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Structural Control of Ore Mineralization in the Southeastern Margin of Western Nigeria Basement

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Abstract

Structural analyses are often ignored in mineral prospecting endeavor of any geological terrain despite the importance of geological structures in the formation of ore deposits. This paper correlates the results of mineral prospecting campaign to those of the structural analysis in the southeastern margin of the western Nigeria basement. The mineral prospecting was executed by essentially geochemical-exploration methods, while the structural analysis was achieved by lineament analysis using Landsat-8 imagery. The mineral prospecting campaign eventually led to the discovery of gold bearing marble deposit in the Dagbala area; silver and copper bearing silicified sheared rock in the Dagbala, Ojirami, Erurhu and Atte areas; lead and zinc bearing metaconglomerate around Egbigele; uranium and thorium bearing pegmatite in the Dagbala area. The Landsat-8 lineament analysis showed the presence of a shear zone in the central, folds in the SW, and fractures in the NE parts of the study area. The relation between the two is such that the gold and silver-copper mineralization is associated with the shear zone, the lead-zinc mineralization to the folds, and the uranium-thorium mineralization to the fractures. Indeed, geological structures guide mineralization and their analysis can be employed for mineral prospecting.

Keywords

Western Nigerian Basement, Igarra Schist Belt, Mineral Prospecting, Mineralization, Structures

1. Introduction

Despite abundant references that illustrate the importance of structural control in the formation of ore deposits (e.g. [1] [2] [3]), it remains a vital subject matter that is often ignored in economic-geological analysis/exploration of ore deposits. Structural control concerns all types of mineral deposits from lode deposits, breccia pipes, stockwork, massive sulphides, skarn, etc., and its importance in their exploration cannot be overemphasized. As a matter of fact, the appropriate grasp of the structural control is, in fact, germane for interpreting the characteristics of the deposit, its emplacement style, its age, and therefore, its origin.

The southeastern margin of western Nigeria basement consists of the Igarra Schist Belt (ISB) surrounded by the rocks of the migmatite-gneiss-quartzite complex (MGQC). The geological setting of ISB, like the remaining schist belts in Nigeria, is somewhat similar to others elsewhere in the world that host important mineral deposits [4]-[12]. There also exists a historical assertion that alluvial gold was mined during the colonial times at Dagbala in ISB [13] [14]). All of these make Adepoju [15] initiated mineral prospecting campaign in this area.

The campaign, which is essentially accomplished through geochemical surveys, led to the discovery of four mineralized rocks in the area [16] [17] [18]. In this paper, the locations of the four mineralized rocks on the geological map are correlated with those of the structures manifested by the lineament map of the area to depict any possible structural control of ore mineralization.

2. Geological Setting of the Study Area

The western Nigeria Basement (WNB) consists of Archean to Paleoproterozoic rocks comprising essentially MGQC, N-S trending belts of metasedimentary rocks with minor metavolcanic rocks (the schist belts), Pan African Granites and other granitoids such as syenites and charnockites, and minor intrusives that cross cut all the pre-existing basement rocks. The study area lies in the southeastern margin of WNB between latitude 7˚10'N - 7˚21'N and longitude 6˚09' - 6˚17'. The area comprises the ISB to the west and MGQC to the east (**Figure 1**). The ISB is made up of essentially low-grade deformed pelitic to semi-pelitic schists, polymictic metaconglomerates, quartzites, calc-silicate gneiss and marbles [5] [12], while the MGQC is dominated by granitic gneisses [16]. These two contrasting rock suites are separated by a narrow Dagbala-Atte Shear Zone (DSZ) [16] [17]. Both the ISB and MGQC were intruded by members of the Older Granite suite including porphyritic granite, syenite and charnockite. Minor felsic and mafic intrusives including pegmatites, aplite, syenite, lamprophyre and dolerite cut-cross the Pan African granites and the pre-existing rocks.

