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# Geotechnical Implications Of Deformation Bands In Bima Sand Stone Of Hinna Area In Yamaltu /Deba Local Government Area Of Gombe State.

*Obiora, F.I., *Yashi,J *Sani, R.O., And *Mondigha, E.B.
**Nigerian Building and Road Research Institute, P.M.B. 1055, Ota, Ogun State*

**ABSTRACT**
*Micro-structures in rock grains usually associated with sandstones occur commonly in the Bima Formation exposed in Hinna town of Deba Local Government Area of Gombe State. The lineations, dips and strikes of the micro structures were measured using a compass clinometer. A rose diagram was plotted that gave a resultant of S68E – N68W. Snapshots of the geologic structures were taken to show tectonic activities in the area. The deformation bands observed in the field appeared as a series of light colored strands with slip surfaces that seem to be more resistant to weathering than the host rock in which they appear. Eight (8) samples were collected at various strategic points within the area. Thin section studies with petrographic microscope, showed a dominance of quartz and feldspar grains cemented with iron oxide. The quartz grains appeared to be faulted which further proves that there is an abundance of micro-structures that would have a large influence on the mechanical behavior; i.e. strength, deformation, differential settlement, etc of soil and rock masses in that area.*

***KEYWORDS**: Deformation Bands, Petrographic, Thin Section, and Fault.*

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## I. INTRODUCTION

Geologic hazards are responsible for loss of life and destruction of property. Geological science may not appear to be of great importance to a construction engineer but any competent construction supervisor should know the basic characteristics of the geologic formation in which his project is being built. Faults, porosity, permeability induced settlement of structures, cave-ins and other soil related problems can confront the construction supervisor on a project. Some of those problems can escalate to huge challenges. Skilled application of relevant technical information contributes to success but ignorance can lead to failure. Deformation bands in granular media are often interpreted as resulting from material instability influenced largely by existing defects or imperfections (Borja and Aydin, 2004). Deformation bands are defined as zones of crushed or reorganized grains that form in highly porous rocks and sediments (Torabi, 2007). They are also defined as small faults with very small displacements. In the past these bands have been called Luther's bands or braided shear fractures. They often precede large faults and develop in porous rocks like sandstones. The materials found along the bands have a smaller grain size, poorer sorting, and a lower porosity than the original sandstone. Deformation bands may have a large influence on the mechanical behavior (strength, deformation, etc.) of soil and rock masses in, for example, tunnel, foundation, or slope construction. Monitoring of deformation bands provides a proactive control of hazards related to possible changes or failure of structures. In addition to buildings linear structures such as roads, railroads, bridges, tunnels and pipelines are susceptible to damage from deformation bands.

### 1.1 Objectives

This study is aimed at caring out field work, petrograhic analysis to deduce the geotechnical implications of deformation bands in Bima Sandstone found in Hinna town in Deba LGA of Gombe State.

## II. GEOGRAPHY

Hinna is a fast growing community located along Zambuk road close to Dadin Kowa Dam in Deba LGA of Gombe State, northeastern Nigeria. The area is within the Gongola arm of the northern Benue Trough. It is located on sheet 153 of Wuyo NW Nigeria. It is a residential and commercial area with such amenities as schools, motor park, market, police station etc. The area covered is bounded by latitudes N 10˚ 18' 22" to N 10˚ 19' 41" and longitudes E 11˚30' 00" to E 11˚ 31' 45". Accessibility is mainly through a network of footpaths but a single major tarred road runs through the area. The Bima Sandstone found there is being exposed as outcrops and in stream channels

**2.1.Climate and Vegetation**

The area experiences two distinct seasons: the dry and rainy seasons. The dry season starts from November and continues till March, while the rainy season lasts from about the end of March till October. There are two continental winds blowing: the moisture laden southwest wind that originates from the Atlantic Ocean and blows from April to October, and the dry northeast wind that originates from the Sahara Desert and blows from November to March. Vegetation in the study area is that of a semi arid region. It is characterized by scattered shrubs and thorn bushes.

