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Inventory Of Abandoned Mine Ponds/Dams On The Jos-Bukuru North-Central Nigeria Using G.I.S And Remote Sensing Technique

[1,]EDUN, E.O and [2,]DAVOU, D. D
Nigerian Institute of Mining and Geosciences, Jos Nigeria Department of Geosciences

ABSTRACT

Between 1904 and the 1970s, intense mining was carried out on the Jos Plateau, Nigeria leaving behind its devastating effect both on human lives and its socio-economic values. An understanding of the aftermath environmental effect of mining should be considered both at mine planning stage and during the exploitaion years of any exploration company.

GIS and Remote Sensing was used in mapping out all abandoned ponds around the Jos-Bukuru area. A total of 100 major ponds and 80 minor ponds were mapped out all spread across the area of study.

A proper evaluation of past mineral exploration and exploitation using GIS and remote sensing as a tool and from both Spot 5 and Land Sat images observations were drawn out for each of these ponds. These open ponds are scattered in almost all the mineralised areas of the Jos Plateau.

With a good knowledge of GIS and accurate interpretation of satellite imagery, challenges in environmental issues, mineral exploration and mine planning would be a thing of the past.

This paper recommends that mining activities without plans for reclamation should be discouraged and thorough ground work should be conducted on the Jos plateau to fully explore unreclamed and partially reclaimed mine site as many of these ponds are located in places people would not really suspect.

Keywords: *Remote Sensing, Inventory, Abandoned Mine, Reclamation, Mining Pond*

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I. INTRODUCTIONS

The tremendous need for mineral resources as a result of the rapid population growth and economical development in Nigeria, exploration and exploitation of various minerals for several decades has greatly accelerated. The exploitation of minerals on the Jos Plateau dated as far back as 1902 Calvert (1977). Some on large/medium scale while some small scale or artisanal mining in the form of “Lotto” mining, as a result, a broad array of environmental problems related to human mining activities, such as air and water pollution, land resources and inhabited environmental devastation generated by non reclamation of these explored and exploited areas, and other hazards posed by these opened and unreclamed mining ponds etc, are daily becoming matters of concern, and furthermore, as the need for these mineral resources gets on the rise, much pressure is places on the environment with urbanization getting higher. The effect of these unreclamed mining pond tends to poses a very big challenge to the style of development and also the potential hazards it posses on human lives. For a sustainable exploration and exploitation of mineral resources, good government policies which will curb future occurrence of these unreclamed to partially reclamated mining program should be put in place. In a bid to analyze the present and the future environmental effect of these ponds, an inventory of those around Bukuru mining field and its environment is carried out in this work using GIS and Remote Sensing techniques with the aim of producing a detail survey and inventory of these mining ponds.Various workers have worked on these areas trying to estimate the degree of damage done to the environment by earlier mining operatives in the area. These mines, filled with water are generally referred to as mine ponds. Patterson (1986) estimated a total of about 1,000 such ponds scattered all over the mine fields of the Jos Plateau. Alexander (1985) estimated that about 325km2 of the land on the Jos plateau is rendered derelict on account of mining. Mining ponds are found some beside major roads, in farm lands,

II. GEOLOGIC SETTING

The Jos-Bukuru Younger Granite Ring Complex is part of generalised ring complexes of the Younger Granite suite. According to Turner (1976), the mode of emplacement of the Younger Granite complexes is not related or associated to any orogenic event or activity. The lack of sediments associated with the volcanic rock of the younger granite complex, which erupted to a land surface undergoing erosion (non deposition), is an indirect evidence to show that the Granites were associated with epirogenic upliftment (Turner, 1976).