3. Methodology

This study correlates the result of the mineral prospecting campaign with that of the lineament analysis in the southeastern margin of the WNB. The methodology of the mineral prospecting, which was mostly executed through geochemical survey have been adequately described in Adepoju [16] [19] and Adepoju *et al.*

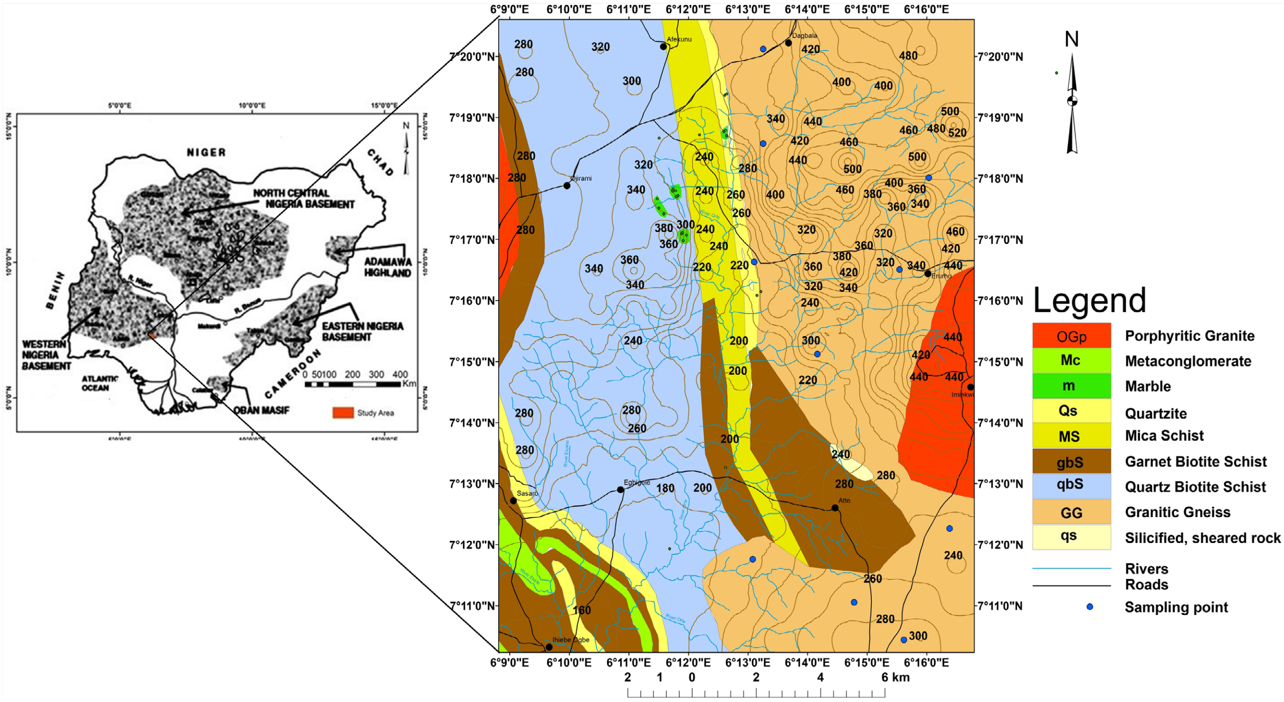

Figure 1. Geologic map of the study area. Inset: Generalized geological map of Nigeria showing the study area at the southeastern margin of Western Nigeria Basement.

[20] [21] [22] as well as Adepoju and Adekoya [18]. Also the methodology for lineament analysis conducted using landsat-8 imagery of the study area has been described in Adepoju [16] and Adepoju *et al.* [17].

4. Results and Discussion

The outcome of the mineral-prospecting campaign and Lineament Analysis in the study area is presented in the ensuing paragraphs.

4.1. Mineral-Prospecting

As said earlier, favourable geologic setting and existence of historical account that gold was mined in the ISB, especially around Dagbala in the colonial days formed the bases for the mineral-prospecting campaign started by Adepoju [15] in the area. This campaign followed the efficient mineral prospecting approach, the sequence of which comprises 1) area selection; 2) reconnaissance survey; 3) follow-up study; and 4) detailed work [18]. The area selection in the southeastern margin of WNB considered the catchment area of Orle River with trellis drainage pattern [15], which drains the largest portion of ISB and also contains Dagbala area [12] [14]. The episode of the trellis drainage pattern in this broad region signifies the presence of structures which usually prepares the ground for mineralization in an area.