**2.2.Relief and Drainage**

The area is dominated by flat terrians with hills of sandstones (Figures 1, and 2). Several minor streams flow in a southeast direction through the area but a single major stream (Figure 1) that flows in a southwest direction serves as the main drainage line of the area. Rock exposures are mostly in streams channels (Figure 1).

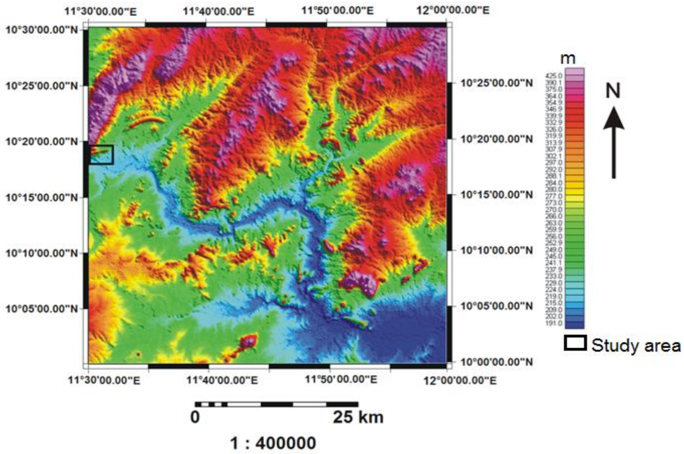


**Figure 1**: Shuttle radar map topographic mission showing elevation (National Centre for Remote Sensing).

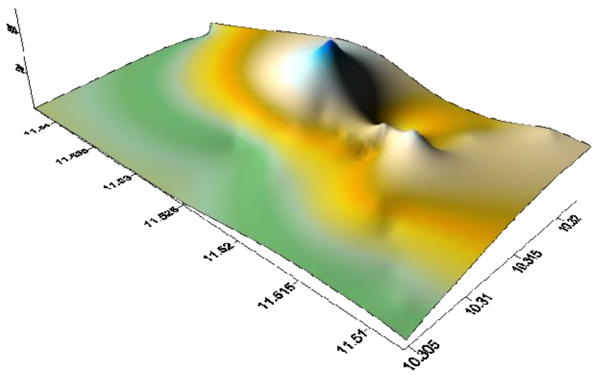


**Figure 2**: Digitized elevation map of study area

**2.3.Geology**

The upper Benue Trough consists of two arms, the Gongola Arm and the Yola Arm, although some authors include a third central Lau-Gombe sub-basin (Akande *et al*., 1998, Zaborski *et al*., 1997). In both arms of the upper Benue Basin, the Albian Bima Sandstone lies unconformably on the Precambian Basement. The Bima Sandstone is of an entirely continental origin throughout the upper Benue Trough (Samaila and Singh, 2010). It consists of coarse to medium grained sandstones, intercalated with carbonaceous clays, shales, and mudstones. The maastrichtian Gombe Sandstone is lithologically similar to the Bima Sandstone, attesting to the reestablishment of the Albian palaeoenvironmental conditions (Obaje, 2009).

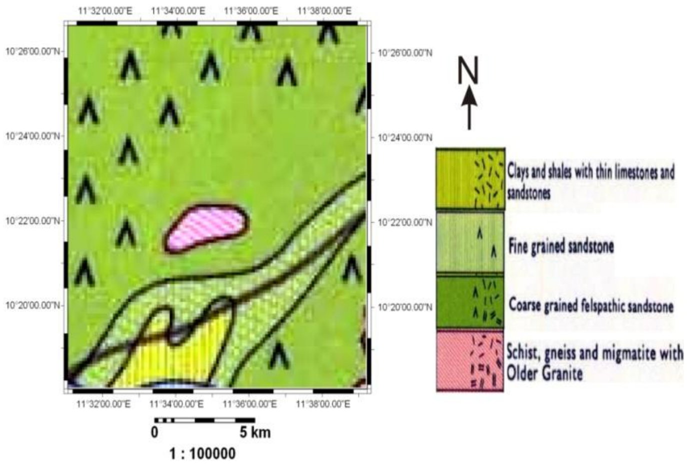


**Figure 3**: Digitized geologic map of the study area

## III. MATERIALS AND METHODS

In order to achieve the desired objectives of this work, certain techniques were adopted;

1. Field work.
2. Petrographic Analysis

## IV. FIELD WORK

This involved taking samples at various strategic points within the study area. The deformation bands, their lineation, dip and strike directions of the deformation bands were measured using a compass clinometer. Snapshots of the geologic structures seen around the area were also taken.

