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SUBSIDENCE WITHIN THE LOCALITY OF WATER BODIES IN BUI DIVISON, NORTH WEST REGION OF CAMEROON (Case Study of Bamkikaiy West-End Water Source)

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Abstract: **Mass movements in form of subsidence, landslides and solifluxion are encountered within the sources of some water bodies in Bui division North West Region of Cameroon, to which little attention is given and assumed to be of supernatural, hence mystical with unquestionable origin. Subsidence within these sources results to land loss with degradation of the integrity of the infrastructure and ecosystem health. Despite the huge impact on the local landscape, the precise cause of the subsidence and related movements are not well understood. Contemporary research works elsewhere on similar aspects attributes a measurement of these movements to many different processes. Individual subsidence studies often focus on a particular subsidence process and use alternative methodologies whose results may not be comparable with or complementary to results of other studies. The hydrolysis of the dominantly feldspar minerals from the volcanic rocks within the locality produces Kaolinite as a secondary stable mineral. Kaolinite with its typical layering structure whose layers are held by predominantly weak hydrogen bonds in halloysite the hydrated form favour sliding movement between the layers that is enhanced by the overbearing weight load of the overlying earth strata, with subsidence often accompanied by Landslides as a consequence. This impedes attempts to synchronize the research into a comprehensive local and regional understanding. This article presents a review of contemporary subsidence research to reveal the most influential of the processes at the Bamkikaiy subsidence zone. The objective is to through light into the origin of the subsidence accompanied by landslides often misconstrued and giving a supernatural origin to this phenomenon by the local population. At the end of the research the population will understand the natural geological link to the subsidence and dispel mystical connotations hitherto associated.**

Keywords: **Subsidence, mass movement, Kaolinite, Clay minerals, hydrolysis, feldspars.**

1. INTRODUCTION

Subsidence generally refers to the downward movement of volume of a ground mass in area causing sinking to a lower level than usual and can occur beneath buildings with varying degrees of damages. This is consequently an enormous problem in landscape degradation (Brendan *et al.*, 2004) and for homeowners as it strikes anywhere due to a variety of different reasons. Potential development in some landscapes and building should be aware of possible causes of subsidence to help avoid or mitigate problems in future. In most situations subsidence is related to the moisture content of the soil underneath the landmass or structure. Certain soil types are more susceptible than others which as consequence

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form the background for natural cause of subsidence (Bronswijk,J.J.B 1989). However, there are many anthropogenic factors that also result into subsidence. Unfortunately within the Bamkikaiy West End water source area, characterized by subsidence coupled with landslide this aspect is often associated to a supernatural and mystical cause that derails the notion of inhabitants on the reality of the mass movement. This article has as objective to elucidate aspects susceptible for the subsidence and avoid ill notions unwittingly inculcated within the population hitherto this research.

2. LOCATION OF STUDY AREA

Bamkikaiy West End water source is situated in the North of Kumbo town, in Kumbo subdivision of Bui division, North West Region of Cameroon along the Kumbo to Nkambe corridor of national road number 11.The site is illustrated in Fig 1.

