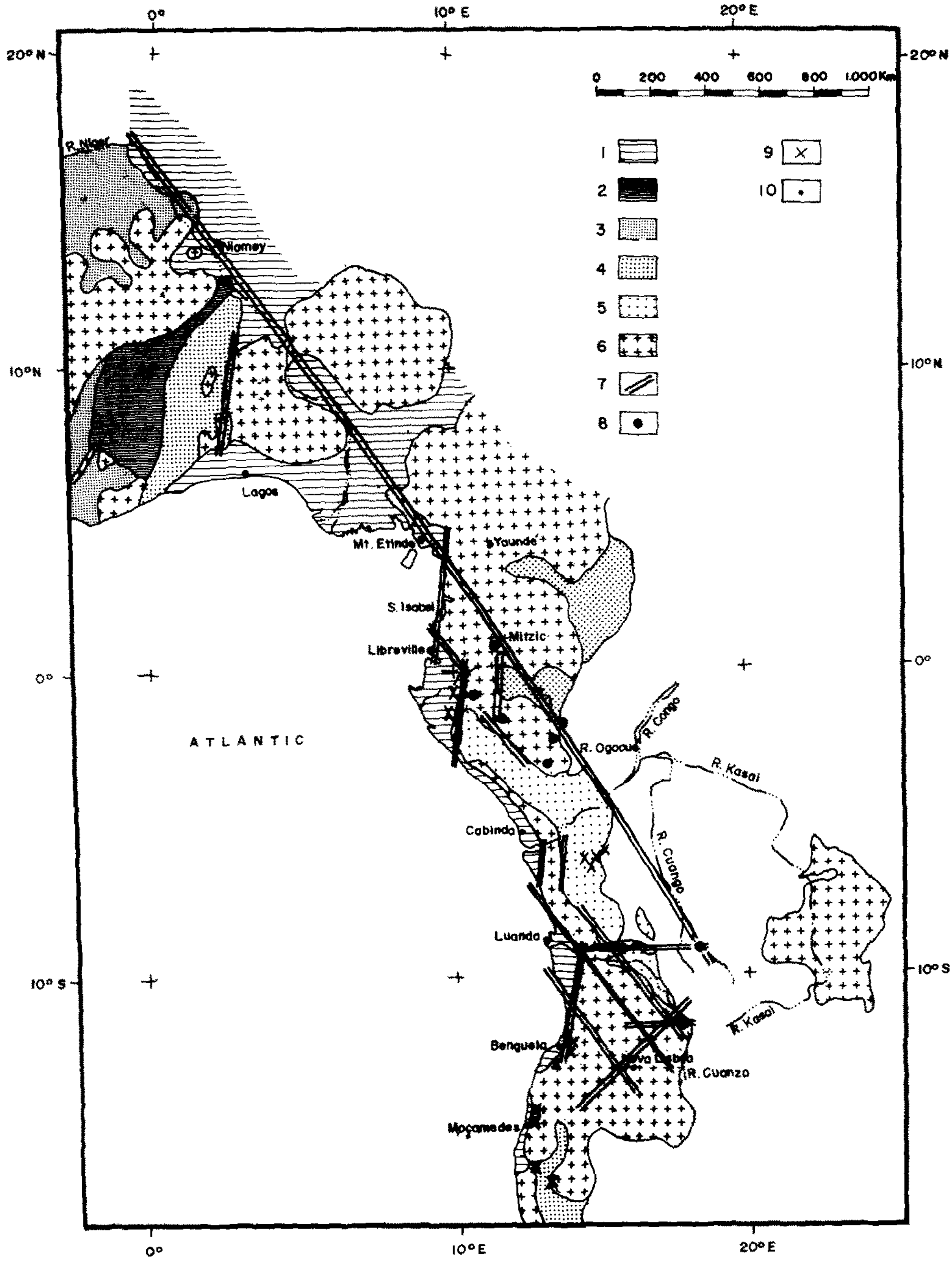

Fig. 3. Diagram of west Central Africa with indication of inferred major lineament pattern in relation to base metal and diamond indications and occurrences of (meta)kimberlite: 1 = Caenozoic marine and continental sediments; 2 = Palaeozoic of Ghana, Togo and Benin (Rep.); 3 and 4 = Precambrian (meta)sedimentary rocks, variably folded and metamorphosed, outside West Congo System proper; 5 = West Congo System; 6 = Precambrian Crystalline Basement; 7 = inferred lineament; 8 = diamond and/or kimberlite indication; 9 = base metal indication; 10 = principal town.

of its diamond content. Apart from its chemical composition kimberlite characteristics are absent. The rock resembles the diamond-bearing type of Seguéla in Ivory Coast, which was classified according to Dawson (1967 a) as altered leucite lamproite (fitzroite). The Mitzic rocks would also show similarities with the diamond bearing mica peridotite of Murfreesboro (Bardet, 1970).

