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Research Article

Analyzing the environmental impacts and potential health challenges resulting from artisanal gold mining in Shango area of Minna, North-Central, Nigeria

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Abstract: The environmental impact and potential health challenges resulting from artisanal mining in Shango area of Minna, North Central Nigeria was put into perspective. The methodology adopted for the research includes field work and laboratory analysis. Results of field observation reveal that mining activity resulted in physical environmental impact such as land degradation, destruction of vegetation, erosion of soils and degrading water quality. Results from the laboratory analyses show that soils are contaminated with elements such as Cu (27.7 ppm), Cd (0.6 ppm), Hg (0.62 ppm) and Ag (0.35 ppm) and generally show high status when compared to published standard for upper continental crust. While, Zn (14.8 ppm), Ni (7.17 ppm), Mn (207 ppm), Pb (0.58 ppm), As (0.4 ppm), Co (0.55 ppm), Mo (0.16 ppm), and Zr (129.8 ppm) are rated low in line with the published standard; other determined elements such as Cr (37.8 ppm), Fe (31.1ppm) and Au (0.2 ppm) are high. These elements can easily be absorbed by plants and subsequently accumulate in their tissues. When such plants are eventually eaten by man, it may lead to different health problems such as slow growth rate, liver and kidney problem. High concentration of these elements in plant tissues may causes different problems.

Keywords: artisanal, environmental, mining, Shango, trace elements

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Introduction

Mining can be described as the processes involved in the extraction of mineral deposits from the surface of the earth or from beneath the surface. The exploitation of natural resources of any type, be it metallic, non-metallic minerals and fossil fuels (petroleum, coal and natural gas) play pertinent role in the economic development of any nation (Ako et al., 2014). These includes; the potential rise in the level of foreign exchange earnings and gross domestic products of such countries, mining activities may ultimately lead to the diversification of countries economy and promotion of job creation in both private and public sectors. To this end, the importance of the mining sector can never be over emphasized and has been published by several authors (Obaje and Abba, 1996, Nwajiuba, 2000; Obaje et al., 2005).

Artisanal Mining is a low resource, poverty driven and localized mining operations where simple, inexpensive tools and equipment are utilized in the extraction of mineral (Bradshaw et al., 1997). This type of mining is commonly practiced in the poorest areas of a country. However, it has been identified as means of livelihood adopted primarily in rural areas (Veiga, 2003). This type of mining is sometimes referred to as "informal sector", which is usually outside the legal and regulatory framework (Azubike, 2011). Opafunso (2010) reported that, the informal, unorganized, unplanned and uncontrolled nature of artisanal mining can be viewed negatively by governments and environmentalists; simply because of its potential for environmental damage, social disruption and conflicts.

Artisanal mining is one of the mechanisms by which air, lands, soils and water are polluted and degraded (Ademoroti, 1996; Ako et al., 2014). It also has considerable effect on the ecosystem and biodiversity. Furthermore, artisanal mining may also result to clearing of vegetation which reduces essential nutrients and organic matter of the soil. Thus, reducing biological activity and leading to decreases in productivity of the soil (Pandey and Kumar, 1996). The act of artisanal mining operations directly or indirectly affects both the living things (including human) and non-livings things through the physical and chemical modification of the soil environment (Ratcliffe, 1974). The use of gravity concentration methods such as panning and sluicing during processing poses health problems. Also, toxic materials are released into the environment, posing huge health risk to the miners, their families and the immediate communities (Azubike, 2011).

Despite the imminent dangers posed by this artisanal mining activity to human and the environmental components (land, air, water, soil animal), it has continued to spread due to large scale poverty, especially, in third world countries like Africa. Lack of jobs, growing unemployment and lack of political will on the part of government to formalize the sector. In addition, the other means through which the people may be affected include drinking contaminated/polluted water, food, inhalation of contaminated dust, oral ingestion of particles especially by children and through breast feeding (Ako et al., 2014).

Mining of gold has being left in the hands of artisanal miners who do not have enough resources and adequate equipment and technology required for the mining activities. Minna and its environment particularly the Shango area suffer in the hands of artisanal miners. This work therefore, studies the environmental problems associated with artisanal gold mining in Shango using both field observations and laboratory analysis of soil samples.