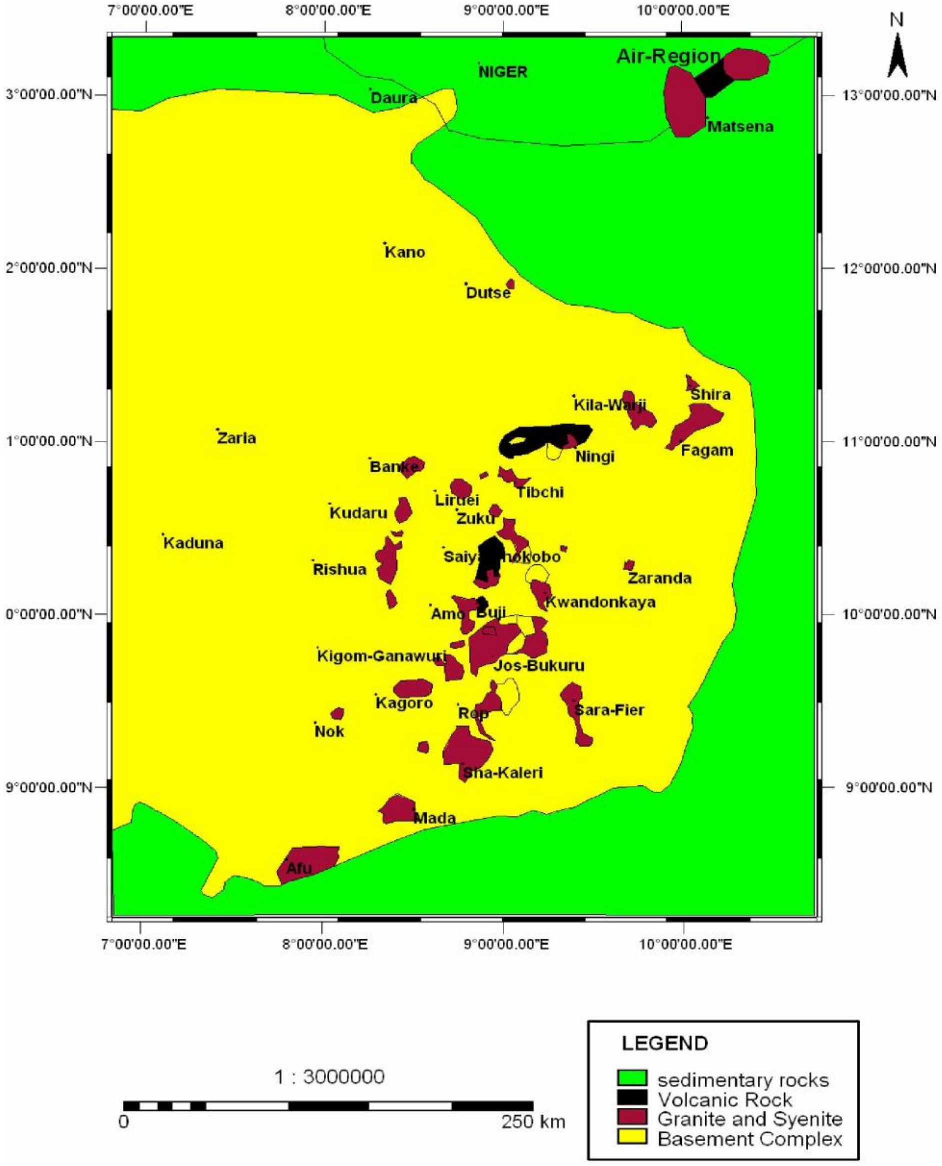

Fig 1: The Younger Granite ring complexes of Nigeria (modified from Turner, 1989)

The Younger Granites are discordant, high-level intrusion, which transgresses all units of the basement complex (Fig 1). They have been preceded by extensive acid volcanism and emplaced by ring faulting and block subsidence (Ike, 1983).

As a whole, the Younger Granite complexes may be inferred to have been emplaced under the following conditions (Ike, 1983):

i.) That there was a regime of faulting in the environment

ii.) That the outcrops of the intrusion are relatively circular

iii.) That there is a sharp contact which is steeply inclined outward (may be vertical) between them and the host Basement Complex.

That the surrounding rocks are undisturbed or show a terminal curvature in consistence with sinking of the central cylindrical block.

The Jos-Bukuru area covers a large area of the central Jos-Plateau north central Nigeria. The Complex is elliptical in surface plan with the longer axis extending for a distance of 30 miles from Shere Hills in the north east to the Forum River in the south. The elliptical Ring-fracture extends around the Northern, Western parts and embraces the separate Jarawa complex to the east (Berridgge 1957-1959, W.N Macleod). The elevation above sea level ranges from 3,800ft near the West and Northern margins to nearly 6000ft in the Shere Hills. Most part of the area lies within a height range of 4,100 - 4,500ft.

The province is characterized by large scale caldron subsidence and the superposition of the Ring structures. It is important to bear in mind that there is essential unity and continuity within each complex. This is due to the controlling mechanism of the Ring fracture and caldron subsidence having been active throughout the entire Younger Granite magmatic cycle.

However, this pattern is not as simple as seen, but rather follows an intricate (complex) pattern of separate granite intrusion.

Sequence of Rock Emplacement in the Jos-Bukuru Complex.

The sequences leading to the emplacement of the Jos-Bukuru Complex are:

i.) Central Granite Cycle

- North Vom Microgranite
- Sabon Gida Biotite-Granite
- Bukuru Biotite-Granite
- Shen Hornblende-Fayalite Granite

ii.) Early Granite Cycle

- Delimi Biotite Granite
- Rayfield-Gona-Biotite Granite
- Kuru Stock Biotite Granite
- N'gell Biotite Granite
- Naraguta Quartz Pyroxene Fayalite Porphyry.
- Neil's Valley Granite Porphyry

iii.) Volcanic Cycle

Rhyolites and Pyroclastics of Neils valley felsic dykes. In the various phases of emplacement of this rock, the study area was affected by the central Granites cycle and early Granite cycle. The rocks encountered are N'gell Biotite-Granite, Vom Hornblende-Biotite Granite (Berridgge, 1957-1959).

