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The Ikom-Mamfe basin, Nigeria: A study of fracture and mineral vein lineament trends and Cretaceous deformations

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ABSTRACT

The Ikom-Mamfe basin is approximately a 130 km long, east–west abutment onto the eastern flank of the lower Benue trough of Nigeria and extends westwards into Cameroon. Two hundred and six fracture lineaments were analyzed in the Nigerian sector of this basin. They vary in length from 0.5 to 23.75 km, with the most frequently occurring fracture length being about 2.25 km. The most prominent fracture sets have NE-SW and NW-SE orientations, while less prominent patterns are in the NNE-SSW and ESE-WNW directions. NW-SE and NNE-SSW fracture sets are interpreted as "ac" extension fractures from two different deformation episodes, while NE-SW and ESE-WNW sets are "bc" tensile fractures parallel to the axes of F_1 and F_2 folds, respectively. This implies two deformation episodes in this basin, with the earlier one producing the NE-SW (F_1) fold axes, exactly as in the Benue trough. Two prominent mineral vein trends in the basin are the NW-SE and NNE-SSW sets, in which minerals are loaded in "ac" extension fractures. The orientations, lengths and frequency of these lineaments should help in differentiating their ages. The less prominent veins are in the NE-SW and ESE-WNW directions, which are in the "bc" tensile fractures. Early Cretaceous sediments are characterized by NW-SE major and NE-SW minor sets of veins, while the late Cretaceous sequence is characterized by NNE-SSW major and ESE-WNW minor, mainly barite, veins. More than 70% of the barite samples tested gave specific gravity values of 4.2 and above, which is the range specified by the American Petroleum Institution (API) as drilling mud additive or weighting agent. Other vein-filling minerals in this basin are lead ore (galena), zinc ore (sphalerite), pyrite and amethyst, which are altogether subsidiary to barite mineralization.

1. Introduction

The Ikom-Mamfe basin is a small, approximately east–west basin that extends from the lower Benue trough, past the Nigeria–Cameroon border, for a total distance of 130 km. It has a maximum width of about 60 km from north to south and it tapers to a minimum of less than 10 km at its most easterly termination, east of Mamfe. The basin is thought to dip westwards, in an undulating manner (Ndougsa-Mbarga et al., 2007), while its sediment load has been ascertained, using geophysical methods, to reach a maximum thickness of 3–4 km (Fairhead et al., 1991; Okereke and Onwuemesi, 1989; Petters et al., 1987). This sediment load thought to be of Aptain to Albian age (Fairhead et al., 1991), is made up of conglomerates, sandstones, mudstones, siltstones, clay stones, carbonaceous and non-carbonaceous shales as well as several limestone occurrences. The entire stratigraphic sequence has now been divided into Early Cretaceous and Late Cretaceous sub-sequences, with the former coinciding with the Cross River Group as defined by Wilson (1928). The view that the basin lacks marine influence and its sediments are essentially fluviatile (Petters et al., 1987) could not have been formed through thorough field investigations, in view of the number of limestone and shale deposits found there. These sediments have been intruded by a number of igneous bodies of different ages, some of which like the Ikom basalt are of volcanic expression (Hossain, 1981). There are also numerous mineral veins, especially on the Nigerian side. These veins, together with those in the Benue trough, supply the oil industry's local barite requirement in Nigeria. Also, Dumort (1968) reports the presence of mineralization in the early Cretaceous sediments of the Ikom-Mamfe basin, within the axial region at the eastern end of the basin. Brine springs; sapphire and lead–zinc ores are mentioned. Recent investigations in this basin have focused on petroleum prospects assessment (Ndougsa-Mbarga et al., 2007; Abolo, 2008). The Ikom-Mamfe basin is thought to have originated as a rift (Petters et al., 1987; Fairhead et al., 1991; Abolo, 2008) or by block rotation of the Oban massif relative to the Obudu basement (Oden et al., 2012), possibly at about the

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same time that South America separated from West Africa. The sediments are thought to have been folded and faulted (Wilson, 1928; Fairhead et al., 1991; Abolo, 2008).

In this paper the fracture lineaments of the western sector of the Ikom-Mamfe basin are analyzed and their relationship to the mineral veins in this basin is shown. The necessary structural and tectonic inferences are drawn through a comparison with similar features in the Benue trough.

2. Methodology and data acquisition

The work or investigation was divided into three parts: the lineament study, the field data acquisition and the analysis of mineral samples and structural data in the laboratory.