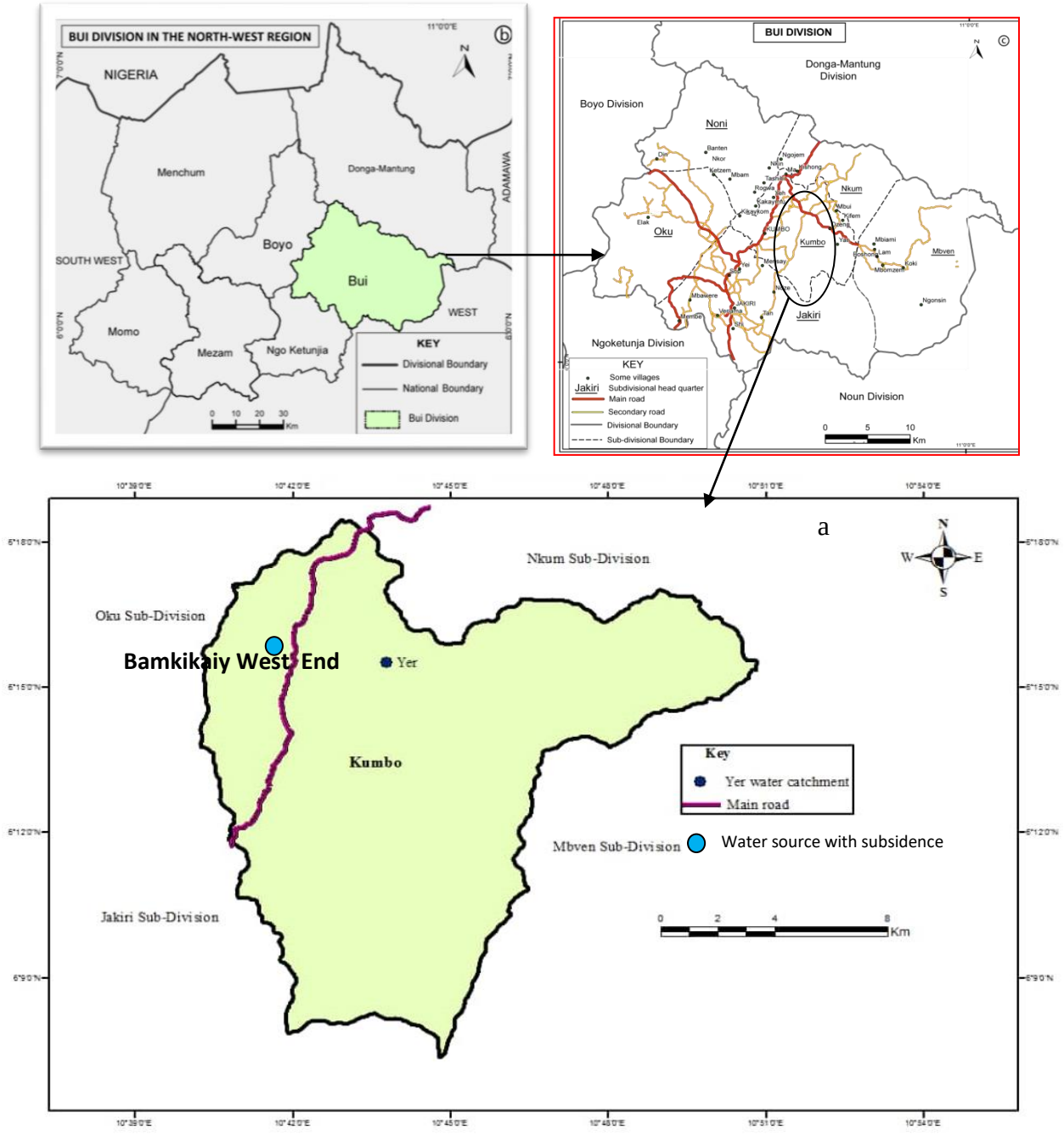

Fig 1: (a) Kumbo subdivision (b) NW Region (c) Bui division

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3. NATURAL CAUSES OF SUBSIDENCE

3.1 Rock type in relation to subsidence

Geologically**,** Bamkikaiy West End (B.W.E) water source in Bui division is in part of the Bamenda highlands, a northward extension of the Bambouto Mountain part of the continental Cameroon Volcanic Line (C.V.L). The rock type is dominantly basaltic and trachytic. This rocktype is similar to that of the Bambouto Mountain expressed in works by (Gountie, 2004, 2011; Youmen, 1994; Tabue 2000 and Kagou *et al*., 2010). The Trachytes are often associated with phonolites, rhyolites and ignimbrites. These rock types have constituted known minerals that were presented in Table 1.

Table 1: Summary of the minerals present in the rocks within B.W.E

Rock	Similar Minerals	Difference (divergence)
Basalt	Plagioclase	Olivine, pyroxene, calcite
Trachyte	Oxides, accessory minerals	Alkaline feldspar, pyroxene, amphibole, biotite
Rhyolite		Alkaline feldspar, quartz, amphibole, biotite
Phonolite		Pyroxene
Ignimbrite		Quartz, biotite, alkaline, feldspar, pyroxene, rocky inclusions

3.2 Soils within the study site

With a similar geologic setting like the Bambouto Mountain, B.W.E has soils developed from volcanic materials. According to Tematio *et al*., (2004), the soils of the Bambouto Mountain from upper to downstream were made up essentially of andosols, andicferralitic, ferralitic and alluvial soils. Fig 2 shows the soils in Kumbo subdivision within the water sources in B.W.E being humic basaltic or trachytic soils. Subsidence is directly related to the stress on the soil whose intrinsic characteristic properties render susceptibility to subsidence

