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ANALYSIS OF AEROMAGNETIC DATA OVER GARKIDA AND ENVIRONS, NORTH-EASTERN NIGERIA

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ABSTRACT

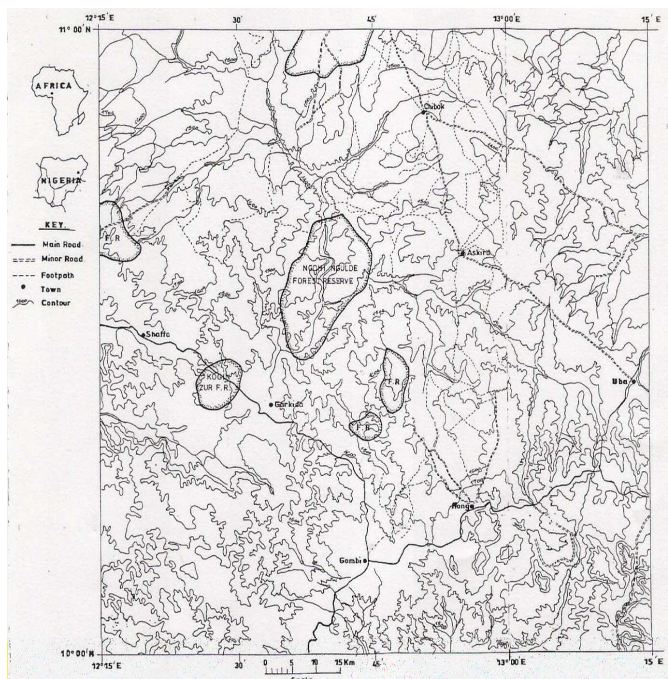
The study area lies between latitude $10^o00'$ and $11^o00'$N and longitudes 12^o $15'$ and 13^o $15'$E in the North-eastern basement complex of Nigeria. The total magnetic intensity over Garkida and its environs after the digitization showed magnetic signature ranging from 7720 nT to 7960 nT. Two dimensional Spectral analysis of Aeromagnetic data over the area has been carried out in order to determine the average depth to magnetic sources .The analysis indicate two source depths which vary from 750 m to 2285 m for deeper sources and 150 m to 744 m for shallower sources .The deeper magnetic source depths in the northern part of the study area coincide with the margins of Chad basin bordering the basement complex; while the shallower depths indicate the presence of intrusive rocks in the area. As illustrated in the azimuth diagram, the magnitude and structural trends of NE-SW, NW-SE, E-W and N-S observed in the area could be good host for secondary mineralization. The structural lineaments from this study are in agreement with the reported deformational Episodes in the area.

KEYWORDS: Garkida and Environs, Spectral analysis, Depths, Lineaments.

INTRODUCTION

The study area lies between latitude $10^o00'$ and $11^o00'$N and longitudes 12^o $15'$ and 13^o $15'$E (Fig.1), in the North-eastern basement complex of Nigeria. Magnetic data over this area provide information about geological patterns at depths on which younger sedimentary rocks lie. A typical total magnetic field map is dominated by broad magnetic anomalies which are largely indicative of the regional/local magnetic variations in the deep basement rocks. (i.e. magnetic variations in the deep basement rocks). The broad magnetic anomalies arises from deep sources (long wavelength, low-frequency), and shallow magnetic sources have a short wavelength (high frequency) responses from near surface magnetic sources (Likkason 2007).

However, the geophysical/geological investigation work published in this area include hydro-geological study of Shani and Duhu carried out by Conred Nig. Ltd for the defunct North-eastern state in 1972 and 1973 and hydrological studies of Duhu area by Bassey et al (1999). Two dimensional spectral analysis of aeromagnetic data was used to determine the depth to magnetic sources in the study area, alongside with delineating magnetic



(*after Federal Surveys of Nigeria, 1972*)

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lineaments that could host secondary mineralization. The results in this work would also be a contribution to a better understanding of the study area.