Reconnaissance survey was accomplished through the geochemical stream sediment survey of the selected region [15] [23] [24]. This survey enabled the recognition of Dagbala and Atte areas as more forthcoming for metallic mineralization. Consequently, Dagbala-Atte district was recommended for the follow up study, which comprised geochemical soil survey [16] [19] [20] [21] [22]. The follow up scheme was able to delineate some areas exhibiting anomalous concentration of some metals [19] [20] [21] [22], which are suspected to be underlain by potential mineralized rocks in the district, and are therefore subjected to the detailed work.

During the detailed study, geological mapping and lithogeochemical survey were executed [16]. The detailed geological mapping of the Dagbala-Atte district with particular aim on the areas thought to be underlain by mineralized rocks created a more detailed geological map (**Figure 1**). Petrographic and mineralographic studies of samples of rocks collected during the mapping was meticulously carried out [16]). The lithogeochemical survey embraced chemical analysis of samples of the different rock types suspected to be mineralized [16] [25]. This detailed study eventually revealed four mineralized rocks, comprising three mappable units (MR1-MR3) and one unmappable unit (**Figure 2**). These mineralized

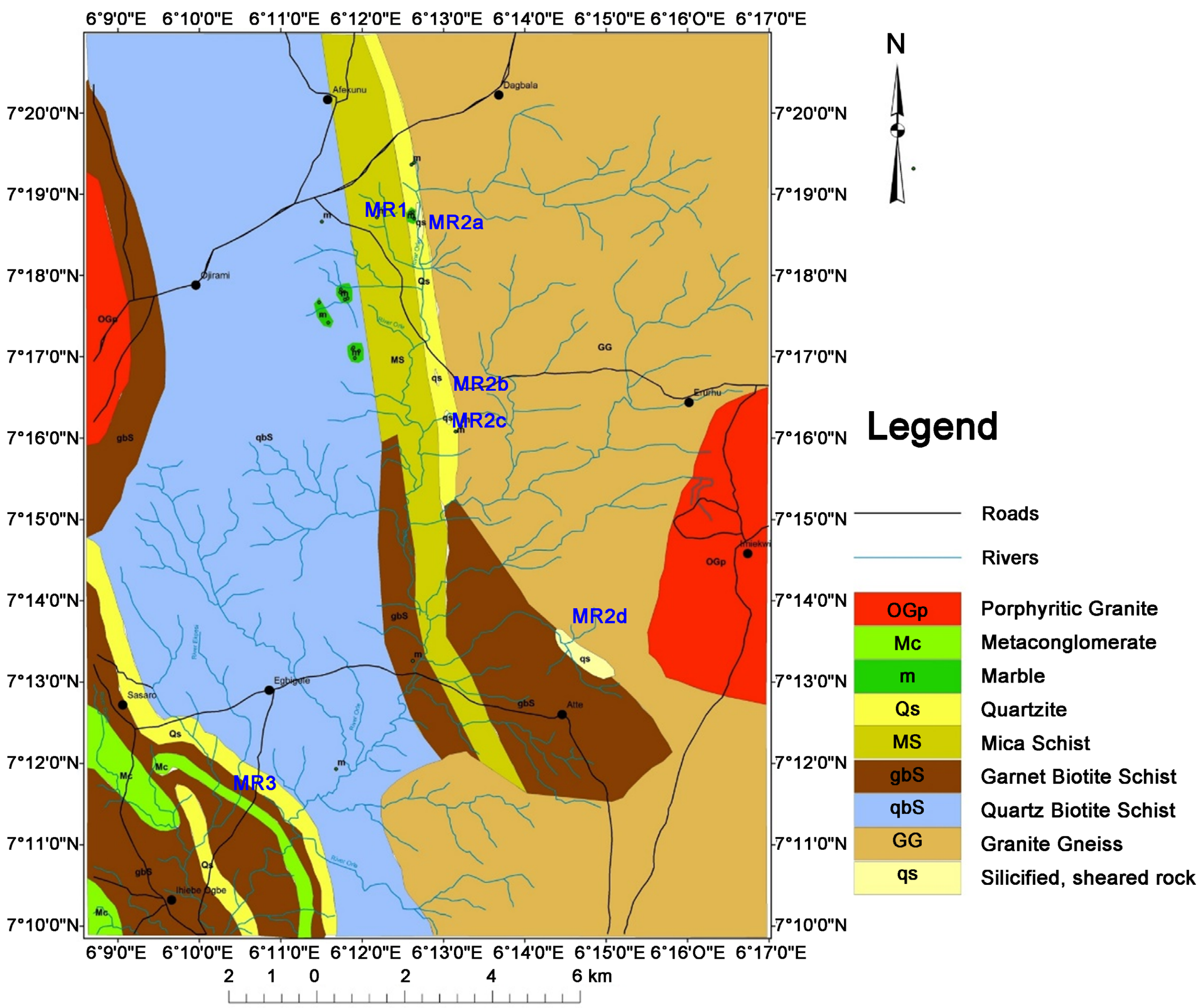

Figure 2. Detailed geologic map of the study area showing locations of mineralized rocks.

rock types are mappable gold (Au) bearing marble deposit in the Dagbala area (MR1); silver (Ag) and copper (Cu) bearing silicified sheared rock in the Dagbala, Ojirami, Erurhu and Atte areas (MR2a-d); lead-zinc (Pb-Zn) bearing metaconglomerate around Egbigele (MR3) and unmapable uranium and thorium (U-Th) bearing pegmatite in the Dagbala area [20] [22].

4.2. Lineament Analysis

The lineament analysis used Landsat-8 image, detailed methodology of which have been explained by Adepoju [16] and Adepoju, *et al.* [17]. This endeavor generated the lineament map of the district (**Figure 3**), which revealed three areas of different lineament attributes and concentrations [17]. **Figure 3** displays