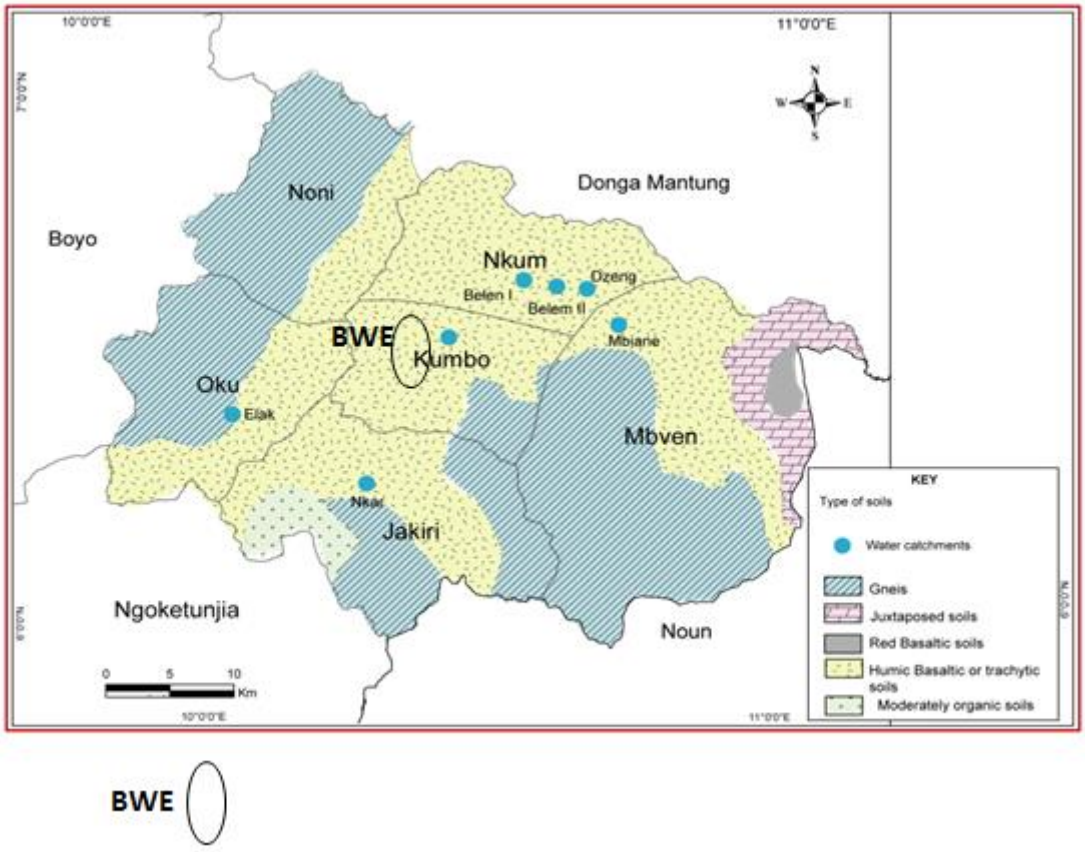

Fig 2: Soils of Kumbo in Bui division(Landsat; 2015)

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3.3 Weathering of rock minerals

The simplest way of representing the evolution of the primary minerals in rocks to secondary minerals (Clays) in the soil is in the form;

Primary minerals + attacking solution ⟶ Secondary mineral + leached solution…… (1)

(Parent rock) (in the soil)

Because feldspars are abundant in most rocks, potassic feldspars can be taken as our primary mineral. When silica is incompletely evacuated in course of weathering it produces secondary clay minerals (White, G.N *et al*., 1992; Schroeder, P.A *et al*., 1998; Bergaya *et al*., 2006). The process leading to the formation kaolinite the main clay mineral is referred to as monosiallitisation. The hydrated form of Kaolinite is Halloysite $Al_2SiO_2O_5\ (OH)_4\ .\times H_2O$

$$2KAlSi_3O_8(s) + 11H_2O\ (1) \longrightarrow \underset{\text{Kaolinite}}{Al_2Si_2O_5\ (OH)_4\ (s)} + 4Si\ (OH)_{4(aq)} + 2KOH_{(aq)} \ldots\ldots (2)$$

The Kaolinite structure is 39.8% Aluminium, 46.8% SiO_2 and 13.9% H_2O in a two layer structure. A silicon-oxygen tetrahedral layer is joined to the Aluminium octahedral layer alternately according to (Gruner and Nakahira, 1959; Frost, R.L 1995; Bickmore et al 1999). The morphology of Kaolinite and Halloysite its hydrated form exist in a plate-like layering structure, with weak hydrogen bonds between the layers (Yuan *et al*., 2013). Fig 3, illustrates the structure of Kaolinite and Halloysite in the soil.