The early rocks lies entirely within the Neils valley ring dyke in the North and Northeast of the complex. It consists largely of sub-aerial lavas and tuffs which forms the southern escarpment of Neil's valley and also includes felsic dykes and a single exposure of agglomerate vent.

iv.) The Early Granite Cycle

The main plutonic cycle commenced with the emplacement of coarser grained Hornblende-Biotite porphyry in the major elliptical fractured zone bounding both Jos-Bukuru and within is internal fractured mosaic, remnants of which are preserved in the Jarawa valley and Neil's valley.

III. MATERIALS & METHODOLOGY

This work was carried out in two GIS environments, namely ILWIS and ERDAS. In general, remote sensing is the practice of deriving information about the earth's surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of electromagnetic spectrum, reflected or emitted from the earth's surface.

Spot 5 image covering the area of study was enhanced with spot data through a process known as pan-sharpening using the ERDAS imagine 8.6 at image processing laboratory of the National Center for Remote Sensing. The ungeoreferenced spot image covering some parts of the Younger Granite Province was imported into the ERDAS Imagine software. A geometric correction was carried out on the image by changing the projection to UTM (Universal Transverse Mercator), the spheroid to Clarke 1880, Datum to Minna, Nigeria and Zone to 32. A georeferenced LandSat image covering the same Younger Granite Province was also imported into the ERDAS environment and placed side by side with the Spot 5 image. Both images were studied and similar features , such as open pond and streams were identified. Subsequently, several image processing techniques such as image enhancements and radiometric enhancements were carried out on the image which eventually enhanced the features on it. The criteria used for the identification of open water filled ponds include two major surface features, these are geomorphic (caused by relief) and tonal (caused by contrast or tonal differences) (Sabins 1978).

Geomorphic features include landforms, linear boundaries between different types of terrain, straight stream valleys and alignment of minor stream segments. Tonal features include straight boundaries between areas of contrasting tone. Each suspected lineament or curvilinear structure was checked and re-evaluated using all the spectral bands and the geological map of the study area.
The processed image of the study area was displayed on the screen and properly studied by zooming in and out to clearly define structures/lineaments that are visible on the image. These features were then used to produce a digitized polygon maps for the studied open ponds.
Field work was also carried out to confirm that features mapped on the images as area covered by the ponds were not just a resemblance of what we are mapping, visit was made to the open ponds to confirm their locations. Pictures of these ponds were also taken to present an aerial view of some of the mining pond (Plate 1-4).

Table 1: Showing GPS location of some of the dams

LONGITUDE	LATITUDE	LOCATION
09^{0}50'31.8"N	008^{0}54'46.6"E	RAYFIELD RESORT
09^{0}50'49.4"N	008^{0}55'00.8"E	RAYFIELD
09^0 47' 64.5" N	008^0 51' 38.3" E	BUKURU
09^{0}51'06.8"N	008^{0}55'32.5"E	RAN KUANGDU
09^{0}50'27.5"N	008^{0}55'29.9"E	DOGO
09^{0}50'20.4"N	008^{0}55'21.1"E	DURA
09^{0}49'37.0"N	008^{0}55'12.3"E	DOI DU
09^{0}45'30.8"N	008^{0}51'54.8"E	ZWANG
09^{0}45'24.5"N	008^{0}50'41.0"E	HBC RESORT
09^{0}47'04.8"N	008^{0}51'38.6"E	BUKURU

Plate 1: An open pond around Du village

Plate 2: An open pond around Rayfield road

Plate 3: A frontal view of Rayfield Resort

Plate 4: An open pond at Ran Kwangdu

IV. RESULTS AND INTERPRETATION

Remote Sensing and GIS Tool Output

As earlier discussed, various image processing techniques were applied to the Spot image of the Naraguta 168 sheet. The results of these processes are discussed in this chapter

Colour Composite and Mappable Features

A colour composite is created by combining 3 raster images or maps. One map is displayed in shades of red, one in shades of green and one in shades of blue. The green vegetation will appear greenish, the water bluish, rocks as reddish brown and the (bare) soil in shades of white and sometimes the chemical constituent and dept of water body can also appear in shades of white. In the colour composite images settlements and built-up areas appear as patches of white (Fig. 2). From this resultant image relevant information such as open ponds and artificially made Dams were extracted.