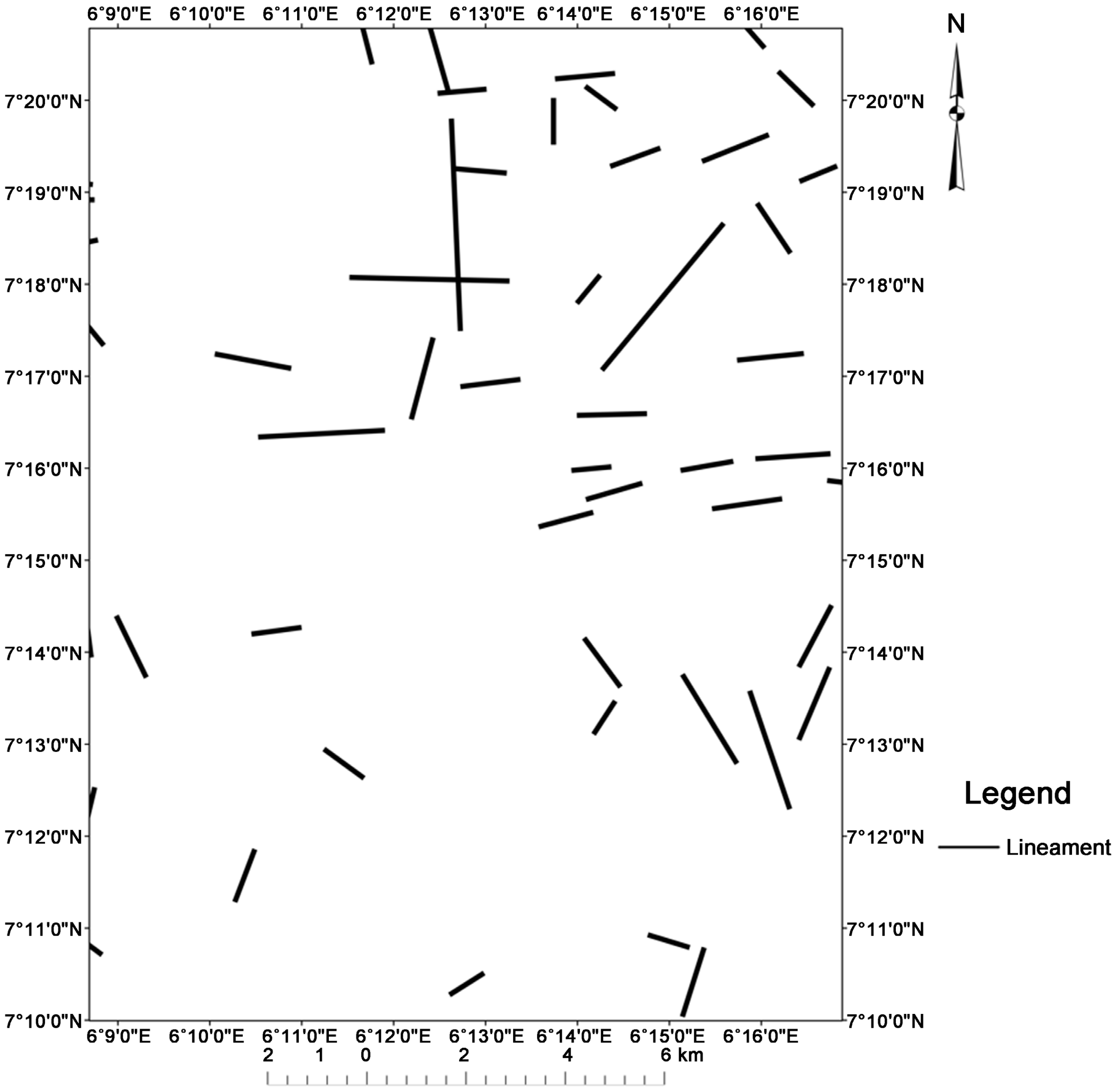

Figure 3. Lineament map of the study area.

abundant distribution of lineament in the eastern part of the study area that concentrate mostly in the north eastern portion. Furthermore, five real/likely lineament intersection points exist along a NW-SE zone (**Figure 4**) in the central part of the study area. Likewise, scanty lineaments exist in the southwestern part of the area.

Guided geologic mapping to confirm the result of the lineament analysis, *i.e.* ground-truth [16] have revealed that the abundant lineaments in the northeastern part of the study area indicate the presence of heavy fractures in the granitic gneisses that underlie the area in that part (**Figure 1**). Most of these fractures