## V. PETROGRAPHIC ANALYSIS

The combination of petrograpic and geochemical data of sedimentary rocks can reveal the nature of their source regions, the tectonic setting of sedimentary basins, and paleoclimatic conditions (e.g., Dickinson and Suczek, 1979; Valloni and Mezzardi, 1984; Amstrong-Altrin et al., 2004). This is simply the systematic description of the texture of rocks and the minerals they contain, using a petrographic microscope. Preparation of samples for this method was carried out as follows: Friable samples were impregnated with resin before mounting on a glass slide using Canada balsam. The samples were polished using carborundum of 0.6mm and 0.4mm size until a thickness of 0.03mm was attained. Carborundum of size 0.2mm was finally rubbed on the sample. The polished surface was then washed and dried. It was covered with Canada balsam and a thin slice of glass after which it was placed on a heater so as to expel air bubbles and to further dry it up. The sample slide was allowed to cool before mounting on a microscope for petrographic studies.

## VI. RESULTS AND DISCUSSION

### 4.1.Field observations

Deformation bands are commonly thin tabular zones of crushed or reorganized grains that form in highly porous rocks and sediments (Torabi, 2007). Although some geochemical ratios can be altered during weathering (through oxidation) (Taylor and McLennan, 1985) and/or diagenesis (Nesbitt and Young, 1989; Milodowski and Zalasiewicz, 1991), as long as the bulk composition of a rock is not totally altered, geochemical analysis is a valuable tool in the study of sandstones (McLennan *et al.*, 1993). The deformation bands observed in the field appear as a series of light coloured strands with slip surfaces that seem to be more resistant to weathering than the host rock. The bands occurring in the Bima Sandstone in much of the area suggest that a lot of tectonic activities took place there. However, some outcrops show faulting that made the bands distorted relative to each other (**Plate 1**). This suggests that tectonic activities continued even after the formation of the deformation bands.

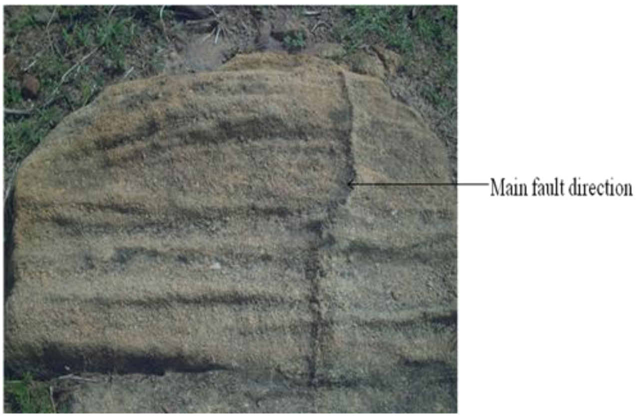


**Plate 1**: Deformation bands associated with fault on Bima Sandstone (notice the fault perpendicular to the bands)

Slickensides were also observed on some outcrops. This further suggests that faulting took place in the study area. Slickensides are often associated with faulting (**Plate 2**).

**Plate 2**: Slickensides in the Bima Sandstone in Hinna

Strike directions of the microfaults were measured in the field using a compass clinometer. These strike values were used in plotting a rose diagram that gave a mean of S68E-N68W. The rose diagram is shown in **Figure 4**.