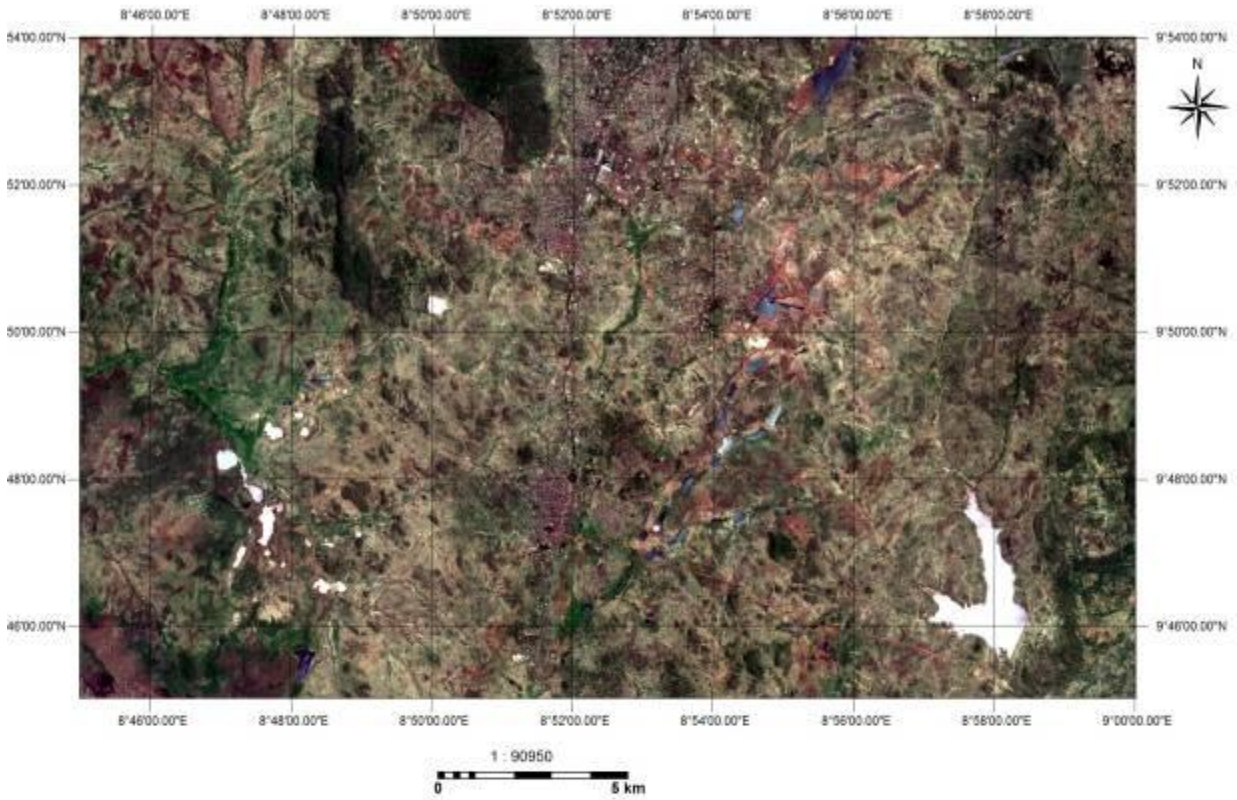

Fig. 2: Colour composite image of the study area.

Filtered Image

The primary aim of passing an image through different filters is to make it more visible to the human eye so as to extract geological information relevant to this research. Figure 3 shows a filtered image of the study area.