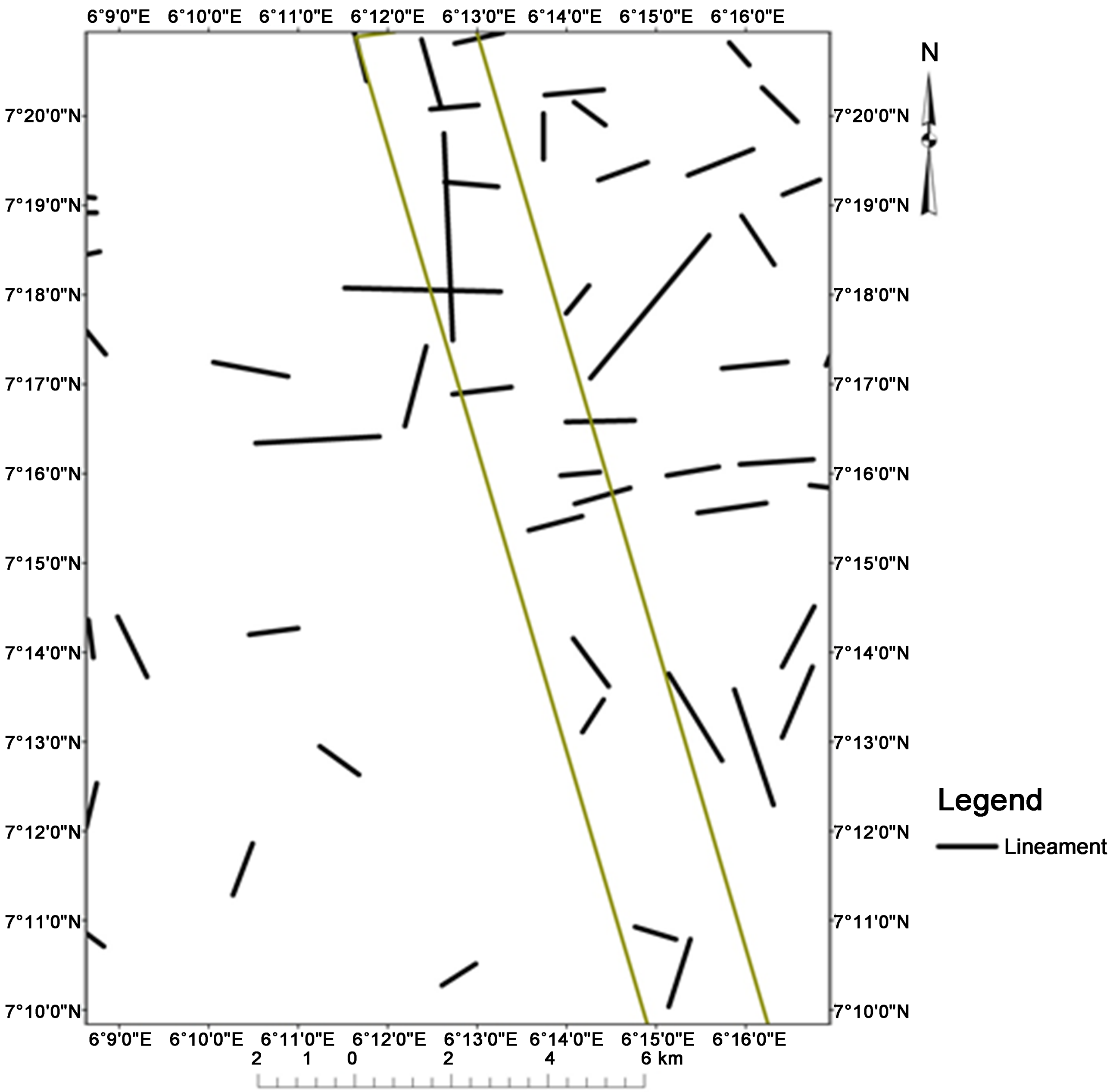

Figure 4. Lineament map of the study area showing demarcated NW-SE Zone along which five actual and possible lineament-intersection points exist.

have been healed by minor felsic and mafic intrusives. The ground-truth also indicate the presence of a shear zone (Dagbala-Atte Shear Zone, DSZ) in the central part of the area where there exist the five actual to near lineament intersection points along the NW-SE direction. Lastly, the scanty lineaments at the SW part of the area reveal few fold axes in the schist-metaconglomerate-quartzite intercalation in that part.

Since the lineaments reflect geologic structures, in order to have an inkling of the structural control on mineralization in the study area, the geological map showing the locations of the mineralized rocks is superimposed on the lineament map of the area (Figure 5). The figure shows that the locations of the mineralized rocks correlate well with the three parts with the presence of geological structures.

5. Summary and Conclusion

Four types of metallic mineralization have been discovered in the study area, namely,