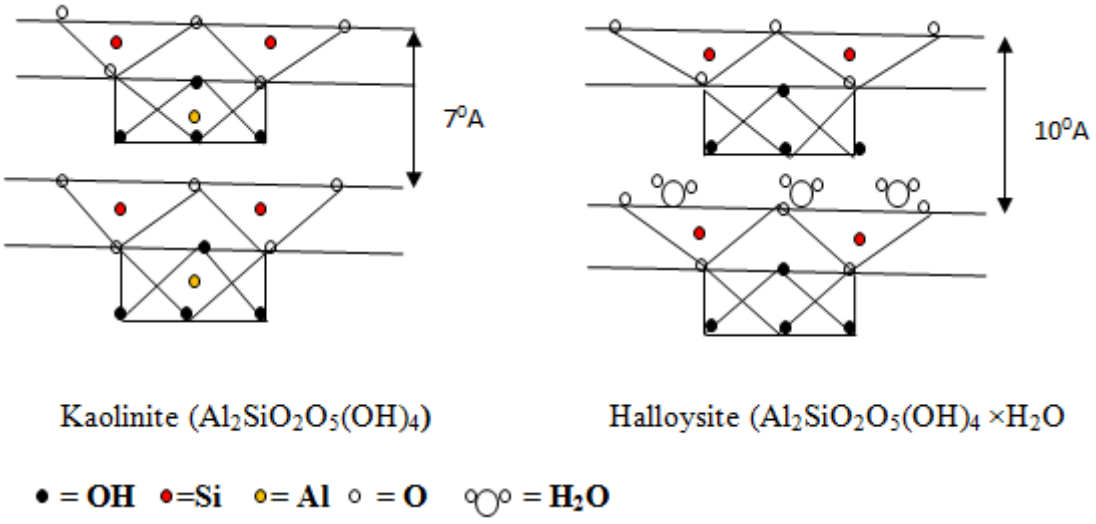

Fig 3: Structure of Clay soil (Kaolinite and Halloysite)

3.4 MAN-MADE CAUSES OF SUBSIDENCE

This was not very preoccupying within our study site. However situated along a main road, water escaping from the damage drains of the road runs into the study site softening and washing away soil resulting into ground movement affecting mainly the gravel soil. Nearby heavy traffic adjacent the Bamkikaiy West End water source resulted to extended vibrations that caused movement of the soil. All these had influence on subsidence though not as imposing as the natural causes.

4. IMPACT OF CLIMATIC CHANGE IN SUBSIDENCE

The world getting warmer is an undeniable fact. Since the late 19th century the average global temperature has risen by 1.1°C and in addition, 16 of the 17 warmest years on record have occurred since 2001, (Ching-Nuo, C and Samleke 2018). Climate change has had a number of high profile effects on planet Earth from rising sea levels to increasing weather events such as floods, with other consequences which are not friendly (Ching-Nuo, C and Samleke 2018). The increase in temperature is causing havoc with soil moisture levels with a great percentage of subsidence cases linked to soil shrinkage, with increasing aridity that leads to a significant impact on the number of cases of subsidence.

In Bui division of the North West Region of Cameroon and at the Bamkikaiy West End water site the focus of this article as elsewhere, the soil type most affected by moisture and temperature is Clay. Clays are cohesive soils hence the drier the weather, the more the soil will shrink due to lack of moisture. On shrinking it creates cracks vulnerable to subsidence a phenomenon conspicuously observed within the study site. Soil shrinkage does not occur instantly as soon as the weather gets drier, but over the course of a few seasons. Several months of dryness create dry soils that lead to subsidence. Property damage from drought induced subsidence is increasing worldwide and at the study site. Subsidence relative to other natural disasters is on the rise because of climate change, but unfortunately this is not given the attention it deserves and hurts land and home owners

5. CONCLUSION

At the end of this research article, a shift could be made from the illusionary imagination that subsidence was of mystical and supernatural origin. A clearer link to natural phenomenon such as rock type, soil and weather within the environment as well as man-made causes were accepted for subsidence whose mitigation could be initiated without fear of any mystical reprisals. Clay minerals in general and particularly kaolinite whose layering structures slide easily favour subsidence, solifluxion and landslides. This is further enhanced by shrinking and swelling potential of the clay soil that is further compounded by climate change to render the soil highly susceptible to subsidence.

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