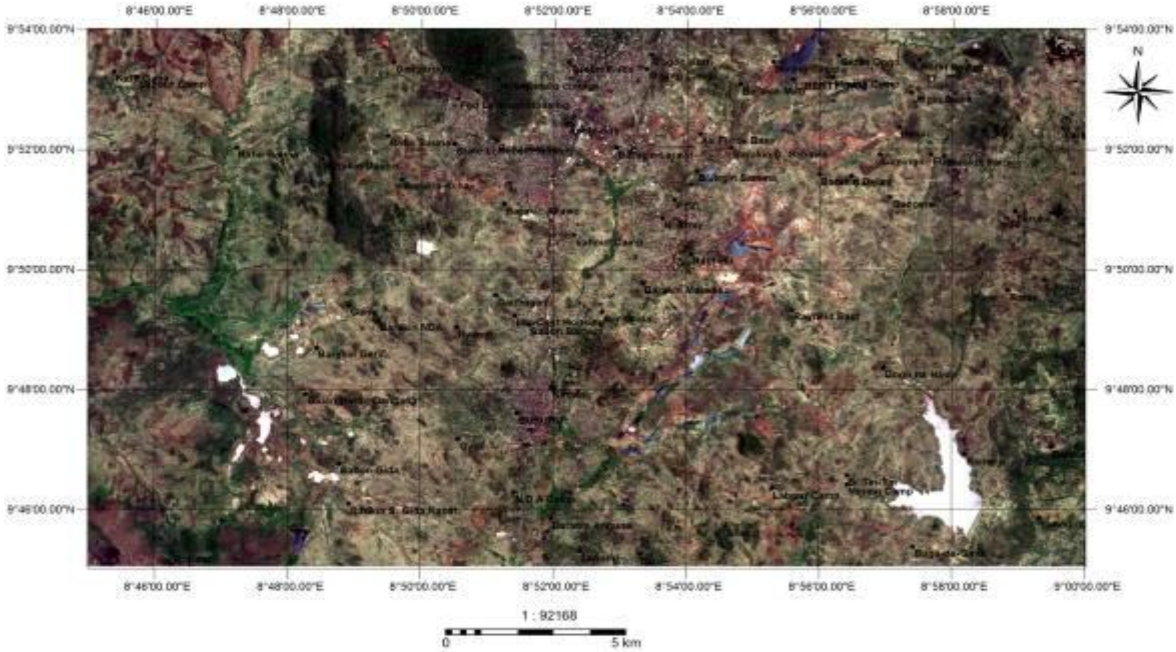

Fig. 3: Filtered Spot 5 image of the study area.

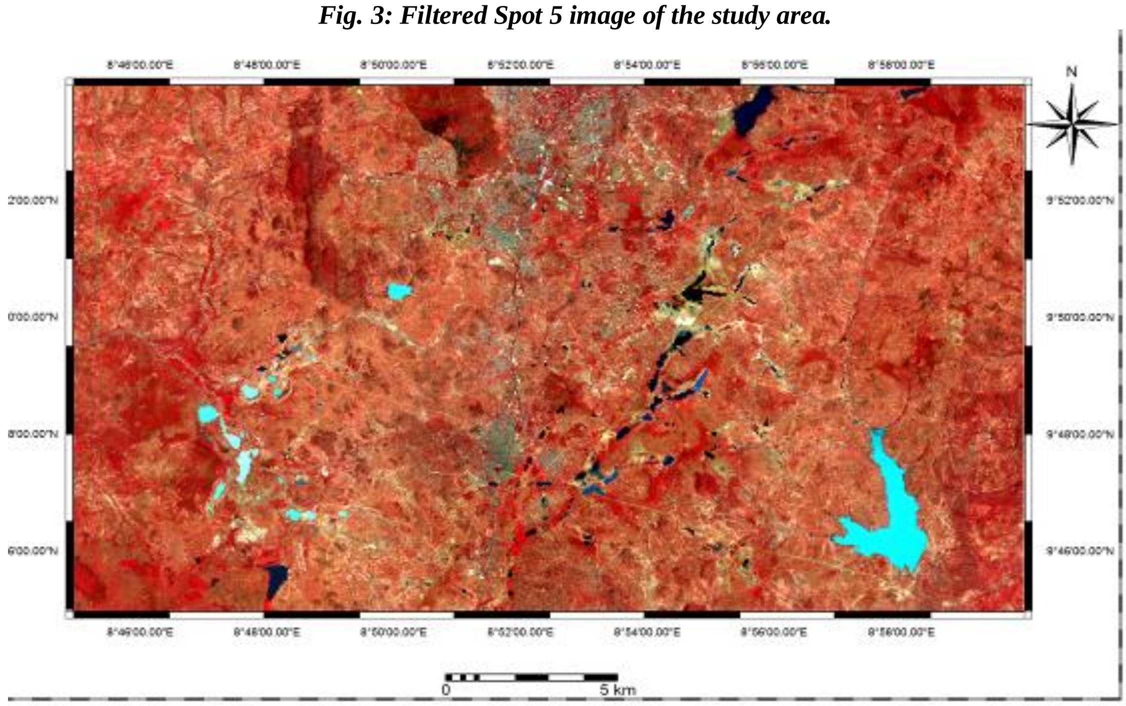

Fig. 4: LandSat Image Bands 432 of the Studied Area.

Open Pond Analysis

The various processed images of the study area were displayed on the screen and properly studied by zooming in and out to clearly define open ponds that are visible on the image (Fig. 3&4). A segment map of these open ponds was created by digitizing the ponds. Majority of the ponds trend in the NE-SW and NW-SE directions and this cluster range from 500m to 16km and some cut across each other while some cut across rock boundaries as also confirmed by Adiuku-Brown (1999) .

From the digitized map, a total of 180 open ponds polygons were observed from the research which was confirmed from field work. With varying length (sizes) and depths which is being shown by the colour composite on the spot imagery of the studied area.