The occurrences of diamond in the Franceville region could in the present context well be related to hitherto unknown (meta)kimberlite emplaced along the NW—SE striking western boundary of the Franceville Basin, the southern extent of the Mitzic-Lastoursville zone.

From the distribution of indications of diamond and of (meta)kimberlite and the apparent structural control in a number of cases, it is concluded that some of the major NW—SE fault belts inferred above are of particular significance for the emplacement of kimberlite. From the situation in the Andulo area in Angola it appears that both NW—SE and E—W faults may be equally significant. In Gabon where fault belts with NW—SE and E—W strike are not conspicuous, tectonic control seems to be conducted by NW—SE striking structures only.

Both in Angola and in Gabon also the distribution of base metal mineralization appears to point to a possible relationship with the tectonic framework inferred above. The geological map of Gabon shows deposits of lead and zinc mineralization exclusively along the margin of the Libreville—Port Gentil Basin in the Cretaceous sediments of the Cocobeach and Madiela Series. The mineral occurrences map of Angola shows deposits of copper with lead, zinc and silver and of silver with lead and zinc along the margins of the Luanda, Benguela and Moçamedes Basins. Within the West Congo System mineralization of copper with lead, zinc and vanadium is conspicuous in the Mavoio—Bembe region along the NNE—SSW Luango fault zone. A small number of copper and zinc deposits figure along the present boundaries of the West Congo System.

DISCUSSION

The presently inferred framework of deep reaching fractures raises a number of questions. In Fig. 3, owing to the small scale of the map, the main lineaments can be depicted as narrow straight belts. However, on maps of larger scales the coincidences are often vague and extrapolations have to cross large areas where consistent signs of an inferred lineament appear to be completely absent, not only at the surface but according to the interpretation of magnetic maps also at some depth.

In Central Angola airborne magnetic investigations resulted in the firm delineation of the Quilengues—Andulo fault belt and several other prominent fracture zones. However, field and photo observation prior to these investigations had only indicated a number of small fault lines which are obviously related to these zones but rarely proved to coincide with what later appeared to be the more fundamental faults. Much of the obscurity in the field, and to a lesser extent on the airphotographs, is due to a substantial cover of residual material or relatively recent sediments.

The contact of the Franceville Basin and the Chaillu Massif in Gabon was known to be in part fault-controlled. This was again observed with airborne magnetometry (Hunting Geology and Geophysics Ltd., 1971). Further northwest faults could not be demonstrated in this zone with magnetometry although photo-interpretation indicated numerous relevant fault lines. Results of previous field work also show NNW—SSE faults in the Lastoursville threshold and NW—SE faults along the River Ogooué in the Booué Basin to the west.

The lineaments inferred must at present be seen as collections of isolated phenomena of different nature as there are morphological linears, tectonically controlled erosional boundaries of major geological systems, major faults and swarms of minor faults, either observed at the surface and confirmed at depth or not observed at the surface but indicated by interpretation of magnetic contour maps, together with manifestations of igneous activity. The latter are generally represented by mafic rocks, but ultramafic and sialic rocks occur as well. The lineaments thus appear discontinuous. Not only because they are in part obscured by surficial material and dense vegetation or unknown due to insufficiently advanced mapping, but also probably because they are indeed not continuous, at least at present surface level. In view of the length and width of some of the proven and otherwise inferred lineaments (e.g. the Quilengues—Andulo belt with minimum length of 400 km and a width of up to 90 km, and the Cuango—Niger lineament with a length in the order of 4000 km) their component structures may occur very deep to become possibly a continuous feature only at some depth in the mantle. Not necessarily as a sharply defined fracture zone but possibly as a relatively narrow corridor of rocks which are chemically and/or physically to a certain extent different from the surrounding material.