Geology of area

The geology is made up of the Precambrian basement complex rocks which are considered to be undifferentiated basement complex (McCurry 1979 and Bassey et al., 1999), mainly gneisses, migmatite and granites outcropping in different parts of the study area which include, Gombi, Hong, Askira Uba and even in Garkida. Cretaceous sediment belonging to Bima sandstone and Yolde formation outcrops at the northern part of the study area (Figure 2). The tertiary to recent Volcanics (Biu basalt) are third most wide-spread rocks in the study area belonging to northern arm of Cameroon volcanic line. The Volcanics vary in composition from basalt to trachyte and rhyolite.

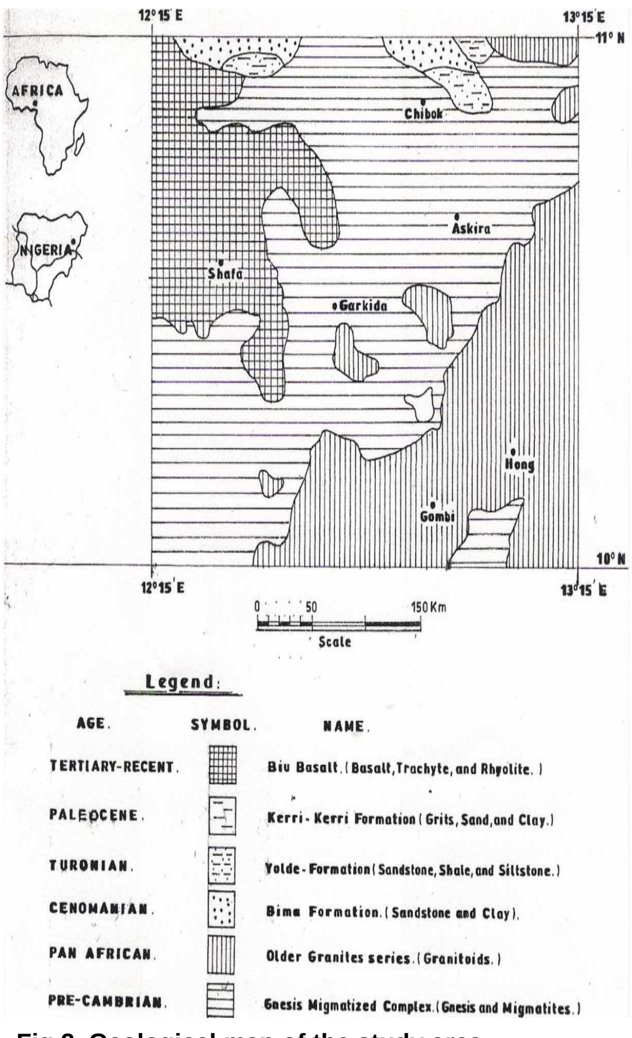

Fig.2. Geological map of the study area (After geological survey of Nigeria 1994)

The keri-keri Formation is composed of sandstones, siltstones and shale underlying the Gombe sand stone. The formation which outcrops in this part of the study area is Palaeocene in age. The Yolde Formation is considered to be transitional between the continental Bima and marine Gongila formations. This formation shows lateral variation of Sandstone and Calcareous shale. The Bima unit varies in thickness between (100-300m).

The Pan-African older granites are the second wide-spread group of rocks in the study area. They intruded into the Gneiss-migmatite complex. The gneiss-migmatite complex is the most widespread and occupies more than half of the area and is the oldest rock here. They are heterogeneous rock group, which is composed gneiss migmatite of various origin and series of metamorphosed basic and ultra basic rocks (Grant 1971).

Analysis of magnetic data

The aeromagnetic data used for this work was obtained as controlled maps of total magnetic intensity on a scale of 1:100,000 compiled by Geological survey of Nigeria (GSN). It consists of sheets 134, 155, and parts of sheet 133, 135, and 156. The relevant survey was conducted along a series of NW-SE profile with a spacing of 2Km, a nominal tie line spacing of 20 Km and an average flight elevation above terrain of 150 m. the geomagnetic gradient was removed using the International Geomagnetic Reference Field (IGRF) of the 1st January, 1974. The magnetic map was digitized at an equal interval of 1cm x 1 cm (which covers to I Km x 1Km) in the N-S and E-W grid lines, giving a data matrix of (112 x 112). The points sampled on the square grid representing the total intensity magnetic map were contoured using Computer software (Fig 3).