Artificial Open Dam

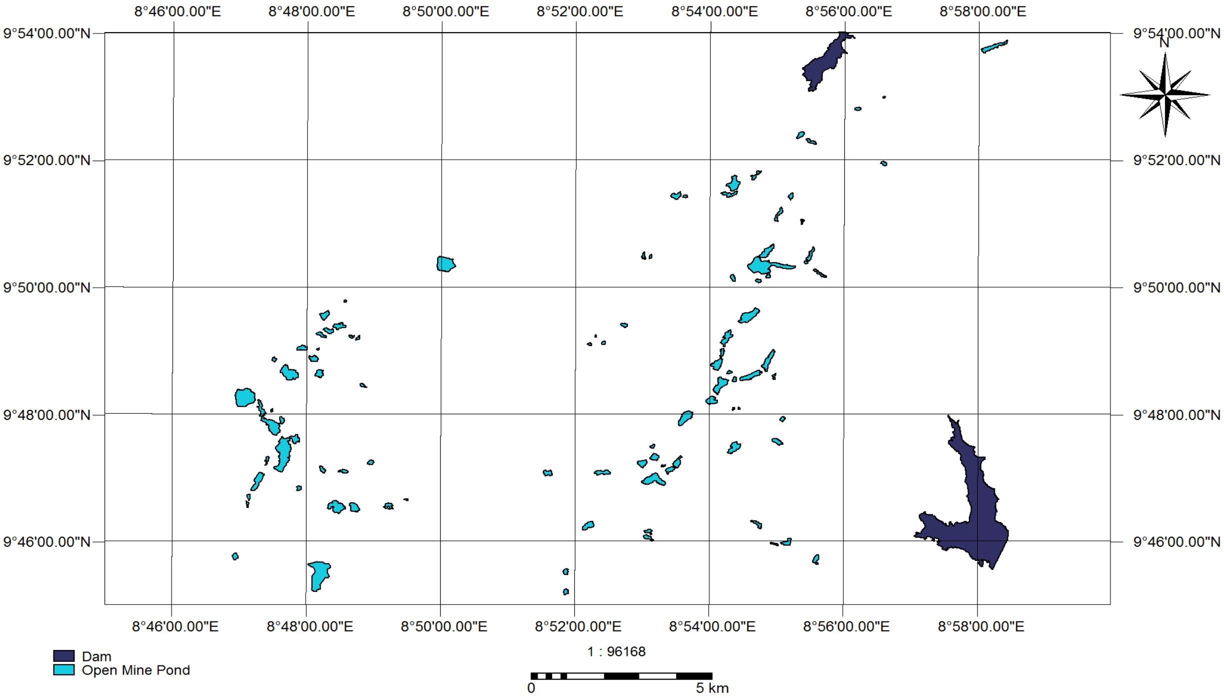

Fig 5: Result of Polygonization of the areas covered ponds and dam on the image of the study area.

The two artificial dam mapped in the course of the exercise are the Lamingo Dam and the Gowon Dam (Fig. 5). These dams were constructed artificially for public water processing and for electrification project. These areas were represented with the blue colour on the digitized map.

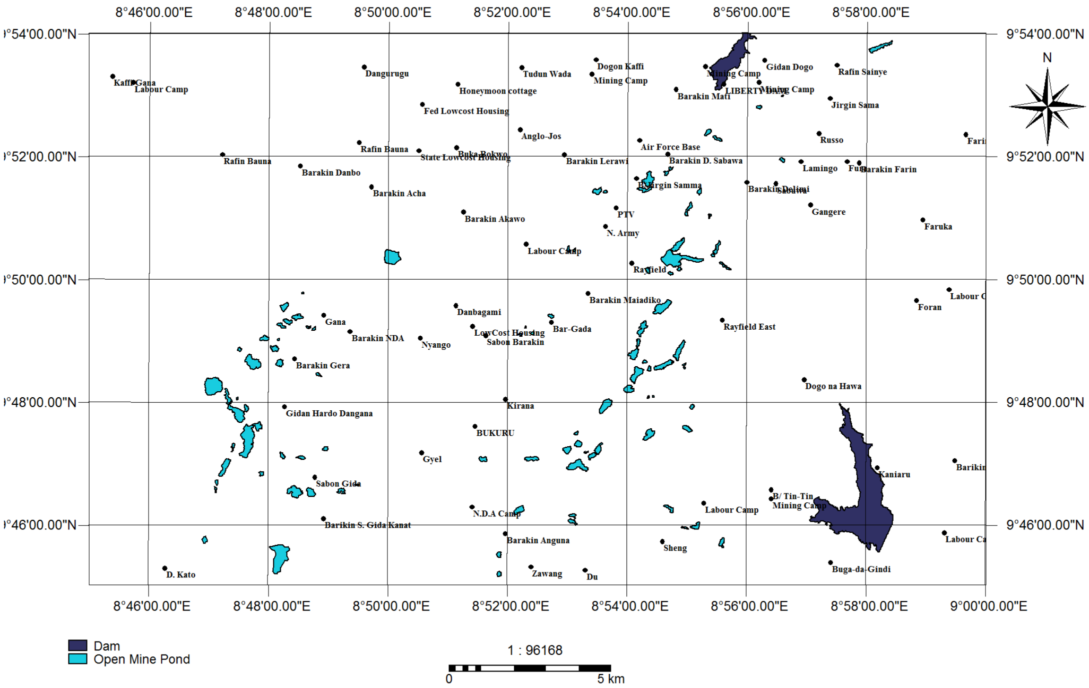

Fig 6: Polygons of open mine and dams with respects to locations.