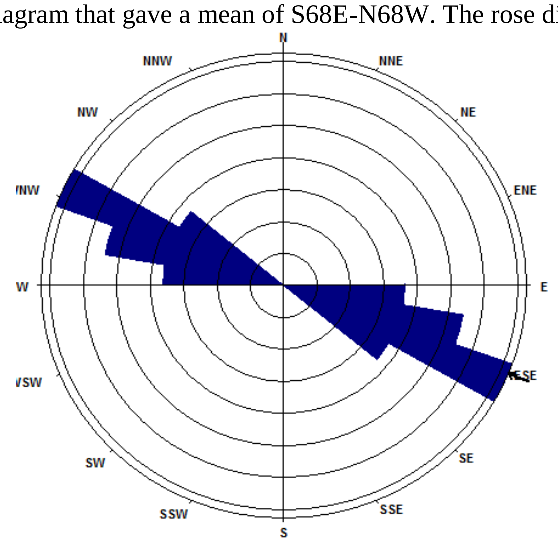


**Figure 4**: Rose diagram showing the lineations of the micro faults in the study area

**4.2.Petrographic studies**

Eight samples were analyzed using a petrographic microscope. The thin section slides were studied under plane and crossed polarized light. The slides show a dominance of quartz and feldspar grains and the cementing material observed is generally iron oxide. Photomicrographs of the samples are shown in **Plates 3-12**.

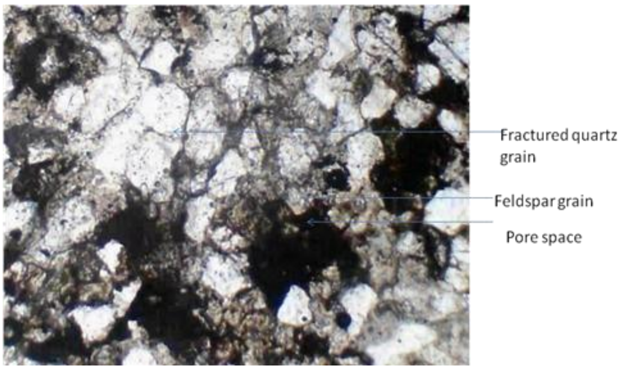


**Plate 3**: Sample L 6B (plane polars) - well sorted, highly compacted quartz and feldspar grains that are rounded to sub-rounded. Notice the fractured quartz grains. (x60)