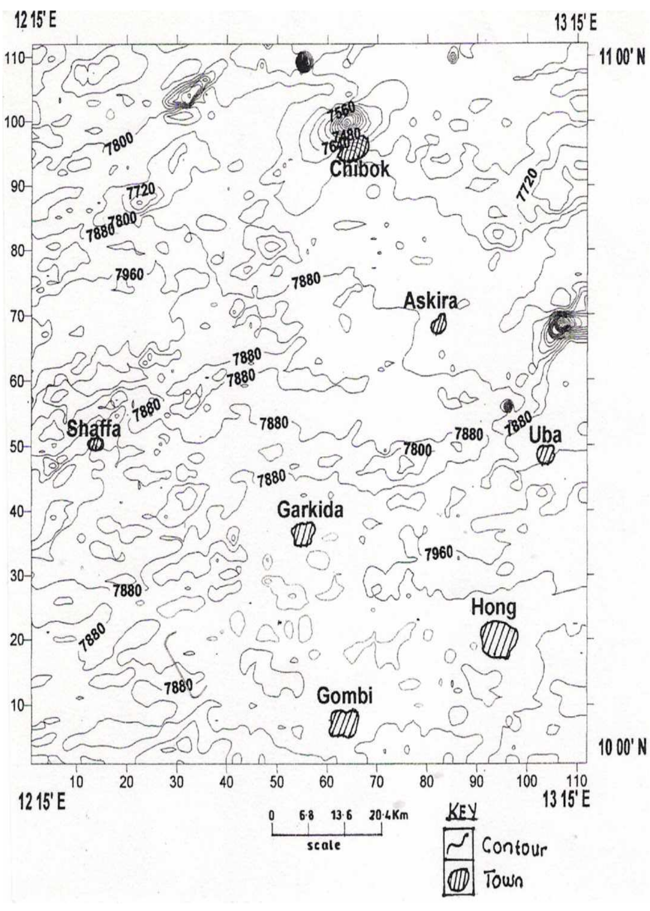

Fig.3. Total intensity magnetic map of the study area (cont. Int. 80 nT)

To obtain the residual, the regional field was calculated using a simple computer programme (visual basic) which was then subtracted from each observed data point using same visual basic programme and the resultant residual field was contoured at an interval of 80 nT (Fig 4).

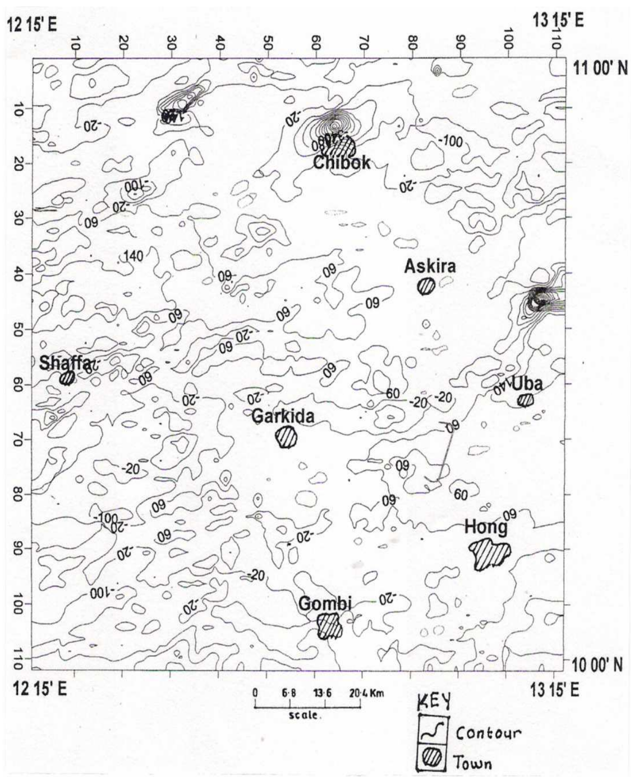

Fig.4. Residual magnetic map of the study area (Cont. Int. 80 nT)

From the residual magnetic map lineaments/fracture from 1.7 km to 24.48 km long were traced parallel along the closures of the magnetic contour lines, the lengths depend on the direction and length magnetic anomaly (Fig. 5). The Azimuth diagram was obtained from the structural map structural map and is shown in figure 6.