An indication of such differences is thought to be represented by the rocks of Mt. Etinde (Little Mt. Cameroon) which is situated along the inferred Cuango—Niger lineament. This volcano belongs primarily to the manifestations of the Fernando Poo zone. Its products are considerably different from those of the other volcanoes in this belt, however. In addition to basalt, andesite, trachyte, and phonolite, Esch (1901) and Tilley (1953) described leucitite, leucite nephelinite, and hauynophyre among the rocks of Mt. Etinde. These undersaturated potassium-rich rocks have not been reported elsewhere in the Fernando Poo belt. Reyment (1965), referring to the work of Gèze (1943), mentions Lower Cretaceous basalt and andesite, Miocene trachyte and phonolite and Plio-Pleistocene basalt of Mt. Cameroon.

Some indications of conditions at depth in at least part of the presently inferred tectonic framework are suggested by Girdler's (1975) interpretation of the "great negative Bouguer gravity anomaly over Africa" brought out on the Bouguer gravity anomaly map of Africa by Slettene et al. (1973). This anomaly extends from the Gulf of Aden along the East African rift and crosses the continent from about 10°S-30°E towards the coast of the Atlantic in

Angola. Apart from its significance as a possible link between the East African rift zone, the Lucapa graben and the Central Angolan alkaline belt, superimposed relatively minor positive anomalies may, according to Girdler (1975), reflect the replacement of lithosphere by asthenosphere. The E—W and NE—SW trends displayed by the anomaly over Angola suggest a relation with the E—W and NE—SW fault systems mentioned above. A systematic gravity survey of Angola could further clarify these relations.

The preferred emplacement of kimberlite along deep reaching linear structures has been put forward by among others Bardet (1956) and by Crockett and Mason (1968), who also concluded that other types of mineralization may be much more controlled by such features and their intersections than is often accepted. However, in view of its localized occurrence, mineralization is clearly dependant of other variables.

It has been suggested that the distribution of kimberlite would be limited to the regions of the oldest stable cratons (Clifford, 1970) because the rigidity of these parts of the crust would facilitate building up of the high pressures required for the generation of kimberlite. The reduced low velocity layer beneath shield regions has been interpreted as an indication of "welding of the crust to the mantle" (Mac Donald, 1963, 1965; Birch, 1965; Meyerhoff et al., 1972). In addition to the low temperature gradient these are characteristics by which these portions of the crust and the underlying mantle are different from those in other regions. Although the extent of the old cratons is roughly known, their accurate delineation is still far from complete due to difficult dating of rejuvenation processes.

The concept of tectono-metallogenetic provinces can be applied to the preferential emplacement of kimberlite in the old cratons, but some portions of these huge provinces appear more favourable than others. The degree of stability within the cratons is to a certain extent indicated by the sequence of successively consolidated zones. However, the kimberlite pipes of southern Africa as shown in fig. 2 of Crockett and Mason (1968) occur in all four tectono-thermal units of the Kalahari shield distinguished by Clifford (1970) and Kroner et al. (1973). Apparently the generation of kimberlite is also determined by additional parameters probably related to a variety of as yet unknown or partly understood inhomogeneities in the mantle and lower crust. According to Crockett and Mason (1968) these would particularly obtain in zones and foci of mantle disturbance displayed at the surface by zones of repeated major tectonic and magmatic activity. Verschure (1966) suggested the generation of kimberlite as one possible product out of a variety of alkaline rest melts, in isolated pockets of tholeiitic magma in the upper mantle, related to but long after a period of tholeiitic basalt emission. In view of the findings of Milashev (1965, referred to by Dawson, 1968) yet other parameters may be of interest in that they would govern a differentiation of type, size and grade of kimberlite pipes in relation to the distance from the centre of the shield.

The minimum age of a considerable part of the suggested framework is probably at least Kibaran, while several of the inferred lineaments suggest that reactivation originated at later stages. The present discontinuity found at shallow levels may in part be due to overprinting by younger tectono-magmatic processes.

From the present study it would also appear that some types of mineralization could be largely controlled by tectonic lineaments, possibly related to persistent discontinuities in the upper mantle (cf. the megastructures of Crockett and Mason, 1968; Heyl, 1972; James, 1972), and their intersections in western Central Africa. Although tholeiitic basalt of the Karroo type is not known in West and Central Africa (unless swarms of dolerite dykes like those along the River Niger would qualify) the development of potassium-rich undersaturated lavas at Mt. Etinde would direct the interest in kimberlite towards the northwestern part of the Congo craton in Equatorial Guinea as a particular focus along the Cuango—Niger lineament. Alluvial diamond deposits appear to be known in some quantity in this region (Bardet, 1970).