Materials and Methods

The method used for this research consists of fieldwork, mapping and laboratory analyses. During the fieldwork, soil samples were collected from the mined and unmined sites. Also, field observations were made to determine the physical environmental effect of the artisanal mining. The soil samples collected were further prepared before taking to the laboratory where their trace element contents were analyzed.

Field work

Field work was carried out within the Shango area of Minna to map the various rock units underlying the area. Subsequently, the mapped rocks out crop in the area were described based on their colour, texture and field relation. Furthermore, representative soil samples were randomly collected from the surface using a shovel from mined and un-mined areas. These samples collected were described based on their colour, texture and carefully put in polyethylene bags and labeled accordingly. The points where samples were collected in the field were plotted on the base map at the appropriate locations with the help of a Garmin Global positioning system (GPS). A total of six soil samples were collected and were used for geochemical analysis in the laboratory. During the field work, observation of the mining site was done so as to evaluate the physical effect of the mining on the area. Observations were equally made on the agricultural land use because of the farming activities going on in the area.

Laboratory work

The powdered samples were analysed for Trace elements using X-ray Fluorescence (XRF) machine, model: PANalytical, at the National Geo-science Research Laboratory (NGRL), of Nigerian Geological Survey Agency (NGSA), Kaduna. The software used for the analysis was Millipal 4. In this method, about 10 g of each the six prepared samples was weighed into the sample cup of the X-ray Fluorescence machine and analysed according to the method described by Ezeaku (2011). The mean concentration of each element in the samples was compared with Wedepohl (1995) and Taylor and McLennan (1985) average concentration of elements in upper continental crust. Values that correspond or fall below the expected limit were accepted as safe while values above the limits indicate very high concentrations of such elements in the soil which can cause serious environmental problems to plants and animals including man.

Results and Discussion

Lithology and field relation

The study area consists of two main rock types. These include the schist and the granites (Figure 1). The schist has been intruded by the granites and form sharp contacts at some places while contacts is only inferred in other places. The schist is more abundant than granite and covers about 90% of the study area (Figure 2).