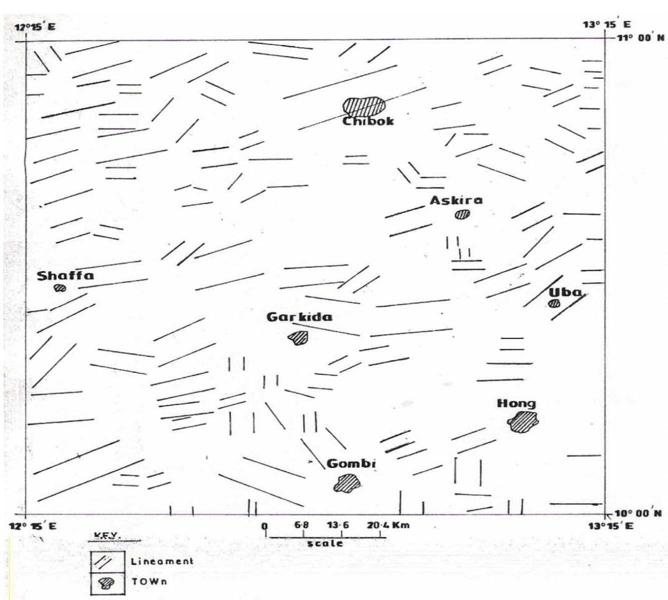

Fig.5. Major magnetic lineaments/joints derived from the anomalies of the residual map Spectral analysis

Two-dimensional techniques of spectral analysis for magnetic data analysis have been described by several authors (Bhattacharyya, 1966; Naidu, 1969; Spector and Grant, 1970; Negi, et al., 1983; Ofoegbu and Onuoha, 1991, Nur et al., 1994; Nur, 2000 and Nur et al., 2003). In the present paper, we utilized the approach of Nur et al., (2003) to analyze the data over the Garkida and its environs. Given a residual magnetic map

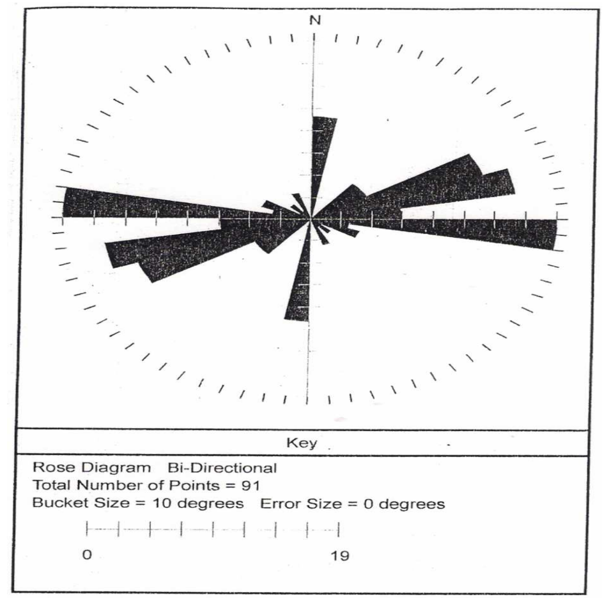

Fig. 6. Azimuth diagram showing the trend and distribution of major lineaments/Fractures in the area

of dimensions L x L digitized at equal intervals, the total residual magnetic anomaly values can be expressed in terms of a double Fourier series expansion. Detailed mathematical formulae used for this study could readily be found in Ofoegbu and Onuoha, 1991, Nur et al., 1994; Nur, 2000 and Nur et al., 2003.

The aeromagnetic data for this work was originally acquired by the Geological Survey of Nigeria along a series of E-W profiles with a spacing of 2 km, and a nominal tie-line spacing of 20 km. The geomagnetic gradient was removed from the data using the International Geomagnetic Reference Field (IGRF) formula of first January 1974. Sixteen complete magnetic map sheets and, parts of nine others were utilized for this work. The digitization was at 1 km intervals. To eliminate the regional field, a plane surface has been fitted to the data by multi-regression least-squares analysis, and the expression for the regional obtained was: -

$$T(x, y) = 7770.55 + 1.742x - 0.178y \quad (1)$$

Where x and y are units of spacing of the digitized magnetic data.