The tectonic framework discussed here would provide another set of parameters for the emplacement of mineralization within and along the Congo craton. However, for the purposes of mineral exploration too little systematic and relevant information is available to define these zones more accurately. In view of the results of airborne magnetometry combined with the interpretation of aerial photographs and geological fieldwork this technique must at present be considered as the most suitable to clarify within reasonably short time the extent and part of the nature of the lineaments inferred. Proper satellite imagery would no doubt be of assistance in these regional studies.

The merits of large and continuous magnetometric coverage are clearly recognized (a.o. by the Gabonese "Plan Mineral" (Direction des Mines de la République Gabonaise, 1971); see also James, 1972). In order to obtain the continuous series of data necessary for the adequate appraisal of the mineral potential of the presently implied structural framework, a thoroughly coordinated effort would be required on a multinational basis.

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ADDENDUM—Regional maps referred to in the text

Canadian International Development Agency — Geological Survey of Canada, Department of Energy, Mines and Resources, 601 Booth Street, Ottawa, Canada K1A OE8

(1) Republic of Niger — Liptako region: magnetic anomaly maps between the borders of Mali, Upper Volta and Dahomey, the point on the Mali border at 1° 45′ E, and the following points 14° N 1° 45′E, 14° N 2° E, 13° 45′N 2° E, 13° 45′N 2° 15′E, 13° 30′N 2° 15′E, 13° 30′N 2° 30′E, 13° N 2° 30′E, 13° N 3° E, and the point where the river Niger intersects longitude 3° E.

82 map sheets at 1:50,000 and 8 map sheets at 1:200,000. Nominal terrain clearance 170 ± 15 m, nominal flightline spacing 500 m.

(2) Republic of Cameroon: magnetic anomaly maps.

Area 2: irregularly shaped area defined by the following points: 10° 30′N 13° 45′E, 10° 30′N 14° 30′E, 10° N 14° 30′E, southward along frontier of Republic of Tchad to 14° 45′E, 8° 30′N 14° 45′E, 8° 30′N 14° 30′E, 8° 15′N 14° 30′E, 8° 15′N 14° 15′E, 8° N 14° 15′E, 8° N 14° E, 7° 45′N 14° E, 7° 45′N 13° 30′E, 10° N 13° 30′E, 10° N 13° 45′E.

Areas 3 and 4: irregularly shaped area defined by the following points: 8° 15′N 13° E, 8° 15'N 13° 30'E, 6° 45'N 13° 30'E, 6° 45'N and frontier with Central African Republic, 5° 15'N and frontier with Central African Republic, 5° 15'N 14° E, 5° N 14° E, 5° N 13° 30'E, 6° 15'N 13° 30'E, 6° 15'N 12° E, 6° 45'N 12° E, 6° 45'N 12° 15'E, 7° N 12° 15'E, 7° N 12° 30'E, 7° 15'N 12° 30'E, 7° 15'N 13° E.

63 map sheets at 1: 50,000 and 8 map sheets at 1:200,000.

Area 5: Nigerian frontier at 6° N, 6° N 9° 30'E, 4° 45'N 9° 30'E, 4° 45'N 8° 45'E, Nigerian frontier at 8° 45'E.

Areas 2 and 5 include 55 map sheets at 1:50,000 scale and 9 map sheets at 1:200,000.

The areas in Cameroon were surveyed with a nominal terrain clearance of 235 ± 20 m and a nominal flightline spacing of 750 m.

Direction des Mines et de la Géologie, B.P. 576, Libreville, Gabon — United Nations Development Project, New York

Magnetic anomaly maps of irregularly shaped area between 1° 30'S and 0° 15'N, and between 11° 30' and 13° 30'E. Nominal terrain clearance 150 m, nominal flightline spacing 1.5 km. Area is also covered by photogeological maps between 11° and 14° E and between 2° S and 0° 15'N.

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Magnetic anomaly maps, photogeological maps, Central Angola. Region illustrated in Fig. 1 of this paper; see also Reis (1971); 51 map sheets at 1:100,000 scale. Nominal terrain clearance 150 m, nominal flightline spacing 1.5 km.