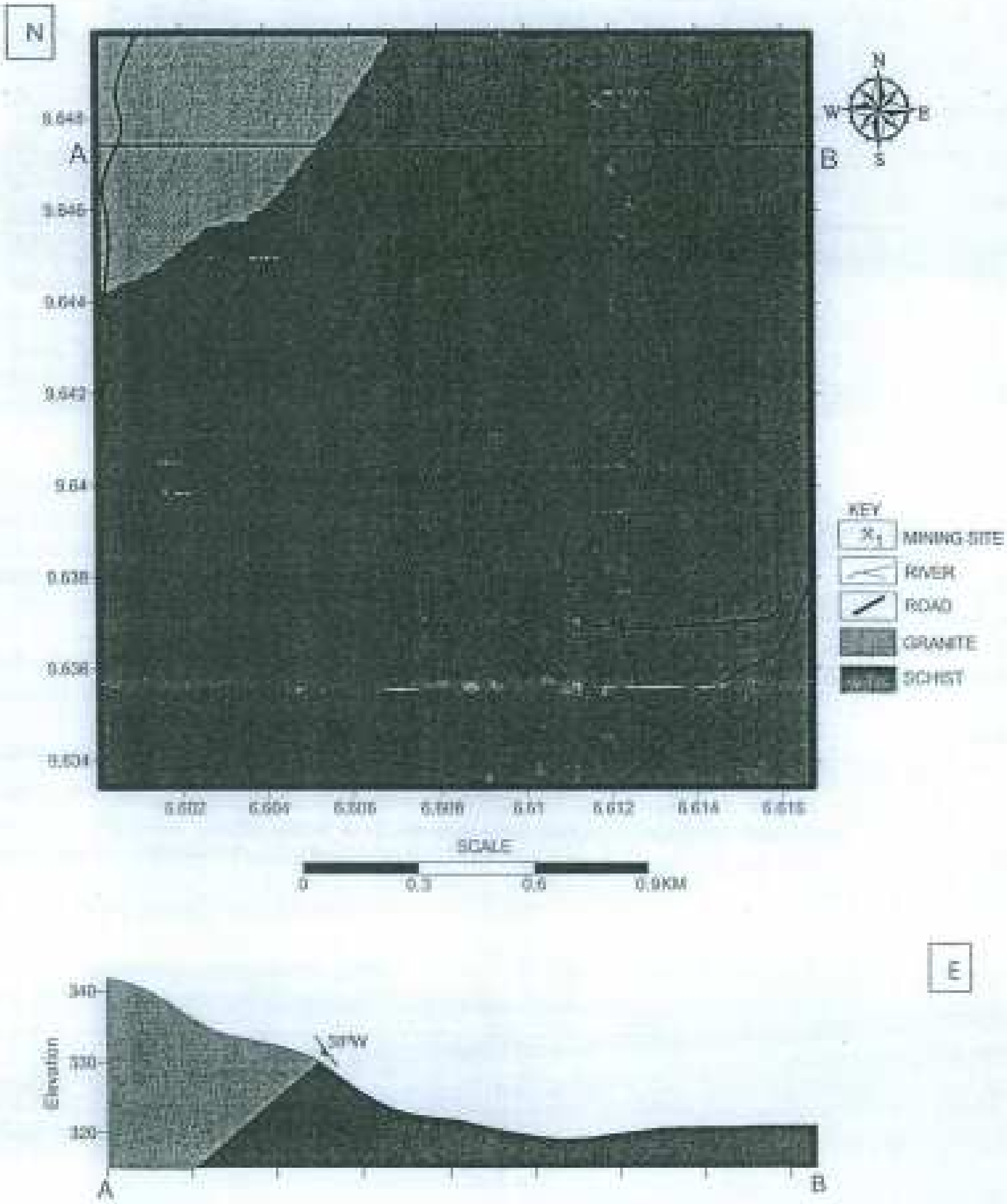

Figure1. Geological map and cross-section of Shango showing the rock units in the study area

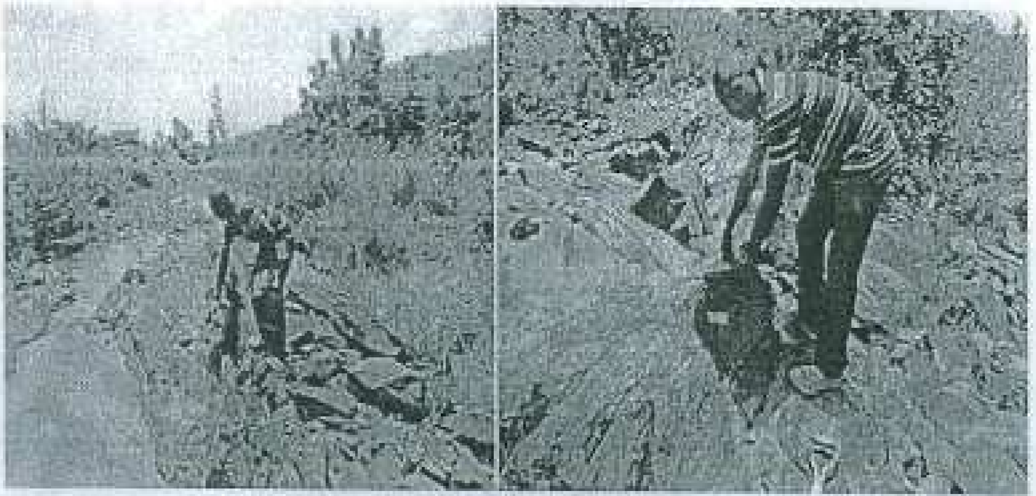

Figure 2. Shows photograph of schist being the dominant rock in the study area.They are generally low-lying, light coloured with characteristic medium to coarse grained texture. Mineral components of the rock consist of quartz, feldspar and mica. The schist is slightly weathered and foliated .The rock generally trend in NW-SE direction and generally dips between 30° - 40° NW. These rocks are jointed and the joints are filled with quartz vein.

The granites cover about 10% of the study area. They intruded the schist and are light in colour. Texturally, they are coarse grained. Mineral constituent of the rock consist of quartz, feldspar and muscovite. The granites have not been affected by weathering and are slightly jointed.'