Lineaments in the study area were first identified from aerial photographs, using a stereoscope. These photographs were obtained from the Forestry Department of the Ministry of Agriculture in Cross River State. All lineaments so identified were transferred from the mosaic of marked photographs to a large tracing paper, which was further reduced to a convenient size (Fig. 1). Comparison with the lineament map of the same area produced by the Cross River Basin and Rural Development Authority, showed correspondence of the structures. The length and strike of each lineament were then measured for further analysis.

At least thirty mine sites and un-mined barite veins were visited as well as about eleven igneous bodies, including Ikom basalt. The geographical coordinates of the mine sites and igneous bodies were determined using a Garmin 76 Global Positioning Satellite-System (GPS) and these were superimposed on the old composite geological maps of the basin (Fig. 2).

The ideal mine sites provided information about the mineral commodity mined, the attitude of the vein, width of the vein, stope

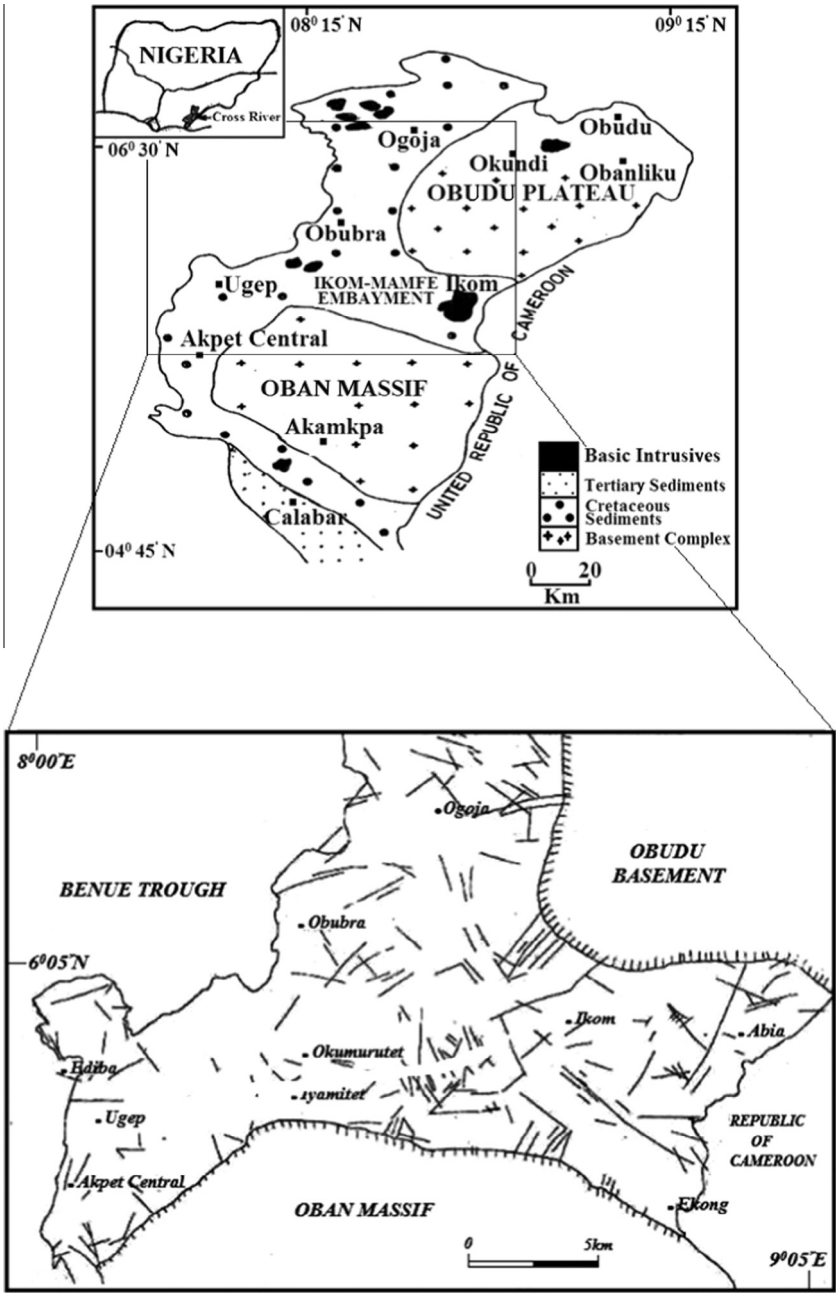

Fig. 1. Fracture lineament map of Ikom-Mamfe basin, S.E. Nigeria showing the surrounding Oban massif, Obudu plateau, Benue trough and parts of western Cameroon.