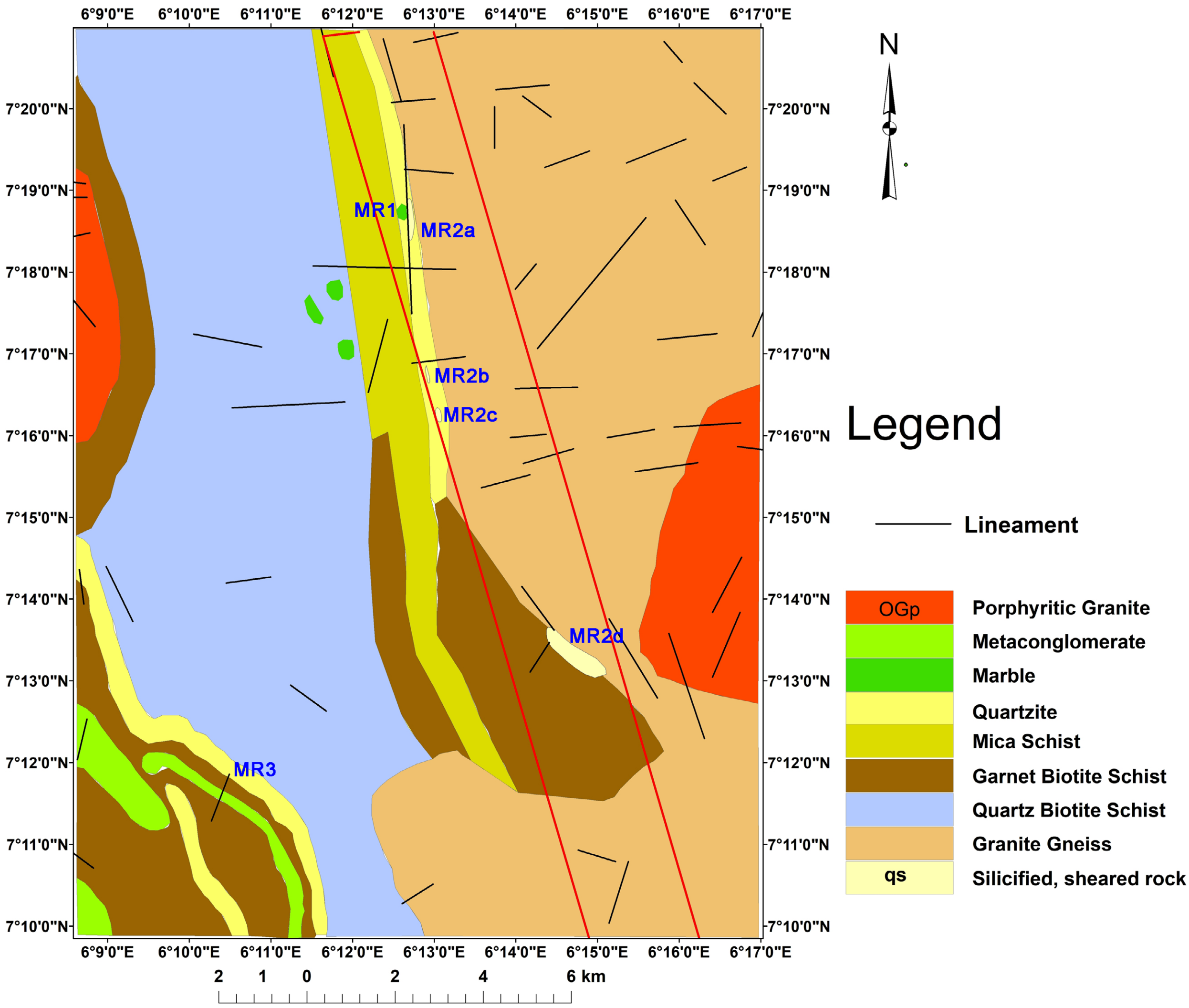

Figure 5. Superimposed geologic/structural map of the study area.

1) Au mineralization in the marble near Dagbala;

2) Ag-Cu mineralization in the silicified shear rock near Dagbala, Ojirami, Erurhu and Atte;

3) Pb-Zn mineralization in the metaconglomerate near Egbigele;

4) U-Th mineralization in the legion of pegmatite veins near Dagbala.

The Au mineralization in the marble near Dagbala (MR1) and the Ag-Cu mineralization in the silicified sheared rock (MR2 a-d) are hosted by the DSZ in the central part of the study area. The Pb-Zn mineralization in the metaconglomerate (MR3) is hosted by the folded metaconglomerate-schist-quartzite intercalation in the southwestern part of the study area (**Figure 5**). Finally, the U-Th mineralization in the pegmatite is hosted by the numerous fractures associated with the granite gneiss [26] in the northeastern part of the study area. Thus the mineralization types in the southeastern margin of the western Nigeria basement are structurally cotrolled.

Therefore, structural analyses of any geological terrains could offer an easier and cheaper alternative in mineral prospecting campaigns.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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