Field observation

From the Field observation carried out, it was revealed that artisanal gold mining in the study area has resulted in numerous physical environmental impacts on the study environment. Some of them are highlighted below:

Farmland reduction and land degradation

It was observed during the fieldwork that, the effect of artisanal gold mining in the study area has led to destruction of the natural landscape as result of excavation of soil using shovel and diggers. This will further exposed the soil to erosion as the landcover are removed during such excavations (Figure 3). Thus, reducing farmland. They were observed pockets of pits found in the study area. These pits can be attributed to, or may have been created as a result of the localized artisanal mining activity in the area (Figure 4).

Figure 3. Photographs showing how natural landscape has been destroyed due to artisanal mining in Shango (source:fieldwork)

Figure 4. Shows the project student in one of the pit created by the mining activities. This pit may become a potential reservoir for polluted water and dangerous habitat for reptiles such as snakes which can cause harm to man.

Destruction of Vegetation

The clearing of the site for mining activities has resulted in loss of vegetation. This may further degenerate into deforestation if not adequately checked. Large amount of vegetation has been destroyed and this exposes the soil to erosion and makes it unsuitable for crop production (Figure 5).

Figure 5.Photograph showing the effect of loss of vegetation on land (source, fieldwork)

Degrading of water quality

Mine waste may increase the total solid load of water bodies which affect the quality of water in the study area (Figure 6). Water contaminated as a result of the gold mining may pose human health and environmental risk.

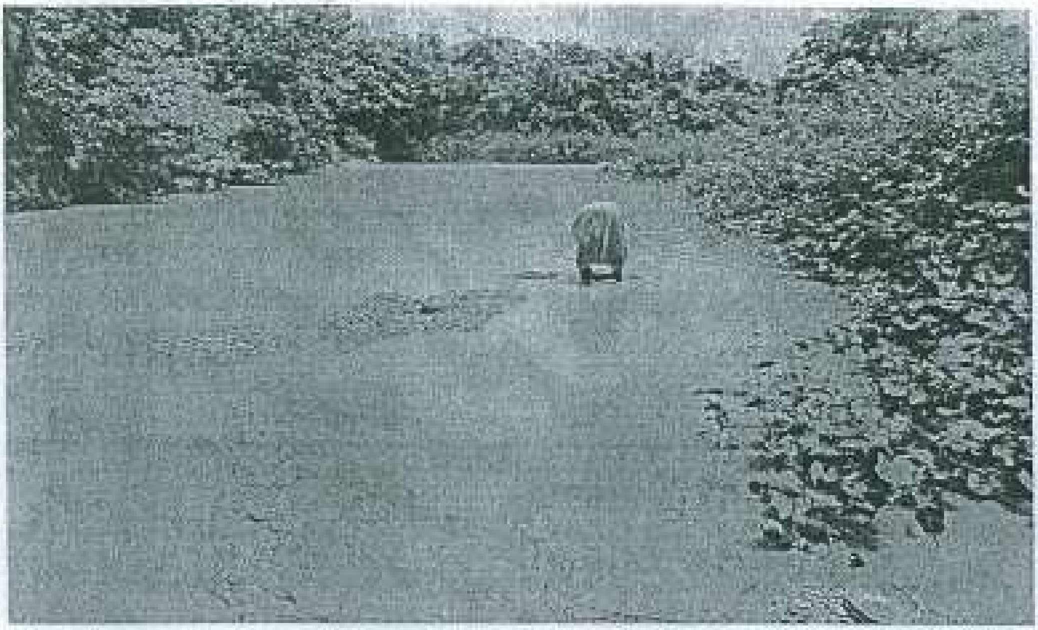

Figure 6.shows a photograph of an artisanal miner panning gold in the Shango River. This has turned the water brown and may further lead to pollution of the water, thus, posing threats to both man and animal health. (Source: fieldwork)

Geochemistry of the soil samples

The results of the concentration of elements in the soils of the study area along with the mean concentrations, as well as comparism with guide for Maximum Allowable Concentration in Upper Continental crust: Wedepohol (1995), Taylor and Mclennan (1985) are presented in Table 1

Table1. Geochemical data of the concentration of elements (ppm) in soils from Shango area compared with average concentrations of the elements in crustal rock