The regional field values were subtracted from the observed data, and the obtained residual field over the study area is shown in Figure 2. In order to carry out the spectral analysis, the residual data Figure 3 was divided into fort-nine blocks containing 16 x 16 data points., the average depths of the forty nine blocks making up the area of study were computed using Fortran Programme, and the depth estimates for the forty nine (49) blocks are shown on table 1; while figure7 shows the contour map of the deepest magnetic source depth in the study area.

Table1. Average Depth to magnetic sources (km)

Blk1 D1=0.493	**Blk2 D1=0.711**	**Blk3 D1=1.080 D2=0.435**	**Blk4 D1=2.285 D2=0.330**	**Blk5 D1=0.720 D2=0.242**	**Blk6 D1=1.557 D2=0.454**	**Blk7 D1=0.682**
Blk8 D1=0.699	**Blk9 D1=1.404 D2=0.262**	**Blk10 D1=0.642**	**Blk11 D1=0.623**	**Blk12 D1=0.929**	**Blk13 D1=1.040**	**Blk14 D1=1.033**
Blk 15 D1=0.776	**Blk16 D1=1.282 D2=0.641**	**Blk17 D1=0.791**	**Blk18 D1=0.820**	**Blk19 D1=1.155**	**Blk20 D1=0.826 D2=0.215**	**Blk21 D1=0.815**
Blk22 D1=0.139	**Blk23 D1=0.722**	**Blk24 D1=0.612**	**Blk25 D1=0.880**	**Blk26 D1=1.007**	**Blk27 D1=0.900**	**Blk28 D1=0.737**
Blk29 D1=1.048	**Blk30 D1=0.796**	**Blk31 D1=0.831**	**Blk32 D1=0.729**	**Blk33 D1=0.661**	**Blk34 D1=0.576**	**Blk35 D1=0.669**
Blk36 D1=0.514	**Blk37 D1=1.338 D2=0.569**	**Blk38 D1=0.555**	**Blk39 D1=0.463**	**Blk40 D1=0.607**	**Blk41 D1=0.674 D2=0.302**	**Blk42 D1=1.468**
Blk43 D1=1.057 D2=0.159	**Blk44 D1=1.092**	**Blk45 D1=1.279 D2=0.517**	**Blk46 D1=0.820**	**Blk47 D1=1.075 D2=0.744**	**Blk48 D1=0.925**	**Blk49 D1=1.072**

DISCUSSIONS

The mineralization of rocks depends on the chemical composition of the rocks and the various tectonic episodes that has affected the rocks. Considering this fact, the total magnetic intensity (Fig.3) over Garkida and its environs after the digitization showed magnetic signature ranging from 7720 nT to 7960 nT. The magnetic highs observed could be as the result of the presence of basic rocks of dark coloured ferromagnetic minerals that contain minerals such as iron in form of magnetite; while the magnetic lows are associated with granitic and allied rocks.