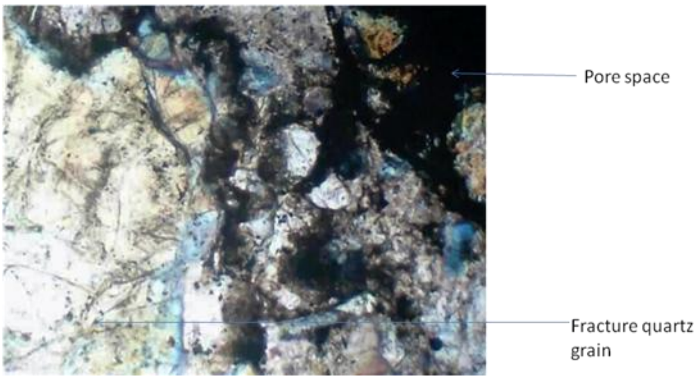


**Plate 4:** Sample L3B (crossed nicols) – coarse grained angular sandstone showing fracturing of quartz grain (x60)

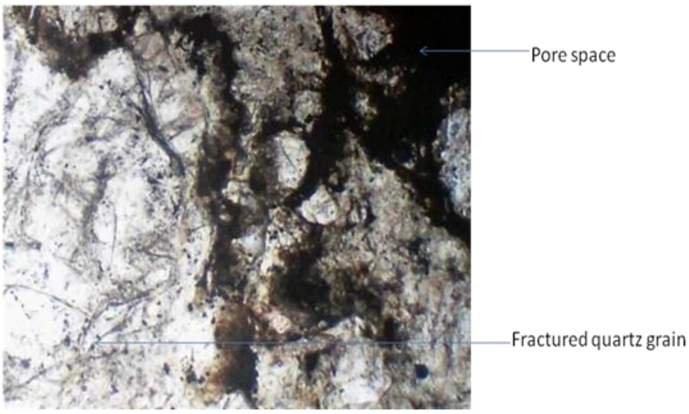


**Plate 5:** Sample L3B (plane polars) - coarse grained angular sandstone showing fracturing of quartz grain (x60)

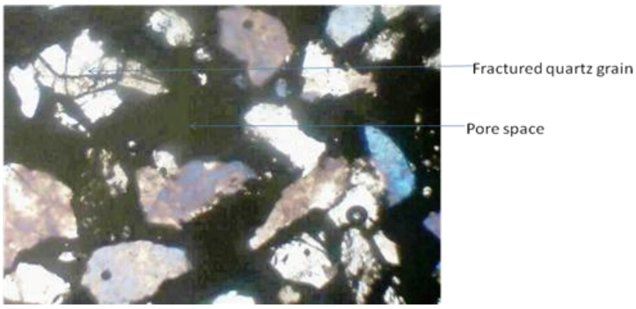


**Plate 6**: Sample L10B (crossed nicols) - poorly sorted angular grains with fractured quartz grains. This thin section slide shows good porosity and permeability due to the empty pore spaces and fractures in the quartz grains. (x60)

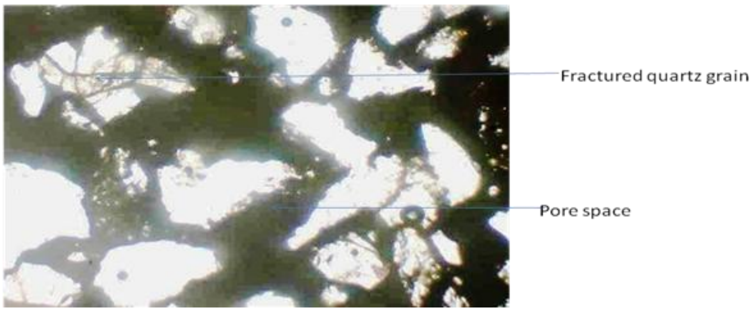


**Plate 7:** Sample L10B (plane polars) - poorly sorted angular grains with fractured quartz grains. This thin section slide shows good porosity and permeability due to the empty pore spaces and fractures in the quartz grains. (x60)