Element (ppm)	L1	L2	L3	L4	L5	L6	Mean Concent ration	Wedepohol (1995)	Taylor and Mclennan (1985)	Status
Pb	0.6	-	0.8	0.4	0.9	0.2	0.58	17 ppm	20 ppm	Low
As	0.3	0.3	0.5	0.2	0.7	0.4	0.4	2.0 ppm	1.5 ppm	Low
Cu	30	32	20	28	25	31	27.7	14.3 ppm	25 ppm	High
Ni	4.0	10	2.0	5.0	16	6	7.17	18.6 ppm	20 pm	Low
Mn	320	192	190	65.0	175	200	207	527 ppm	600 ppm	Low
Cd	0.7	0.5	0.5	0.9	0.6	0.5	0.62	0.102 ppm	98 ppb	High
Co	0.3	0.6	0.3	0.4	1.0	0.7	0.55	11.6 ppm	10 ppm	Low
Mo	0.2	0.1	0.2	0.1	0.16	0.2	0.16	1.4	1.5	Low
Hg	0.8	0.9	0.6	0.6	0.4	0.4	0.62	0.056 ppm	40 ppb	High
Ag	0.29	0.30	0.30	0.46	0.28	0.20	0.305	0.055 ppm	50 ppb	High
Zr	60	17	212	78	102	100	129.8	237 ppm	190 ppm	Low
Zn	27	12	10	8	15	17	14.8	52 ppm	71 ppm	Low
Cr	18	41	33	34	61	40	37.8	-	-	-
Fe	38.2	27.3	32.2	30.6	28.1	30.1	31.1	-	-	-
Au	0.2	0.3	0.2	-	0.1	-	0.2	-	-	-

From the result in Table 1 and the bar chart in Figure 7, it was revealed that Pb range from 0.9ppm to 0.2ppm and has a mean concentration of 0.58 ppm. However, when the mean concentration of Pb in the study area was compared to the average crustal abundance determined by Wedepohol, 1995, and Taylor and Mclennam, 1985, it shows a low status. This indicated that the concentration of Pb in the area is not high with respect to crustal abundance. The low level of Pb in the study area indicates that, the artisanal mining in the area has not release Pb into the soil and thus cannot be connected. Several reports (WHO, 1996; Hongu et al, 2005; Osher et al., 2006; Ako et al, 2014) stressed the fact that, Pb is transported in water, food and soil and may get accumulated in plants tissues and animal's tissue and may affect humans who eat such plants and animal products. Pb content in food may also, be due to air pollution. It may get into human body or system through food and drinking water (WHO, 1996). Ling et al. (2006) and Nagajyoti et al. (2010) further reported that, Pb in human body and plants can causes brain and kidney problems and affect plants morphology, growth and photosynthetic processes.

The result on Table 1 and Figure 7, shows that, As concentration in the soil range from 0.7ppm to 0.2ppm, with and a mean of 0.4ppm, when compared to standards, it has a low status. Ako et al. (2014) reported that Arsenic gets into the food chain through their accumulation in plants. It causes cancer and death from respiratory and cardiovascular failure in human. It also results in change of skin colouration. However, from the findings of this work, has a low status with respect to crustal abundance. This implies that, it does not pose any immediate health risk to the mining environment of shango.

Cu,Ni, and Mn ranges from 32 ppm to 20 ppm, 16 ppm to 2 ppm, 320 ppm to 165 ppm respectively. Also their respective mean concentrations are 27.7 ppm, 7.17 ppm and 207 ppm. However, compared with crustal abundance determined by Wedepohol (1995) and Taylor and Mclennan (1985), they show high, low and low status respectively.