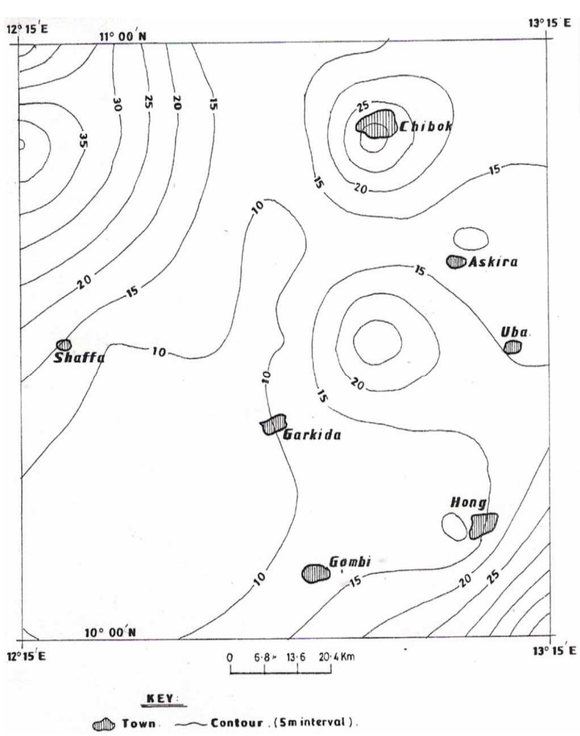

Fig. 7. Magnetic source depth (m) obtained from spectra of the study area

The results obtained from the residual magnetic map (Fig.4) showed magnetic values ranging from -520 nT to +160 nT; and most anomalies formed closure patterns of NE-SW and NW-SE directions. Generally, there would always be a magnetic susceptibility contrast across fracture zones due to oxidation of magnetite to hematite and or infilling of fracture planes by dyke like bodies, whose magnetic susceptibilities are different from those of their host rocks (Likkason 2007). Such geological features appeared as thin elliptical closures or nosing on the aeromagnetic maps which is observed as magnetic lineaments on the residual magnetic map of the study area (Fig.4) From the residual map; lineaments deduced indicated that 52% have NE-SW; 18% NW-SE and 18% E-W directions respectively; while the remaining 12% have N-S direction. The azimuth diagram (fig.5) further illustrated the magnitude and the trend of the fractures; they are in line with the pan-African and pre-pan-African deformational episode in the area. The fractures could be related to those developed in the pre-existing zones of weakness; which are also in alignment to the major lineaments though Africa (Grant, 1978 and Ekwueme, 1994b).

Relating the lineaments to the geology; areas of high density of lineaments occur in the north-western part of the area, and has been intruded by igneous rocks of Biu basalts, while the less dense lineaments occurred in the older granite series of the basement complex. In the south-western part also showed dense patterns of lineaments that occurred in the older granite and migmatite gneiss complex. Most high magnitude lineament could be attributed to deep seated fractures; while the low magnitude ones could be attributed shallow weathered zones in the study area.

The magnetic source depth determination through spectral analysis over Garkida and Environs suggest the existence of two source depth. The deepest sources lies at between 750 m to 2285m and the shallower source depth obtained ranges from 150 m to 744 m and could be attributed to intrusive bodies. The Single sources depth cover 76% of the area, while the two source depth covers only 24% of the study area. The deeper sources in the northern part of the study area resulted from the Chad basin bordering the study area as well as the intrusive rocks. While the shallow sources result from rocks of the northern arm of Cameron volcanic line as it outcrops in Shafa and other parts of the study area.

The results obtained from the spectral analysis of Garkida and its environs demonstrated variations of thickness to the magnetic source depths of the basement; with the highest value of 51 meters and the lowest value of 5 meters (table 1 and Fig.7). The thickness of the magnetic sources range 10-51 meters western part; while in the eastern past thicknesses range 10-46 meters. These results showed that the area is covered shallow weathered regolith basement. Multi-Drillers Nigeria Ltd (2005) reported weathered zones of 12-50 meters in some parts of Gombi and Hong areas without reaching the fresh basement.

A close look at the results revealed that the inferred lineaments/fractures and depths to the magnetic source bodies could serve a good hydorgeologic potential for sitting hand dug wells/boreholes. According to Edet et al., 1994 and Okereke et al., 1998 reported that high lineament density zones could be recommended for shallow boreholes and hand dug wells; while low lineament density zones for deep boreholes. Furthermore, lineaments are sties for localized concentration of pegmatite dykes that could host various types of mineralization in major granitic intrusions. This study is therefore gives an encouraging impetus for more serious and detailed geophysical, geological and hydrogeological investigations for groundwater and mineral exploration in Garkida and its environs.

CONCLUSIONS

The analysis of the aeromagnetic data over Garkida and its environs indicated that the structural lineaments/fractures of the area are dominantly in NE-SW direction with others trending NW-SE, E-W and N-S directions. Most high magnitude lineament could be attributed to deep seated fractures; while the low magnitude ones could be attributed to shallow weathered zones in the study area. The magnetic source depth determination through spectral analysis over Garkida and Environs suggest the existence of two source depths. The deepest sources lie at between 750 m to 2285m and the shallower source depth obtained ranges from 150 m to 744 m and could be attributed to intrusive bodies.

The azimuth diagram illustrated the magnitude and the trend of the fractures; they are in line with the pan-African and pre-pan-African deformational episode in the area. Furthermore, lineaments are sties for localized concentration of pegmatite dykes that could host various types of mineralization in major granitic intrusions. In addition the results also showed areas of groundwater resources in shallow weathered regolith basement suitable for locating shallow boreholes and hand dug wells.

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