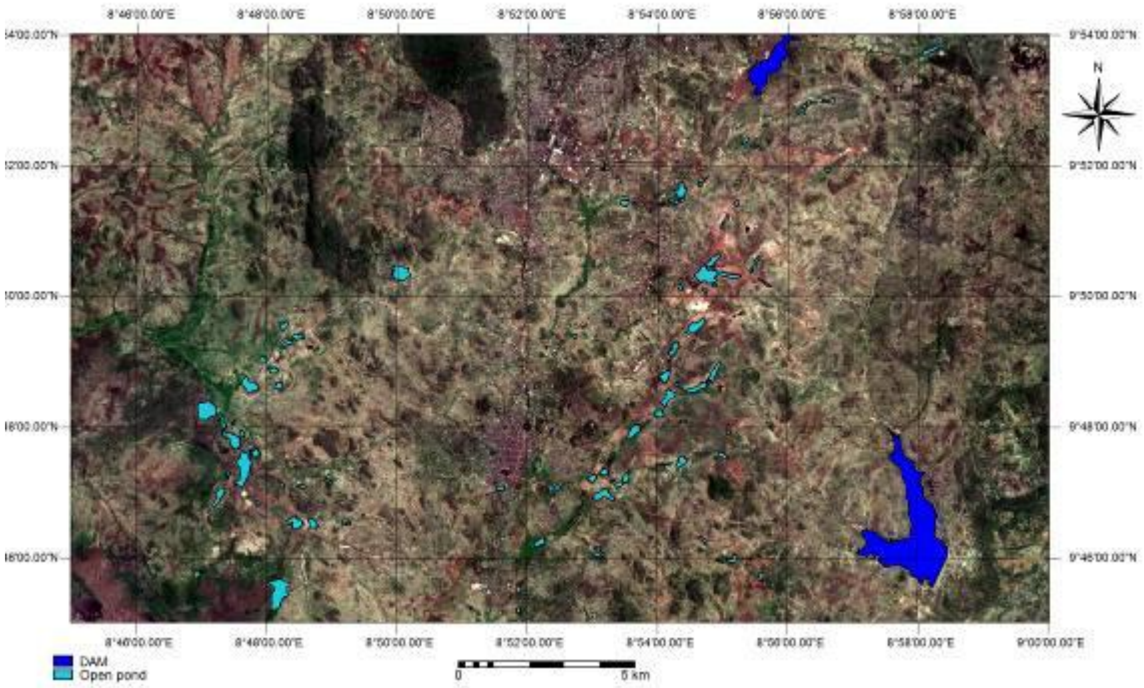

Fig 7: Interpolation of the ponds on the image

V. DISCUSSION

Associated Issues with Abandoned Mines

The issue of abandoned mines, with it's the associated physical, environmental and public safety concerns, constantly emerges around the world as a reminder of the legacy that past mining operations created. While the safety hazards were historically appreciated by the public and media although it's not always addressed, ongoing damage from such sites and the serious potential risks from the gradual deterioration of large abandoned mine features, such as open ponds, tailings piles and unstable walls, were often ignored.

It was only during the latter half of the twentieth century that it was realized that some abandoned mines were a potential threat to the environment and needed to be assessed. Attempts have been made in many countries, especially in developed ones (Ghana, South Africa, United States), to locate study and rehabilitate abandoned mines sites. In some countries programmes exist to address the environmental, social and economic issues that surround abandoned mines. In addition, the impact of abandoned mines on the image of the industry can be detrimental to future developments.

In countries with a long mining history, the magnitude of the impacts from past mining is often considerable, as environmental regulation of mining activities has in most cases only been introduced relatively recently. Although the most important issues of abandoned mines are the physical hazards (safety of excavations and structures), and environmental contamination, public opinion, especially in the developed countries, usually focuses initial opinions on visual impacts. However, as these evaluations are qualitative, rather than quantitative, value this section will examine the physical, environmental and socio-economic concerns of abandoned mines.