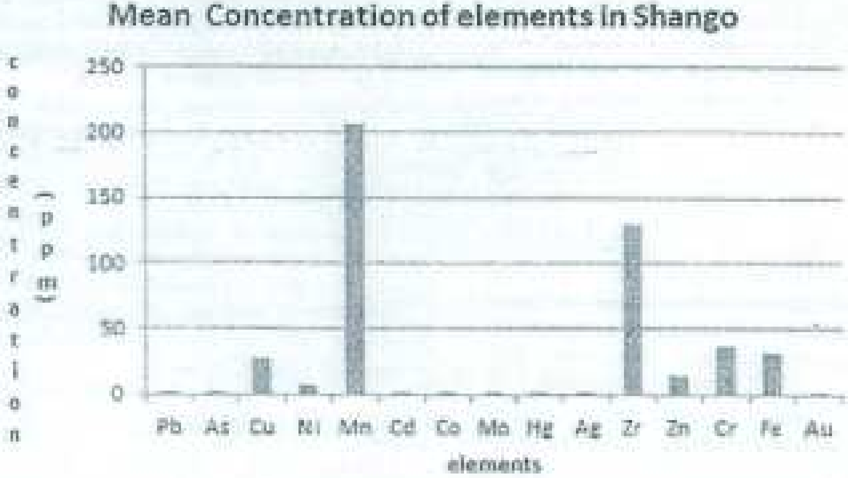

Figure 7. Mean concentration of elements in the soils in Shango area

The results in Table 1 have shown clearly that, the mean concentration of Cu is higher compared to the published crustal averages. Cu is an important micronutrient for plant (Thomas et al., 1998). It is essential at low concentration but hazardous in plants, animals and human at excessive level. According to Ako et al. (2014), high ingestion of Cu leads to liver and kidney damage. It slows down the growth of plants and causes leaf chlorosis (Lewis et al., 2001). Cu content is generally high with highest concentration at location 6 in the study area. Cd, Co and Mo ranges from 0.9 ppm to 0.5 ppm, 1.0 ppm to 0.3 ppm, 0.2 ppm to 0.16 ppm respectively. Their mean concentrations are 0.6 ppm, 0.55 ppm, 0.16 ppm respectively. Cd has a high status, while Co and Mo have low status respectively.The research shows that mean concentration of Cd is higher compared to the published crustal concentrations. Crops grown in soils with high Cd concentration lead to chlorosis, browning of roots and death of plants (Sanita di Toppi and Gabbrielli, 1999;

Wojcik and Tukiendorf, 2004; Guo et al., 2008). Ako et al. (2014) also reported in their work that, in human, source of exposure is through ingestion of food and water and inhalation of dust. High Cd concentration may cause kidney damage. Generally, it was observed that Cd concentrations in all the sampled locations are high.

Hg, Ag, Zr and Zn range from 0.9 ppm to 0.4 ppm, 0.46 ppm to 0.20 ppm, 212 ppm to 78 ppm and 27 ppm to 8 ppm, respectively. Their respective mean concentrations are 0.62 ppm, 0.305 ppm, 129.8 ppm, 14.8 ppm. After comparing with Wedepohol (1995) and Taylor and Mclennam (1985), Hg and Ag have high status while Zr and Zn has low status respectively. Hg occurs naturally in trace quantity in the earth crust (Cava-Montesinos et al., 2004). Berzas et al. (2003) reported that mining of ore expose human to mercury. Mercury contamination is passed through food chain to human. It is toxic to the reproductive and nervous system (Frumkin et al., 2001). High Hg content interrupt metabolism in plants (Messer et al., 2005).The result on Table 1 indicates that, the mean concentration of Ag is higher compared to the published crustal averages. Ako et al. (2014) reported that, Ag gets into human through ingestion and inhalation. Cr, Fe and Au range from 61 ppm to 18 ppm, 38.2 ppm to 27.3 ppm, 0.3 ppm to 0.1 ppm, respectively. Their mean concentrations are 37.8 ppm, 31.1 ppm and 0.2 ppm respectively.

Conclusions

Artisanal gold mining is a means of livelihood adopted in parts of Shango area. The research preliminarily concludes that artisanal gold mining activities are harmful to plants, animals, humans and the environment where such activities are carried out. Some of the physical immediate environmental problems in the study area are land degradation, landscape destruction, deforestation, soil erosion and loss of soil quality and degradation of water quality. The result of chemical analysis of the soil samples shows that, Cu,Cd,Hg, and Ag are high while Pb, As, Ni, Mn,Co, Mo, Zr and Zn are low when compared to published/established data for concentrations of elements within the upper continental crust. Artisanal mining activities have the potential to introduce these elements into the environment. These elements with higher concentration may cause potential to plants, animal and humans. Most especially, if such plants are eaten by man, they accumulate in the tissues and thus lead to different health problems.

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