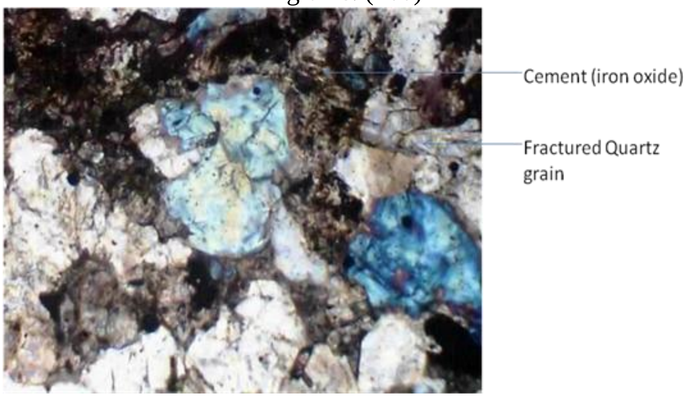


**Plate 8:** Sample L7B (crossed nicols) - poorly sorted, sub rounded grains with fractured quartz grains. (x60)

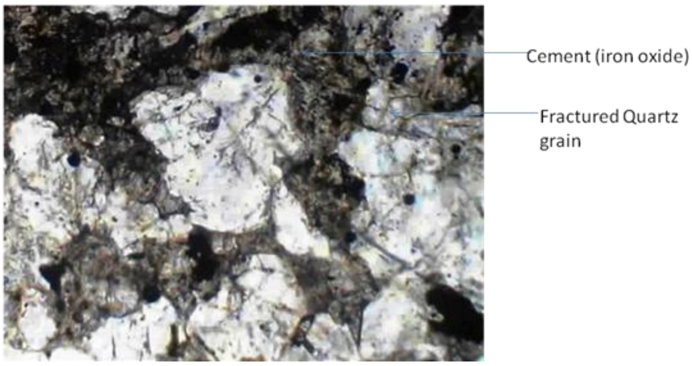


**Plate 9:** Sample L7B (plane polars) - poorly sorted, sub rounded grains with fractured quartz grains. (x60)

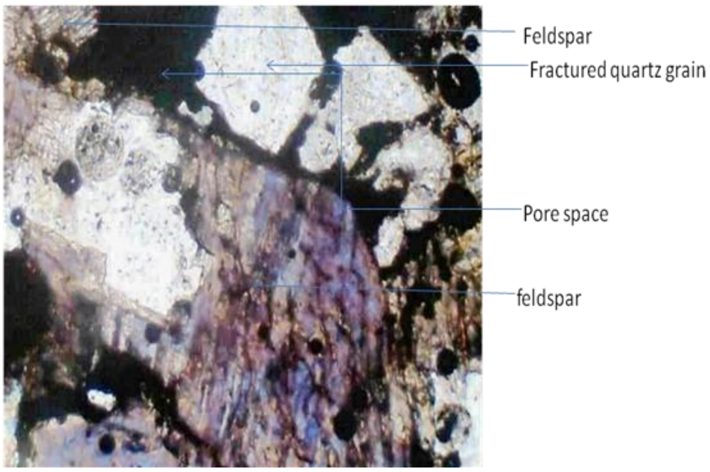

**Plate 10:** Sample L9A (crossed nicols): poorly sorted feldspar and quartz grains. The quartz grains are fractured. (x60)

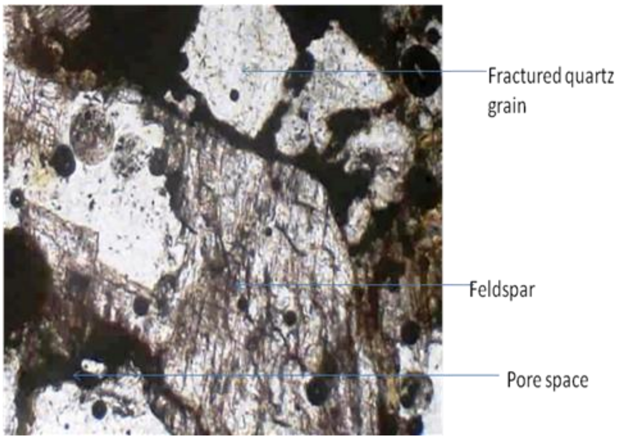


**Plate 11:** Sample L9A (plane polars): poorly sorted feldspar and quartz grains. The quartz grains appear to be fractured. (x60)

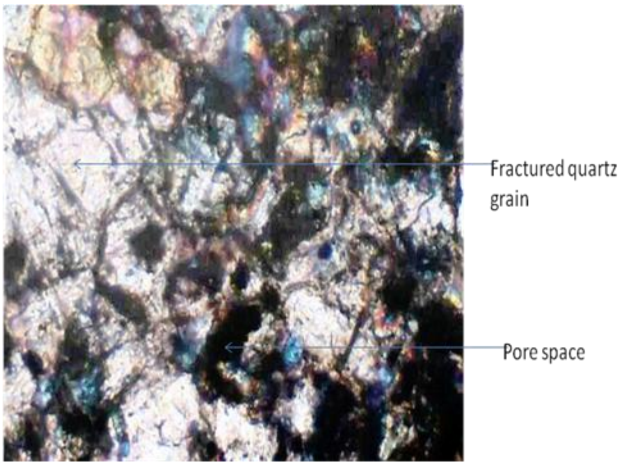


**Plate 12:** Sample L9B (crossed nicols): poorly sorted well compacted highly fractured sandstone (x60)

## VII. Conclusions

Hinna is a fast growing community experiencing a population growth which has led to an increase in infrastructures i.e. buildings, roads, railroads, bridges etc. Field and petrographic analysis of the geological formation underlying the area showed an abundance of deformation bands. Therefore, the following mitigating measures could be followed in the absence of further confirmatory engineering soil and rock strength tests to avoid infrastructural damage in the area;

- Restricting permissible uses to facilities compatible with deformation bands, i.e. open space and recreation areas, freeways, parking lots, cemeteries, solid-waste disposal sites, etc
- Establishing an easement that requires a setback distance from active fault traces.
- Prohibiting all uses except utility or transportation facilities in areas of extremely serious hazard, and setting tight design and construction standards for utility systems traversing active fault zones.
- More detailed soil and rock strength testing should be carried out before the commencement of construction works.

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