Physical Considerations

Some abandoned mines present only physical concerns. These concerns include public health and safety, visual impacts and stability concerns. Accidents related to vertical openings or steep and unconfined ponds which are located in plane lands where unknown to victims are the most common cause of death and injury in abandoned mines this has also been reported by Adiuku-Brown (1999) and Ugodulunwa (1997).

Many abandoned mines become flooded and shallow water can conceal other dangerous reptiles and its has also led to the death of tens of people as most areas are situated in open field which are not too obvious to unfortunate victims as also confirmed by Adiuku-Brown (1999) . Also lethal concentrations of toxic gases like methane, carbon monoxide, hydrogen and radioactive gases can accumulate making the use of the water hazardous to the locals who use the water for irrigation and domestic uses.

Environmental Issues

Abandoned mines in areas which have been explored on the plateau are daily becoming something of concern and in years to come as the tin city expands and develop. Today's research might have not proven in actual fact that these abandoned pond poses an urgent environmental hazard to human and plant life but when the radioactive radiation in those areas becomes alarming due to interaction between the water table and those filling those ponds. Over the years the mine waste piles which are exposed for years were investigated and a high level of radiation was discovered in homes built with this sand. Abandoned mines and associated features can have a detrimental effect on soils, water, plants and animals. The extent of the effects is not fully known because inventories are incomplete and some are still being evaluated. Generally, the common environmental consequences associated with abandoned mine sites include altered landscape, unused pits and land no longer useable due to loss of soil or soil contamination, spoil heaps covering the land, abandoned tailings disposal facilities, contaminated aquatic sediments, subsidence, overused works sites with compacted and polluted soil, dumps and workings and changes in vegetation.

Water is one of the resources most frequently polluted by abandoned mines. Water is also the main conduit by which impacts from abandoned mines extend beyond the immediate site. High concentrations of metals and increased levels of suspended sediment, toxicity, and radioactive exposure can threaten surface and underground water quality and aquatic life. Probably the most common and also most significant problem at abandoned mines, especially ones that have sulphide mineralization, is acid drainage.

Acid drainage occurs when surface or groundwater flows from or over abandoned mine features containing sulphide mineralization.

Also some of the abandoned mines serve as breeding place for some microbes which are dangerous to the human health not forgetting the malaria bearing mosquitoes and the dangerous animals that has made those ponds their hiding place. Structures that seem to be partially rehabilitated are dilapidating with torn walls and failing arms have also been recorded.

Abandoned mines may include disturbed lands and unprotected slopes that are susceptible to erosion. Uncontrolled surface drainage can remove soils and may make large areas unstable. Also the piles of overburden dumps around the banks of these ponds (Plate 5) have over the years been a source of concerned as current research being carried out by a department at the national centre for remote sensing during their preliminary report shows that these heaps has high level of radioactive elements which can be devastating to lives. Reworking of the previously areas have been reported by Eziashi (1998)

Plate 5: Waste pile at one of the sites

Socio-Economic Consideration

The socio-economic considerations of abandoned mines mostly arise from both the physical and environmental considerations discussed in the preceding sections. These include the safety hazards caused by abandoned mines that usually result in the loss of lives.

The physical impacts of abandoned mines like slope stability, contamination of soils by acid drainage and other metals released from waste piles usually cause the loss of productive land. Also the cost for reclamation only increase as the year goes by as the government plans for reclamation, cost of this program also increases. Funds that should have been of benefit to the entire populace would be diverted to reclaim these ponds if only government policy concerning reclamation has been put in place this would not happen.

VI. CONCLUSION

In summary, it was discovered that about 178 different ponds has been left behind as a result previous mining activities within the studied area which has either been partially reclamated or not reclamated. From this study we have been able to infer that with proper knowledge and application of remote sensing, at every stage of mine development, cost is greatly reduced and environmental hazards will also be prevented to ensure a more safe and environmental friendly mineral exploration and exploitation

Using the tool of remote sensing we have been able to deduce that numerous unreclamed mining abandoned ponds exist on the Jos plateau and on a daily basis becomes more of a treat to growth in the state and if reclamation program is not taken more serious, urbanization will be deterred by these areas. Furthermore seeing the environmental, physical, socio-economic and health hazard effect of past uncontrolled mining, strict law and enforcement is required to build a strong mineral industry in a developing country like ours. Also remote sensing as a tool in mineral exploration and environmental geology would minimize future occurrence of this menace if it is used as a tool during mine planning.

VII. RECOMMENDATION

As the use of remote sensing as a tool in both exploration and environmental is new in this part of the world, its use should be encouraged in educational institution as well as on the field for exploration, exploitation and final reclamation activities. Also further ground work should be conducted on the Jos plateau to fully explore unreclamed and partially reclaimed mine site as many of these ponds are located in places people would not really suspect.

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PLATES

Plate 1: An open pond around Du village
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Plate 5: Waste pile at one of the sites

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